Florida Department of Transportation

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January 20, 2011

Monica Gourdine
Program Operations Engineer
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: Office of Design, Specifications
Section **455**
Proposed Specification: **4550510 Structures Foundations.**

Dear Ms. Gourdine:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

These changes were proposed by Larry Jones of the State Structures Design Office to revise the requirements for Dynamic Load Tests on piles, and by Sherry Valdez of the State Construction Office to clarify payment for set-checks and redrives and remove duplicated language.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to SP965RP or rudy.powell@dot.state.fl.us.

If you have any questions relating to this specification change, please call Rudy Powell, State Specifications Engineer at 414-4280.

Sincerely,

Signature on file

Rudy Powell, Jr., P.E.
State Specifications Engineer

RP/dt
Attachment
cc: Gregory Jones, Chief Civil Litigation
Florida Transportation Builders' Assoc.
State Construction Engineer

STRUCTURES FOUNDATIONS.
(REV 1~~12~~-~~*19*~~*24*~~18~~*13*-10~~*1*~~)

SUBARTICLE 455-5.10.4 (Pages 534 – 535) is deleted and the following substituted:

455-5.10.4 Set-checks and Pile Redrive:

(a) Set-checks: In the event that the Contractor has driven the pile to approximately 12 inches above cut-off without reaching the required resistance, the Engineer may require the Contractor to interrupt driving up to two hours prior to performing a set-check. Provide an engineer's level or other suitable equipment for elevation determinations to determine accurate pile penetration during the set-checks. ~~There will be no separate payment for an initial set-check.~~ In the event the result*s* of ~~an~~*the* initial set-check*s* ~~is~~*are* not satisfactory, the Engineer may direct additional set-checks. ~~For each additional set-check ordered by the Engineer within two working days from the end of original driving, the Contractor will be paid an additional Set Check.~~ The Engineer may accept the pile as driven when a set-check shows that the Contractor has achieved the minimum required pile bearing and has met all other requirements of this Section.

(b) Pile Redrive: Pile Redrive consists of redriving the pile after ~~two~~*the following* working day~~s~~ from ~~original~~*initial* driving to determine time effects, to reestablish pile capacity due to pile heave, or for other reasons determined by the Engineer. Redrive piles as directed by the Engineer.

(c) Uninstrumented Set-Checks and Uninstrumented Pile Redrive: The Engineer may consider the pile 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 inch rebound per blow. When the total penetration during a set-check or redrive is greater than six inches or pile rebound exceeds 1/4 inch per blow, the Engineer may consider the pile to have sufficient bearing resistance when the specified blow count criteria is achieved in accordance with 455-5.10.1.

(d)Instrumented Set-Checks and Instrumented Pile Redrive: When considered necessary by the Engineer, dynamic load tests will be used to determine whether the pile bearing is sufficient. The Engineer may consider the pile to have sufficient bearing resistance when dynamic measurements demonstrate the static pile resistance during at least one hammer blow exceeds the required pile resistance, the average static pile resistance during the next five hammer blows exceeds 95% of the required pile resistance and the static pile resistance during all subsequent blows exceeds 90% of the required pile resistance.

SUBARTICLE 455-5.11.2 (Pages 535 – 537)

455-5.11.2 Wave Equation:

(a) 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.

The Engineer may modify the scour resistance shown in the plans if the dynamic load test is used to determine the actual soil resistance through the scour zone. Also, the Engineer may make modifications in scour resistance when the Contractor proposes drilling and/or jetting to reduce the soil resistance in the scour zone.

Use Wave Equation Analyses to show the hammer is capable of driving to a resistance equal to at least 2.0 times the factored design load plus the scour and down drag resistance (if applicable) shown in the Contract Documents, without overstressing the piling in compression or tension and without reaching practical refusal (20 blows per inch). Ensure that the hammer provided also meets the requirements described in 455-5.2.

(b) Required Equipment For Driving: Hammer approval is solely based on satisfactory field trial including ~~PDA, CAPWAP~~*dynamic load test results* and Wave Equation Analysis. Supply a hammer system that meets the requirements described in the specifications based on the above analysis. Obtain approval from the Engineer for the pile driving system 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.

(c) Maximum Allowed Pile Stresses:

(1) General: The maximum allowed driving stresses for concrete, steel, and timber piles are given below. In the event 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 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.

(2) 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:

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

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

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

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

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).

(3) Steel Piles: Ensure the maximum allowed 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.

(4) Timber Piles: Ensure the maximum allowed 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.

