SECTION 505 - PILING

505.01 Description. This work includes furnishing and installing foundation piles of the type and dimensions according to the contract. Also, the Contractor shall drive these piles at the location and to the elevation, penetration and pile bearing capacities shown in the contract or as ordered by the Engineer.

The terminologies used in this section are in Section 101 - Definitions and Terms; ASTM D 653 - Standard Terminology Relating to Soil, Rock, and Contained Fluids; and HWY-TS 6 - Terminology Relating to Piling.

505.02 Materials.

(A) Reinforced Precast Non-Prestressed Concrete Piles. The Contractor shall construct reinforced precast non-prestressed concrete piles according to details shown in the contract and Subsection 505.03(B) - Reinforced Precast Non-Prestressed Concrete Piles.

(B) Precast Prestressed Concrete Piles. The Contractor shall pretension and construct precast, prestressed concrete piles according to details shown in the contract and Section 504 - Prestressed Concrete Members.

(C) Steel Piles. Steel piles include steel shapes of the weight and shape called for in the contract. The steel shall conform to ASTM A 328.

(D) Timber Piles. Timber piles shall conform to Subsection 714.04 - Timber Piles.

(E) Steel Shells for Cast-in-Place Piles. The Contractor may drive the metal shells, with a core or mandrel. Metal shells shall be of sufficient thickness and rigidity to withstand driving without harmful distortion. Also, the shell shall have sufficient strength and rigidity to prevent harmful distortion from soil pressures or the driving of adjacent piles. This is after the Contractor have driven and the core or mandrel, if any, withdrawn. Metal shells may be cylindrical, tapered, step tapered or a combination of either.

(F) Bituminous Coating. Bituminous coating shall be an asphalt type bitumen conforming to ASTM D 946, with a minimum penetration grade 50 at the time of pile driving.

(G) Primer for Bituminous Coating. Primer for bituminous coating shall conform to ASTM D 41.

505.03 Construction Requirements.

(A) General.

(1) Test Borings. The Contractor shall look at Subsection 102.05 - Examination of Contract and Site of Work and the "Log of Test Borings" shown in the contract.

The "Log of Test Borings" is a record of the data obtained from its investigation of the subsurface conditions. The "Log of Test Borings" represents its opinion to the character of material met in its test borings. This record is for the bidder and made available according to Subsection 102.05 - Examination of Contract and Site of Work.

(2) Order List for Piling. If the contract calls for test piles and load test piles, the Contractor shall furnish these piles according to an itemized list. The itemized list will show the number, length, and type of piles given by the Engineer.

The lengths given in the itemized list will be the lengths assumed to remain in the completed structure. The Contractor may increase the lengths given to suit its method of operation.

If the contract calls for pile testing, the Contractor shall order only the number, length and pile type specified initially. The Engineer will furnish the complete order list for production piles after the Engineer reviews the information according to Subsection 505.03(G) - Test Piles. The number and lengths of the production piles will prevail over those on the plans.

(B) Reinforced Precast Non-Prestressed Concrete Piles. The Contractor shall construct reinforced precast non-prestressed concrete piles according to details shown in the contract. Concrete shall have a minimum twenty-eight (28) day compressive strength of five thousand (5,000) pounds per square inch. The Contractor shall place the concrete according to the contract. The Contractor shall place the reinforcing steel according to Section 602 - Reinforcing Steel.

Precast concrete piles shall be cast in a horizontal position on a casting platform placed on a level and firm unyielding support precluding danger of settlement. Forms shall conform to Section 503 - Concrete Structures. The Contractor shall build forms of surfaced lumber, true to line, and with a one (1) inch chamfer strip at corners.

Side forms shall remain in place at least twenty-four (24) hours after placing the concrete. The Contractor shall not subject the pile itself to handling stresses until the concrete has set for at least ten (10) days.

The reinforcing shall be of the unit type, rigidly fastened together and lowered into the form before the Contractor places the *| concrete. The Contractor shall hold the reinforcing securely in the form *| by concrete blocks or other accepted devices. Also, the Contractor shall *| hold the reinforcing securely so that the center of the main bars shall *| not be closer to the surface of the concrete than shown in the contract. *|

The Contractor shall place the concrete with care to produce a bond *| with the reinforcing steel and to avoid the formation of stone pockets, honeycomb or other defects.

The Contractor shall place the concrete in each pile continuously *| and compact by vibrators or by other accepted means. Also, the *| Contractor shall rod the concrete thoroughly around the reinforcing *| steel and spade well along the sides. The Contractor shall overfill the *| forms and screed off the surplus concrete. Before the concrete has taken *| a hard set, the Contractor shall float the top surface and bring the top *| surface finally to a smooth finish of a uniform and even texture.

After casting and finishing, the Contractor shall cover the piles *| with a damp burlap or duck. For piles used in soil, fresh water or on *| shore, the Contractor shall keep the piles damp for not less than *| eighteen (18) days. For piles used in sea water, the Contractor shall *| keep the piles damp not less than twenty-eight (28) days. After the *| concrete has taken its final set, the Contractor may substitute the *| burlap or duck with a four (4) inch thick damp sand. *|

When removed from the forms, the piles shall present a true, *| smooth, and even surface. Also, the space between an imaginary line *| stretched from butt to tip and to the face of the pile shall not be more *| than one (1) inch. *|

The Contractor shall not drive piles until the piles have set for *| at least twenty-one (21) days. Also, the pile shall have a concrete *| strength of three thousand five hundred (3,500) pounds per square inch *| in compression. The Contractor shall set the concrete piles for use in *| salt or brackish water for not less than thirty (30) days. *|

(C) Cast-In-Place Concrete Piles Cast in Sells. The Contractor shall *| drive the shells or casings to the required bearing and left permanently *| in place. The Contractor shall remove and replace improperly driven, *| broken, or defective shells by at no cost to the State. *|

The Contractor shall clean the inside part of the shell and casings *| and remove loose material before the Contractor places the concrete. The *| Contractor shall remove the accumulation of water in the shell before *| placing concrete. *|

The Contractor shall not place the concrete until the driving within a radius of fifteen (15) feet is complete. Also, the Contractor shall not place the concrete until the driving for the shells is complete. If the Contractor cannot do this, driving within the above limits shall not continue until the concrete in the last pile cast has set at least seven (7) days.

The Contractor shall place the concrete continuously and shall be compact the concrete by vibrating or other accepted method. The Contractor shall take special care to place the concrete.

(D) Pile Driving Equipment.

(1) Pile Hammers.

(a) General. The Contractor shall drive the piles with an impact hammer. The impact hammer shall be either steam, air, or diesel type.

The Contractor shall maintain the valve mechanism and other parts of the impact hammer. The Contractor shall get the length of stroke and number of blows per minute for which the design of the hammer is for. The Contractor shall remove the inefficient impact hammers from the work.

The Engineer will not permit gravity hammers.

(b) Steam or Air Hammers. The Contractor shall furnish steam or air hammers with boiler or air capacity specified by the manufacturers. The Contractor shall equip the boiler or compressor with an accurate pressure gage. The Contractor shall supply another pressure gage for occasional use at the hammer intake.

The weight of the striking parts shall not be less than one-third (1/3) the weight of the drive head and pile. The weight of the striking parts shall not be less than two thousand seven hundred and fifty (2,750) pounds.

(c) Diesel Hammers. The Contractor shall equip open-end (single acting) diesel hammers with a device such as rings on the ram or a scale (jump stick) extending above the ram cylinder. Also, the Contractor shall provide the Engineer a gauge and a chart. The chart shall be from the hammer manufacturer equating stroke and blows per minute for the open-end diesel hammer used.