SUBARTICLE 455-5.11.4 (Page 537) is deleted and the following substituted:

455-5.11.4 Dynamic Load Tests: Dynamic load testing consists of ~~predicting~~ *estimating* pile capacity ~~from blows of the hammers during drive and/or redrive of an~~ *by the analysis of electronic data collected from blows of the hammer during driving of an* instrumented pile.

SUBARTICLE 455-5.12.1 (Pages 537 – 538) is deleted and the following substituted:

455-5.12.1 Description: 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:

(a) the installation criteria for the piles.
(b) the nature of the soil.
(c) the lengths of permanent piles required for the work.
(d) the driving resistance characteristics of the various soil strata.
(e) the amount of work necessary to obtain minimum required pile penetration.
(f) the ability of the driving system to do the work.
(g) 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. ~~Build up~~*Splice* test piles which have been driven their full length and have developed only minimal required bearing, and proceed with further driving.

As a minimum, unless otherwise directed 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. The Department will consider the work of extracting the pile to be Unforeseeable Work.

When driving test piles other than low displacement steel test piles, have preforming equipment available at the site and water jets as specified in 455-5.7 when jetting is allowed, ready for use, before the test pile driving begins.

The Engineer may elect to interrupt pile driving up to four times on each test pile, two times for up to two hours and two additional times during the next working day of initial driving to determine time effects during the driving of test piles ~~at no additional cost to the Department~~.

~~If additional set-checks are determined necessary by the Engineer within two working days following the end of initial driving, each set-check will be paid as an additional set-check. If set-checks are determined necessary by the Engineer after two working days from the end of initial driving, each set-check will be paid for as Pile Redrive.~~

Install instruments on test piles when dynamic load tests are included in the plans or when directed by the Engineer.

SUBARTICLE 455-5.13 (Pages 538 – 539) is deleted and the following substituted:

455-5.13 Dynamic Load Tests: The Engineer will take dynamic measurements during the driving of piles designated in the plans or authorized by the Engineer ~~as Dynamic Load Test Piles~~. Install instruments ~~on test piles and selected permanent piles for dynamic load testing~~ *prior to driving*. All test piles will have dynamic load tests. The Engineer will perform Dynamic Load Tests to evaluate any or all of the following:

1. Evaluate suitability of Contractor's driving equipment, including hammer, capblock, pile cushion, and any proposed follower.
2. Determine pile capacity.
3. Determine pile stresses.
4. Determine energy transfer to pile.
5. Determine distribution of soil resistance.
6. Evaluate soil variables including quake and damping.
7. Evaluate hammer-pile-soil system for Wave Equation analyses.
8. Evaluate pile installation problems.
9. Other.

Either install Embedded Data Collectors (EDCs) in the piles in accordance with Design Standards, Index No. 20602 or ~~A~~*a*ttach instruments (strain transducers to measure force and accelerometers to measure acceleration) with ~~screws~~*bolts* to the pile for dynamic load testing.

Make each pile to be dynamically tested *with externally attached instruments* available to drill holes for attaching instrumentation and for wave speed measurements. Support the pile with timber blocks placed at appropriate intervals. Ensure that the pile is in a horizontal position and does not contact adjacent piles. Provide a sufficient clear distance at the sides of the pile for drilling the holes. The Engineer will furnish the equipment, materials, and labor necessary for drilling holes and taking the wave speed measurements. If the Engineer directs dynamic load testing, *instrumented set-checks or instrumented redrives* ~~of piles already driven~~, provide the Engineer safe access to the top of the piles for drilling the attachment holes. After placing the leads provide the Engineer reasonable means of access to the piles to attach the instruments and for removal of the instruments after completing the pile driving.

The Engineer will monitor the stresses in the piles with the dynamic test equipment during driving to ensure the Contractor does not exceed the maximum allowed stresses. 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 as directed by the Engineer.

Drive the pile to the required penetration and resistance or as directed by the Engineer. Dynamic load testing of a pile may average up to two hours longer than for driving an uninstrumented pile.

When directed by the Engineer, perform instrumented *set-checks or* redrives. Do not use a cold diesel hammer for a *set-check or* redrive unless in the opinion of the Engineer it is impractical to do otherwise. 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.

SUBARTICLE 455-7.7.3 (Page 545) is deleted and the following substituted:

455-7.7.3 Precast Reinforced Build-ups: Construct Precast Reinforced Build-ups in accordance with the requirements of this Subarticle, Section 346, and Section 400. Provide the same material for the form surfaces for precast build-ups as was used to form the prestressed piles. Use concrete of the same mix as used in the prestressed pile and dimension the cross-section the same as piling being built up. Install build-ups as specified in 455-7.7.2(b) through 455-7.7.2(i). Apply to the build-ups the same surface treatment or sealant applied to the prestressed piles. ~~The Department will make payment for authorized build-ups at the respective Contract unit prices per foot for Prestressed Concrete Piling~~.