The Contractor shall equip closed-end (double acting) diesel hammers with a bounce chamber pressure gauge. This gauge shall be in good working order and mounted near ground level. Also the Contractor shall provide the Engineer with a

calibrated chart of the actual hammer performance used. The chart shall equate bounce chamber pressure to either equivalent energy or stroke. The manufacturer or its authorized personnel shall calibrate within ninety (90) days of use. The calibration shall identify the type, size and length of hose used. The Engineer will allow only the same type, size and length of hose for pile driving.

The Contractor shall supply the Engineer means to monitor diesel hammers. Also, the Contractor shall provide for diesel hammers an instrument such as a Saximeter to measure the ram stroke and/or blows per minute.

(d) Non-Impact Hammers. The Contractor shall not use the non-impact hammers, such as vibratory hammers, unless permitted in writing by the Engineer.

When permitted, the Contractor shall use the non-impact hammer for installing production piles only. The Contractor shall establish the pile tip elevation for safe support of the pile load by load testing and/or test piles driven with an impact hammer. The Contractor shall load test and/or drive test piles as a condition of permitting the non-impact hammers at no cost to the State.

The Contractor shall drive production piles installed with vibratory hammers to the tip elevation specified by the Engineer. Also, the Contractor shall control them according to power consumption, rate of penetration, or other accepted methods. The Contractor shall retap one (1) of every ten (10) piles with an impact hammer of suitable energy.

(2) Driving Appurtenances.

(a) Hammer Cushion. The Contractor shall equip impact pile driving equipment with a suitable thickness of hammer cushion material. The Contractor shall the make the hammer cushions durable, manufactured materials according to the hammer manufacturer's guidelines. The Contractor shall not use wood, wire rope, and asbestos hammer cushions. The Contractor shall place a striker plate recommended by the hammer manufacturer on the hammer cushion. The Contractor shall inspect the hammer cushion in the presence of the Engineer when the Contractor begins pile driving at each structure or after every one hundred (100) hours of pile driving, whichever is less. The Contractor shall replace the hammer cushion when the hammer cushion thickness is less than seventy-five (75) percent of the original thickness.

(b) Pile Drive Head. Piles driven with impact hammers shall require an adequate drive head to distribute the hammer blow to the pile head. The Contractor shall align the drive head axially with the hammer and the pile. The Contractor shall guide the drive head by the leads and not be free-swinging. The drive head shall fit around the pile head to prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

For timber piles, the Contractor shall cut the pile head squarely and provide a drive head to hold the axis of the pile in line with the axis of the hammer according to hammer manufacturer. The drive head shall distribute the blow of the hammer throughout the cross section of the pile.

For precast non-prestressed concrete and precast prestressed concrete piles, the pile head shall be plane and perpendicular to the longitudinal axis of the pile.

For steel piles, the Contractor shall cut the pile heads squarely and provide a drive head to hold the axis of the pile in line with the axis of the hammer as recommended by the hammer manufacturer.

The Contractor shall provide the steel casings or shells for cast-in-place piles with driving heads, mandrels or other accepted devices according to manufacturer's recommendation.

(c) Pile Cushion. The Contractor shall provide pile cushions. The pile cushion includes laminated wood not less than four (4) inches.

During driving, the Contractor shall change the pile cushion before excessive compression or damage to the pile takes place. The Contractor may provide a new cushion for each pile. The Contractor shall replace the pile cushion when the cushion has compressed more than half (1/2) the original thickness or is smoking or burning. The cushion must not restrain the pile head to rotate in the helmet. The pile cushion dimensions shall match the cross sectional area of the pile top.