SUBARTICLE 455-8.3 (Page 546) is deleted and the following substituted:

455-8.3 Pile Splices: Order and use the full authorized pile length where practicable. Do not splice to obtain authorized lengths less than 40 feet except when shown in the plans. When approved by the Engineer, perform splicing to obtain

authorized lengths between 40 and 60 feet. The Engineer will permit splicing to obtain authorized lengths in excess of 60 feet.

Where the pile length authorized is not sufficient to obtain the required bearing value or penetration, order an additional length of pile and splice it to the original length.

Make all splices in accordance with details shown in the plans and in compliance with the general requirements of AWS D1.1 or American Petroleum Institute Specification 5L (API 5L). ~~Payment for pile splicing will be limited as specified in 455-11.9.~~

SUBARTICLE 455-9.4.4 (Page 548) is deleted and the following substituted:

455-9.4.4 Grouting and Caulking: Concrete sheet piles are generally detailed to have tongues and grooves on their lower ends, and double grooves on their upper ends. Where so detailed, after installation, clean the grooves of all sand, mud, or debris, and fully grout the grooves. Use approved plastic bags (sheaths) which will meet the shape and length of the groove to be grouted to contain the plastic grout within the double grooves. Provide grout composed of one part cement and two parts sand. The Contractor may use clean local sand or ~~beach~~ sand *meeting the requirements of Section 902* in this grout. In lieu of sand-cement grout, the Contractor may use concrete meeting the requirements of Section 347, using small gravel or crushed stone coarse aggregate. Deposit the grout through a grout pipe placed within a watertight plastic sheath (bag) extending the full depth of the double grooves and which, when filled, completely fills the slot formed by the double grooves.

SUBARTICLE 455-11.2 (Pages 549 – 551) is deleted and the following substituted:

455-11.2 Prestressed Concrete Piling:

455-11.2.1 General: The quantity to be paid for will be the length, in feet, of Prestressed Concrete Piling furnished, driven and accepted according to the authorized lengths list, including any additions and excluding any deletions thereto, as approved by the Engineer.

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 455-5.14.3 subject to provisions of 455-11.2.3 through 455-11.2.10, 455-11.9, 455-11.10 and 455-11.14.

455-11.2.3 Build-ups: The lengths of pile build-ups authorized by the Engineer, measured from the plane of cutback or the joint between the sections, to head of build-up, will be included in the quantities of Piling.

455-11.2.4 Piles Requiring Cut-offs: No *adjustments in*~~deduction from~~ the length, in feet, of Piling will be made if cut-offs are required after the pile has been driven to satisfactory bearing.

455-11.2.5 Piles Driven Below Cut-off Elevation: Where a pile is driven below cut-off elevation and satisfactory bearing is obtained so that no further driving is required, the length of pile will be measured from cut-off elevation to tip of the pile.

455-11.2.6 Driving of Splice: If a pile is driven below cut-off and satisfactory bearing is not obtained, and additional driving is required after construction of a satisfactory splice, an additional 10 feet of piling will be paid for the additional driving. This compensation for driving of splice, however, will not be allowed for test piles that are spliced and redriven.

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 455-5.15.5.

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 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.

455-11.2.8 Underwater Driving: When the Contractor selects one of the optional underwater driving methods, payment will be made by selecting the applicable method from the following:

(a) Using a pile longer than the authorized length: Payment for piling will be made only for the authorized length at that location unless the length of pile from cut-off elevation to the final tip elevation is greater than the authorized length, in which case payment for piling will be made from cut-off elevation to final tip elevation. No payment will be made for pile splice, when this option is selected, unless the pile is physically spliced and the splice is driven below cut-off elevation to achieve bearing. When making and driving a pile splice below cut-off elevation to achieve bearing, the length to be paid for piling will be the length between cut-off elevation and final pile tip elevation.

(b) Using an underwater hammer: Payment for piling and pile splices will be in accordance with 455-11.2.1 through 455-11.2.7 and 455-11.~~2.10~~*10.2*. The Contractor shall furnish additional lengths required to provide the full length confirmation pile at no expense to the Department. Payment for piling for the full length

confirmation pile will be the authorized length of the pile, unless the length driven below cut-off elevation is greater than the authorized length, in which case the length to be paid for will be the length between cut-off elevation and the final tip elevation. Splices in confirmation piles will be paid for only when the splice is driven below cut-off elevation.

(c) Using a pile follower: When a pile follower is used with a conventional pile driving system, the method of payment will be the same as shown above in 455-11.~~2.10(b)~~*10.2*.

~~**455-11.2.9 Set-Checks/Test Piles:** As described in 455-5.12.1, there will be no separate payment for the initial four set-checks performed within one working day of initial driving. For each additional set-check performed within two working days of initial driving, an additional quantity of 10 feet piling will be paid.~~

~~**455-11.2.10 Set-Check/Production Piles:** As described in 455-5.10.4(a), there will be no separate payment for one initial set-check. For each additional set-check performed within two working days from the end of initial driving, an additional quantity of 10 feet of piling will be paid.~~

SUBARTICLE 455-11.5 (Pages 551 – 552) is deleted and the following substituted:

455-11.5 Dynamic Load Tests: Payment will be based on the number of dynamic load tests as shown in the plans or authorized by the Engineer, 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 in the Pay Item 455-34. *No payment will be made for dynamic load tests on test piles.*

Payment for *attaching equipment to each production pile for* ~~D~~*d*ynamic ~~L~~*l*oad ~~T~~*t*est~~s~~*ing prior to initial driving and as authorized by the Engineer*~~, including up to two instrumented set checks~~ *will be 20 feet of additional pile.* ~~No additional payment for attaching equipment will be made for additional set checks performed within two days of the initial driving~~ will include all costs related to dynamic testing as described in 455-5.13 including the initial instrumented drive, and up to two instrumented set-checks that day. In the event the Engineer requires an instrumented set check or redrive of a ~~production~~ pile after the day of initial driving, 1/2 the payment for a Dynamic Load Test will be added to the payment for the set check or redrive.~~two set-checks within two days of initial driving, an additional 10 feet will be added to the quantity of piling. In the event the Engineer requires an instrumented redrive of a production pile, 10 feet will be added to the quantity of piling.~~

SUBARTICLE 455-11.9 (Page 552) is deleted and the following substituted:

455-11.9 Pile Splices: *The quantity to be paid for* ~~A~~*a*uthorized splices in concrete piling, ~~steel piling~~ and test piling, which are made for the purpose of obtaining authorized pile lengths longer than shown as the maximum length in the Standard Indexes, for obtaining greater lengths than originally authorized by the Engineer, to incorporate test piling in the finished structure, for further driving of test piling, or for splices shown in the plans, will be ~~paid for as described in 455-12.13.~~*30 feet of additional prestressed concrete piling.*

For concrete piles, where the head of the pile to be spliced is not more than 2 feet below the elevation of cut-off, ~~the Contractor, if he so elects, may cast~~ the pile build-up *may be cast* with the cap~~, under the following conditions:~~.

The ~~(a) R~~*r*einforcing steel and pile dimensions ~~will~~*shall* generally conform in every respect to a standard splice. *The quantity to be paid for will be* ~~(b)~~ 9 feet of piling~~, will be paid for~~ as compensation for drilling and grouting the dowels and reinforcing steel and concrete used for-build up and all other costs for which provision has not otherwise been made.

The quantity to be paid for authorized splices in steel piling and test piling for the purpose of obtaining lengths longer than the lengths originally authorized by the Engineer will be as 20 feet of additional steel piling.

SUBARTICLE 455-11.10 (Pages 552 – 553) is deleted and the following substituted:

455-11.10 ~~Pile~~ ***Set-Checks and*** **Redrive*s*:** ~~The quantity to be paid for will be the number of redrives, each, authorized by the Engineer. Pile Redrive is defined in 455-5.10.4(b). Payment for any pile redrive ordered by the Engineer will consist of 20 feet of additional piling. The size of the pile redriven will be the same size as the furnished item for payment.~~

~~Pile Redrive will be paid under any of the following conditions:~~

~~(a) When the Engineer directs the Contractor to redrive a pile to determine its capacity as described in 455-5.10.4.~~

~~(b) When the Engineer orders the Contractor to redrive piles to reestablish their capacity as the result of pile heave as described in 455-5.10.5.~~

455-11.10.1 Set Checks/Test Piles: *There will be no separate payment for the initial four set-checks performed ~~within two~~ the day of and the working day~~s~~ ~~of~~following initial driving. For each additional set-check ordered by the Engineer and performed within ~~two~~the following working day~~s~~ of initial driving, an additional quantity of 10 feet of piling will be paid.*

455-11.10.2 Set Checks/Production Piles: *There will be no separate payment for the initial two set-checks performed ~~within two~~ the day of and the working day~~s~~ ~~of~~following initial driving. For each additional set-check ordered by the Engineer and performed within ~~two~~the following working day~~s~~ of initial driving, an additional quantity of 10 feet of piling will be paid.*