(d) Leads. The Contractor shall use pile driver leads to support piles in line and position. The pile driver lead may either be fixed, semi-fixed or swinging type. The Contractor shall construct the leads to afford freedom of movement of the hammer. The Contractor shall hold the leads in position by guys and rigid braces. The Contractor shall not extend the driving

pile section above the leads. The Contractor shall the embed *|
the leads in the ground or constrain the pile in a structural *|
frame such as a template to maintain alignment. The length of *|
the leads shall be sufficient so the use of a follower is not *|
necessary. The Contractor shall use inclined leads in driving *|
batter piles. The Contractor shall design inclined leads to *|
permit proper alignment. *|

The Contractor shall rig the swinging or semi-fixed *|
leads, if used, to maintain the travel of the hammer in line *|
with the axis of the pile. The Contractor shall give adequate *|
support to drive the pile within the specified tolerance of |
accuracy. The Contractor shall fit both types of leads with a *|
pile gate at the bottom of the leads. For batter piles, the *|
Contractor shall install a horizontal brace between the crane *|
and leads. |

(e) Additional Equipment. If the Contractor does not get the *|
required penetration, the Contractor shall provide a heavier *|
hammer or other accepted methods at no cost to the State. *|

(3) Review of Pile Driving Equipment. Pile driving equipment |
furnished by the Contractor shall be subject to acceptance by the |
Engineer. Acceptance of pile driving equipment includes a dynamic |
analyses of the pile driving equipment using the wave equation. |
When specified in the contract or requested by the Engineer, the |
Contractor shall dynamic test the driving system using the dynamic *|
analyzer. *|

The Contractor shall not transport the driving equipment until |
the Engineer has accepted the dynamic analysis of the pile driving |
equipment. |

The Contractor shall submit for acceptance an analysis of the |
proposed pile driving equipment using the wave equation. The |
Contractor shall submit the analysis at least twenty-five (25) *|
working days before pile driving. The method of analysis shall *|
conform to Subsection 505.03(J)(2)(b) - Dynamic Analysis. A Hawaii *|
Licensed Civil Engineer specializing in Geotechnical Engineering *|
shall stamp the analysis. If necessary, the Licensed Engineer shall *|
provide record of experience in Geotechnical Engineering. The |
proposed equipment analysis submittal shall include the following: |

(a) Pile driving equipment information as listed on the "PILE |
AND DRIVING EQUIPMENT DATA FORM". The Engineer will include *|
the form in the contract documents or supply upon request; *|

(b) Complete computer printout of the analysis;

(c) A graph showing driving resistance in blows per foot versus pile bearing capacity. The graph shall show the range of energy levels such as stroke and bounce chamber pressure at which the Contractor shall operate the hammer for the various soil conditions anticipated;

(d) A graph showing driving resistance in blows per foot versus maximum driving stresses (both tension and compression) in kips per square inch. The graph shall show the range of energy levels such as stroke and bounce chamber pressure at which the Contractor shall operate the hammer for the various soil conditions anticipated;

(e) For variable energy hammers, a chart various capacities showing the driving resistance in blows per foot versus the energy level of the hammer. The Contractor shall measure the energy as appropriate for the hammer. The capacities shall be that equaling to fifty (50) percent and one hundred (100) percent of the pile bearing capacity shown on the plans.

The Contractor shall use the following efficiencies in the wave equation analysis:

Hammer Type	Efficiency (%)
Single Acting Air/Steam	67
Double Acting Air/Steam	50
Diesel	72

Failure to obtain the form and submit the analysis with the necessary information shall not relieve the Contractor for completing the contract on time.

For the driving equipment to be acceptable, the pile stress shall not exceed the values where pile damage impends. The driving equipment shall generate the pile stress under the various soil conditions anticipated. The Contractor shall decide the point of impending damage from Table 505-I.