455-11.10.3 Redrives: *The quantity to be paid for will be the number of redrives, each, authorized by the Engineer. Payment for any pile redrive (test pile or production pile) ordered by the Engineer will consist of 20 feet of additional piling.*

SUBARTICLE 455-12.5 (Page 554) is deleted and the following substituted:

455-12.5 Dynamic Load Tests:

455-12.5.1 Dynamic Load Tests/ Test Piles: *Price and payment will be full compensation for all labor, equipment, materials, instrumentation and installation required to assist the engineer in performing this work.* ~~No separate payment will be made for dynamic load tests on test piles. Anticipate a~~*A*ll test piles will require dynamic load tests, and include all costs associated with dynamic load tests in the pay items for test piles.

455-12.5.2 Dynamic Load Tests/ Production Piles: Price and payment will be full compensation for all labor, equipment,~~ and~~ materials*, instrumentation and installation* required to assist the Engineer in performing this work.~~ Payment for each dynamic load test on a production pile authorized by the Engineer will be made as 20 feet of additional piling.~~

SUBARTICLE 455-12.9 (Page 555) is deleted and the following substituted:

455-12.9 Preformed Pile Holes: ~~There will be no separate pay item for Preformed Pile Holes. Payment will be made as the unit price for Piling of the applicable pile type (excluding sheet pile) for 30% of each foot of hole which is preformed when authorized by the Engineer.~~ Price and payment will be full compensation for all labor, equipment, casings and materials required to perform this work.

SUBARTICLES 455-12.13 thru 455-12.15 (Pages 555 – 556) is deleted and the following substituted:

~~**455-12.13 Pile Splices:** The quantity of this item will be determined as provided in 455-11.9. Payment for each Steel Pile Splice authorized by the Engineer will be made as 20 feet of additional steel piling. Payment for each Concrete Pile Splice authorized and approved by the Engineer will be made as 30 feet of additional prestressed concrete piling.~~

455-12.1~~4~~3 Pile Cut-Off: ~~There will be no separate pay item for pile cut-off.~~ Anticipate all piles will require cutting-off, and include all costs associated with pile cut-off in the pay items for piling.

455-12.1~~5~~4 Payment Items: Payment will be made under:

Item No. 455- 2-	Treated Timber Piling - per foot.
Item No. 455- 14-	Concrete Sheet Piling - per foot.
Item No. 455- 18-	Protection of Existing Structures - lump sum.
Item No. 455- 34-	Prestressed Concrete Piling - per foot.
Item No. 455- 35-	Steel Piling - per foot.

Item No. 455- 36-	Concrete Cylinder Piling - per foot.
Item No. 455- 37-	Fiberglass Structurally Reinforced Composite Piles- per foot.
Item No. 455-119-	Test Loads- each.
Item No. 455-120-	Point Protection - each.
Item No. 455-133-	Steel Sheet Piling - per square foot.
Item No. 455-143-	Test Piles (Prestressed Concrete) - per foot.
Item No. 455-144-	Test Piles (Steel) - per foot.
Item No. 455-145-	Test Piles (Concrete Cylinder) - per foot.

STRUCTURES FOUNDATIONS.
(REV 1-13-11)

SUBARTICLE 455-5.10.4 (Pages 534 – 535) is deleted and the following substituted:

455-5.10.4 Set-checks and Pile Redrive:

(a) Set-checks: In the event that the Contractor has driven the pile to approximately 12 inches above cut-off without reaching the required resistance, the Engineer may require the Contractor to interrupt driving up to two hours prior to performing a set-check. Provide an engineer's level or other suitable equipment for elevation determinations to determine accurate pile penetration during the set-checks. In the event the results of the initial set-checks are not satisfactory, the Engineer may direct additional set-checks. The Engineer may accept the pile as driven when a set-check shows that the Contractor has achieved the minimum required pile bearing and has met all other requirements of this Section.

(b) 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 determined by the Engineer. Redrive piles as directed by the Engineer.

(c) Uninstrumented Set-Checks and Uninstrumented Pile Redrive: The Engineer may consider the pile 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 inch rebound per blow. When the total penetration during a set-check or redrive is greater than six inches or pile rebound exceeds 1/4 inch per blow, the Engineer may consider the pile to have sufficient bearing resistance when the specified blow count criteria is achieved in accordance with 455-5.10.1.

(d)Instrumented Set-Checks and Instrumented Pile Redrive: When considered necessary by the Engineer, dynamic load tests will be used to determine whether the pile bearing is sufficient. The Engineer may consider the pile to have sufficient bearing resistance when dynamic measurements demonstrate the static pile resistance during at least one hammer blow exceeds the required pile resistance, the average static pile resistance during the next five hammer blows exceeds 95% of the required pile resistance and the static pile resistance during all subsequent blows exceeds 90% of the required pile resistance.

SUBARTICLE 455-5.11.2 (Pages 535 – 537)

455-5.11.2 Wave Equation:

(a) 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.

The Engineer may modify the scour resistance shown in the plans if the dynamic load test is used to determine the actual soil resistance through the scour zone. Also, the Engineer may make modifications in scour resistance when the Contractor proposes drilling and/or jetting to reduce the soil resistance in the scour zone.

Use Wave Equation Analyses to show the hammer is capable of driving to a resistance equal to at least 2.0 times the factored design load plus the scour and down drag resistance (if applicable) shown in the Contract Documents, without overstressing the piling in compression or tension and without reaching practical refusal (20 blows per inch). Ensure that the hammer provided also meets the requirements described in 455-5.2.

(b) Required Equipment For Driving: Hammer approval 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 the above analysis. Obtain approval from the Engineer for the pile driving system 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.

(c) Maximum Allowed Pile Stresses:

(1) General: The maximum allowed driving stresses for concrete, steel, and timber piles are given below. In the event 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 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.

(2) 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:

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

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

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

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

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).

(3) Steel Piles: Ensure the maximum allowed 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.

(4) Timber Piles: Ensure the maximum allowed 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.

SUBARTICLE 455-5.11.4 (Page 537) is deleted and the following substituted:

455-5.11.4 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.

SUBARTICLE 455-5.12.1 (Pages 537 – 538) is deleted and the following substituted:

455-5.12.1 Description: 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:

(a) the installation criteria for the piles.

(b) the nature of the soil.

(c) the lengths of permanent piles required for the work.

(d) the driving resistance characteristics of the various soil strata.

(e) the amount of work necessary to obtain minimum required pile penetration.

(f) the ability of the driving system to do the work.

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

As a minimum, unless otherwise directed 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. The Department will consider the work of extracting the pile to be Unforeseeable Work.

When driving test piles other than low displacement steel test piles, have preforming equipment available at the site and water jets as specified in 455-5.7 when jetting is allowed, ready for use, before the test pile driving begins.

The Engineer may elect to interrupt pile driving up to four times on each test pile, two times for up to two hours and two additional times during the next working day of initial driving to determine time effects during the driving of test piles.

Install instruments on test piles when dynamic load tests are included in the plans or when directed by the Engineer.

SUBARTICLE 455-5.13 (Pages 538 – 539) is deleted and the following substituted:

455-5.13 Dynamic Load Tests: The Engineer will take dynamic measurements during the driving of piles designated in the plans or authorized by the Engineer . Install instruments prior to driving. All test piles will have dynamic load tests. The Engineer will perform Dynamic Load Tests to evaluate any or all of the following:

1. Evaluate suitability of Contractor’s driving equipment, including hammer, capblock, pile cushion, and any proposed follower.
2. Determine pile capacity.
3. Determine pile stresses.
4. Determine energy transfer to pile.
5. Determine distribution of soil resistance.
6. Evaluate soil variables including quake and damping.
7. Evaluate hammer-pile-soil system for Wave Equation analyses.
8. Evaluate pile installation problems.
9. Other.

Either install Embedded Data Collectors (EDCs) 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.

Make each pile to be dynamically tested with externally attached instruments available to drill holes for attaching instrumentation and for wave speed measurements. Support the pile with timber blocks placed at appropriate intervals. Ensure that the pile is in a horizontal position and does not contact adjacent piles. Provide a sufficient clear distance at the sides of the pile for drilling the holes. The Engineer will furnish the equipment, materials, and labor necessary for drilling holes and taking the wave speed measurements. If the Engineer directs dynamic load testing, instrumented set-checks or instrumented redrives, provide the Engineer safe access to the top of the

piles for drilling the attachment holes. After placing the leads provide the Engineer reasonable means of access to the piles to attach the instruments and for removal of the instruments after completing the pile driving.

The Engineer will monitor the stresses in the piles with the dynamic test equipment during driving to ensure the Contractor does not exceed the maximum allowed stresses. 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 as directed by the Engineer.

Drive the pile to the required penetration and resistance or as directed by the Engineer. Dynamic load testing of a pile may average up to two hours longer than for driving an uninstrumented pile.

When directed by the Engineer, perform instrumented set-checks or redrives. Do not use a cold diesel hammer for a set-check or redrive unless in the opinion of the Engineer it is impractical to do otherwise. 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.