TABLE 505-I - TYPE OF PILE STRESS	
Reinforced Concrete Pile	
Tensile Stress	0
Compressive Stress	$(0.6)(F'_c)$
Prestressed Concrete Pile	
Tensile Stress	F_{ep}
Compressive Stress	$[(0.6)(F'_c)]-F_{ep}$
Steel Pile	$(0.90)(F_y)$
Timber Pile	$(3.0)(F_s)$

Where:

F'_c= Compressive strength of concrete

F_{ep}= Effective prestress value of the strands

F_y = Yield point of the steel material

F_s = Allowable design stress of the timber pile

The Engineer will use the above criteria in evaluating the wave equation results. The Engineer will notify the Contractor of the results within fifteen (15) working days of receiving the required information listed above. If the analyses show that pile damage will occur or that the equipment is unable to drive the pile to the pile bearing capacity shown in the contract, the Contractor shall resubmit a new analysis modifying its proposed methods, equipment or system at no cost to the State. The Contractor shall continue to resubmit until subsequent analysis implies that the piles can be driven to the desired pile bearing capacity and pile tip elevation without damage. The Contractor shall show modifications, adjustments and/or controls necessary to ensure that the driving system will not induce excessive stresses. The Contractor shall list the changes in the "PILE AND DRIVING EQUIPMENT DATA FORM". The Engineer will notify the Contractor of the acceptance or rejection of the analysis of the revised driving system within ten (10) working days of receipt of the revised analysis. Acceptance of the proposed method does not relieve the Contractor of responsibilities to provide an installed pile free of defects to the required pile tip elevation and/or pile bearing capacity.

The Contractor shall dynamic test using the dynamic analyzer only when specified in the contract or when deemed necessary by the Engineer. Dynamic testing shall conform to Subsection 505.03(G)(4)

- Dynamic Load Testing. Also, the Contractor shall use the results of this testing to evaluate the pile stresses during driving. The Contractor shall dynamic test only after making a dynamic analysis of its proposed system and the system has met stress requirements according to TABLE 505-I using the wave equation analysis. When the Contractor does the dynamic test, the results using the dynamic analyzer shall prevail over that of the wave equation. If necessary, the Contractor shall modify the driving system at no cost to the State to maintain the stress below the limits specified.

During pile driving operations, the Contractor shall use the accepted system. The Engineer will not permit variations in the driving system until accepted by the Engineer. The Engineer will consider changes in the driving system only after the Contractor has submitted the necessary information for a revised wave equation analysis.

(4) Alternate Accepted Method for the Pile Driving Equipment. The Contractor shall use the following for acceptance only when the contract states that the Contractor will not use the wave equation analysis. Also, only when the Engineer waives the wave equation analysis method in writing. Acceptance by the Engineer using the alternate method shall include the requirements of Table 505-II. Pile driving equipment furnished by the Contractor shall be subject to the acceptance by the Engineer. The Contractor shall not transport the driving equipment to the project site until the Engineer accepts the equipment in writing.

The Contractor shall submit to the Engineer the pile driving equipment information as listed on the "PILE AND DRIVING EQUIPMENT DATA FORM" at least twenty-five (25) working days before the Contractor drives the piles. The Engineer will include the form in the contract documents or supply upon request. Failure to obtain and submit the form with the necessary information shall not relieve the Contractor for completing the contract on time. The driving equipment shall meet the minimum requirements in TABLE 505-II.

During the pile driving operations, the Contractor shall use the system accepted. If the Engineer determines that its hammer is unable to transfer sufficient energy to the pile, the Contractor shall remove the hammer from service until repaired. The Engineer will not permit variations in the driving system without the Engineer's written acceptance. The Engineer will only consider the changes in the driving system after the Contractor submits a new "PILE AND DRIVING EQUIPMENT DATA FORM". The Engineer will notify the Contractor of the acceptance or rejection of the proposed change in the driving equipment within ten (10) working days of its receipt of the data form.

TABLE 505-II - MINIMUM PILE HAMMER REQUIREMENTS	
PILE BEARING CAPACITY (kips)	MINIMUM MANUFACTURER'S RATED HAMMER ENERGY (foot-lbs)
180 and less	9,000
181 to 300	15,000
301 to 420	20,000
421 to 540	24,000
541 to 600	26,000
601 and over	Wave equation required

(E) Pile Driving Aids.

(1) Followers. The Contractor may use the driving of piles with followers only under written acceptance by the Engineer or when stated in the contract.