SUBARTICLE 455-7.7.3 (Page 545) is deleted and the following substituted:

455-7.7.3 Precast Reinforced Build-ups: Construct Precast Reinforced Build-ups in accordance with the requirements of this Subarticle, Section 346, and Section 400. Provide the same material for the form surfaces for precast build-ups as was used to form the prestressed piles. Use concrete of the same mix as used in the prestressed pile and dimension the cross-section the same as piling being built up. Install build-ups as specified in 455-7.7.2(b) through 455-7.7.2(i). Apply to the build-ups the same surface treatment or sealant applied to the prestressed piles..

SUBARTICLE 455-8.3 (Page 546) is deleted and the following substituted:

455-8.3 Pile Splices: Order and use the full authorized pile length where practicable. Do not splice to obtain authorized lengths less than 40 feet except when shown in the plans. When approved by the Engineer, perform splicing to obtain authorized lengths between 40 and 60 feet. The Engineer will permit splicing to obtain authorized lengths in excess of 60 feet.

Where the pile length authorized is not sufficient to obtain the required bearing value or penetration, order an additional length of pile and splice it to the original length.

Make all splices in accordance with details shown in the plans and in compliance with the general requirements of AWS D1.1 or American Petroleum Institute Specification 5L (API 5L).

SUBARTICLE 455-9.4.4 (Page 548) is deleted and the following substituted:

455-9.4.4 Grouting and Caulking: Concrete sheet piles are generally detailed to have tongues and grooves on their lower ends, and double grooves on their upper ends. Where so detailed, after installation, clean the grooves of all sand, mud, or debris, and fully grout the grooves. Use approved plastic bags (sheaths) which will meet the shape and length of the groove to be grouted to contain the plastic grout within the double grooves. Provide grout composed of one part cement and two parts sand. The Contractor may use clean local sand or sand meeting the requirements of Section 902 in this grout. In lieu of sand-cement grout, the Contractor may use concrete meeting the requirements of Section 347, using small gravel or crushed stone coarse aggregate. Deposit the grout through a grout pipe placed within a watertight plastic sheath (bag) extending the full depth of the double grooves and which, when filled, completely fills the slot formed by the double grooves.

SUBARTICLE 455-11.2 (Pages 549 – 551) is deleted and the following substituted:

455-11.2 Prestressed Concrete Piling:

455-11.2.1 General: The quantity to be paid for will be the length, in feet, of Prestressed Concrete Piling furnished, driven and accepted according to the authorized lengths list, including any additions and excluding any deletions thereto, as approved by the Engineer.

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 455-5.14.3 subject to provisions of 455-11.2.3 through 455-11.2.10, 455-11.9, 455-11.10 and 455-11.14.

455-11.2.3 Build-ups: The lengths of pile build-ups authorized by the Engineer, measured from the plane of cutback or the joint between the sections, to head of build-up, will be included in the quantities of Piling.

455-11.2.4 Piles Requiring Cut-offs: No adjustments in the length, in feet, of Piling will be made if cut-offs are required after the pile has been driven to satisfactory bearing.

455-11.2.5 Piles Driven Below Cut-off Elevation: Where a pile is driven below cut-off elevation and satisfactory bearing is obtained so that no further driving is required, the length of pile will be measured from cut-off elevation to tip of the pile.

455-11.2.6 Driving of Splice: If a pile is driven below cut-off and satisfactory bearing is not obtained, and additional driving is required after construction of a satisfactory splice, an additional 10 feet of piling will be paid for the additional driving. This compensation for driving of splice, however, will not be allowed for test piles that are spliced and redriven.

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 455-5.15.5.

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 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.

455-11.2.8 Underwater Driving: When the Contractor selects one of the optional underwater driving methods, payment will be made by selecting the applicable method from the following:

(a) Using a pile longer than the authorized length: Payment for piling will be made only for the authorized length at that location unless the length of pile from cut-off elevation to the final tip elevation is greater than the authorized length, in which case payment for piling will be made from cut-off elevation to final tip elevation. No payment will be made for pile splice, when this option is selected, unless the pile is physically spliced and the splice is driven below cut-off elevation to achieve bearing. When making and driving a pile splice below cut-off elevation to achieve bearing, the length to be paid for piling will be the length between cut-off elevation and final pile tip elevation.

(b) Using an underwater hammer: Payment for piling and pile splices will be in accordance with 455-11.2.1 through 455-11.2.7 and 455-11.10.2. The Contractor shall furnish additional lengths required to provide the full length confirmation pile at no expense to the Department. Payment for piling for the full length confirmation pile will be the authorized length of the pile, unless the length driven below cut-off elevation is greater than the authorized length, in which case the length to be paid for will be the length between cut-off elevation and the final tip elevation. Splices in confirmation piles will be paid for only when the splice is driven below cut-off elevation.

(c) Using a pile follower: When a pile follower is used with a conventional pile driving system, the method of payment will be the same as shown above in 455-11.10.2.

SUBARTICLE 455-11.5 (Pages 551 – 552) is deleted and the following substituted:

455-11.5 Dynamic Load Tests: Payment will be based on the number of dynamic load tests as shown in the plans or authorized by the Engineer, 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 in the Pay Item 455-34. No payment will be made for dynamic load tests on test piles.

Payment for attaching equipment to each production pile for dynamic load testing prior to initial driving and as authorized by the Engineer will be 20 feet of additional pile.

SUBARTICLE 455-11.9 (Page 552) is deleted and the following substituted:

455-11.9 Pile Splices: The quantity to be paid for authorized splices in concrete piling, and test piling, which are made for the purpose of obtaining authorized pile lengths longer than shown as the maximum length in the Standard Indexes, for obtaining greater lengths than originally authorized by the Engineer, to incorporate test piling in the finished structure, for further driving of test piling, or for splices shown in the plans, will be 30 feet of additional prestressed concrete piling.

For concrete piles, where the head of the pile to be spliced is not more than 2 feet below the elevation of cut-off, the pile build-up may be cast with the cap. The reinforcing steel and pile dimensions shall generally conform in every respect to a standard splice. The quantity to be paid for will be 9 feet of piling as compensation for drilling and grouting the dowels and reinforcing steel and concrete used for-build up and all other costs for which provision has not otherwise been made.

The quantity to be paid for authorized splices in steel piling and test piling for the purpose of obtaining lengths longer than the lengths originally authorized by the Engineer will be as 20 feet of additional steel piling.

SUBARTICLE 455-11.10 (Pages 552 – 553) is deleted and the following substituted:

455-11.10 Set-Checks and Redrives:

455-11.10.1 Set Checks/Test Piles: There will be no separate payment for the initial four set-checks performed the day of and the working day following initial driving. For each additional set-check ordered by the Engineer and performed within the following working day of initial driving, an additional quantity of 10 feet of piling will be paid.

455-11.10.2 Set Checks/Production Piles: There will be no separate payment for the initial two set-checks performed the day of and the working day following initial driving. For each additional set-check ordered by the Engineer and performed within the following working day of initial driving, an additional quantity of 10 feet of piling will be paid.

455-11.10.3 Redrives: The quantity to be paid for will be the number of redrives, each, authorized by the Engineer. Payment for any pile redrive (test pile or production pile) ordered by the Engineer will consist of 20 feet of additional piling.

SUBARTICLE 455-12.5 (Page 554) is deleted and the following substituted:

455-12.5 Dynamic Load Tests:

455-12.5.1 Dynamic Load Tests/ Test Piles: Price and payment will be full compensation for all labor, equipment, materials, instrumentation and installation required to assist the engineer in performing this work. All test piles will require dynamic load tests, and include all costs associated with dynamic load tests in the pay items for test piles.

455-12.5.2 Dynamic Load Tests/ Production Piles: Price and payment will be full compensation for all labor, equipment, materials, instrumentation and installation required to assist the Engineer in performing this work.

SUBARTICLE 455-12.9 (Page 555) is deleted and the following substituted:

455-12.9 Preformed Pile Holes: Price and payment will be full compensation for all labor, equipment, casings and materials required to perform this work.

SUBARTICLES 455-12.13 thru 455-12.15 (Pages 555 – 556) is deleted and the following substituted:

455-12.13 Pile Cut-Off: Anticipate all piles will require cutting-off, and include all costs associated with pile cut-off in the pay items for piling.

455-12.14 Payment Items: Payment will be made under:

Item No. 455- 2-	Treated Timber Piling - per foot.
Item No. 455- 14-	Concrete Sheet Piling - per foot.
Item No. 455- 18-	Protection of Existing Structures - lump sum.
Item No. 455- 34-	Prestressed Concrete Piling - per foot.
Item No. 455- 35-	Steel Piling - per foot.
Item No. 455- 36-	Concrete Cylinder Piling - per foot.
Item No. 455- 37-	Fiberglass Structurally Reinforced Composite Piles- per foot.
Item No. 455-119-	Test Loads- each.
Item No. 455-120-	Point Protection - each.
Item No. 455-133-	Steel Sheet Piling - per square foot.
Item No. 455-143-	Test Piles (Prestressed Concrete) - per foot.
Item No. 455-144-	Test Piles (Steel) - per foot.
Item No. 455-145-	Test Piles (Concrete Cylinder) - per foot.