The use of the follower shall include its performance under the wave equation analyses and dynamic testing.

When the Engineer permits followers, the Contractor shall place a pile driven with the follower next to and driven with each of the test piles. The Contractor shall drive test piles full length. The Contractor shall drive the first production pile in each footing or pier bent full length without a follower. Also, the Contractor shall drive every tenth pile driven full length without a follower. The Contractor shall hold and maintain the follower in equal and proper alignment during driving. The material and dimensions of the follower shall permit the piles to be driven to the pile tip elevation determined necessary from driving the full length piles. The Contractor shall verify the final position and alignment of the first two (2) piles installed with followers according to Subsection 505.03(H)(5) - Accuracy of Driving. The Contractor shall not install additional piles until the Contractor makes the verification for each substructure unit. The Contractor shall submit for acceptance the pile location data for each substructure unit.

(2) Water Jets. The Engineer will not permit jetting unless accepted in writing by the Engineer or when stated in the contract documents. The Contractor shall not use water jets at locations where the Contractor would endanger the stability of embankments or other improvements.

When the Engineer allows jetting, the Contractor shall decide the number of jets and the volume and pressure of water at the jet nozzle necessary to erode the material freely next to the pile. Jetting shall not affect the lateral stability of the final in-place pile. The Contractor shall cease jetting when the Contractor endangers the site, stability of embankment and improvement. The Contractor shall restore damages to the site and improvement at no cost to the State. Acceptance of the proposed method does not relieve the Contractor of responsibility to install piles free of defects to the required pile tip elevation and/or pile bearing capacity.

When the contract specifies jetting, the jetting plant shall have sufficient capacity to deliver a pressure equivalent to at least one hundred (100) pounds per square inch at two (2) three-quarters (3/4) inch jet nozzles. The Contractor shall stop jetting and remove the pipes when the pile tip is a minimum of five (5) feet above the prescribed tip elevation. The Contractor shall then drive the pile to the required pile bearing capacity with an impact hammer. Also, the Contractor shall control, treat, if necessary, and dispose the jet water.

(3) Drilling. The Contractor shall drill in locations where the Contractor will drive the piles through embankments that are more than five (5) feet above the natural ground or when required in the contract. The Contractor shall drill as specified in the contract.

The Contractor shall auger, wet-rotary drill or other methods of drilling as accepted by the Engineer. The drilling method used for the test piles shall be the same method used for the production piles.

The Contractor shall construct the drilled holes so the holes when finished will allow the pile to stand accurately in the position shown in the contract.

The Contractor shall drill so the drilling will not impair the carrying capacity of the piles already in place or the safety of existing adjacent structures.

If the Engineer concludes that the drilling has disturbed the load bearing capacities of previously installed piles, the Contractor shall restore these piles to conditions conforming to the contract. The Contractor shall redrive or do other remedial measures acceptable to the Engineer. The Contractor shall institute the redriving or other remedial measures after completing the drilling operations in the area. The Contractor shall be responsible for the cost of necessary remedial measures.

The Contractor shall drive the piles driven through embankments that are more than five (5) feet above the natural ground in holes drilled through the embankments. The diameter of the hole shall be equal to the diameter of the pile plus six (6) inches. After driving the pile, the Contractor shall fill the space around the pile to the ground surface with dry calcareous sand. Such sand shall have a minimum sand equivalent (SE) value of seventy (70) or with coarse aggregate conforming to AASHTO M 43-82 size number 8. The Contractor shall dispose the material resulting from drilling holes.

The Contractor shall drill holes only when required in the contract. For piles driven through natural ground and not through embankments that are more than five (5) feet, the drilled holes shall be of a size smaller than the diameter or diagonal of the pile cross section that is sufficient to allow penetration of the pile to the specified depth. If the Contractor meets subsurface obstructions, such as boulders or rock layers, the Contractor may increase the hole diameter to the least dimension that is adequate for pile installation.

Except end bearing piles, the Contractor shall stop drilling at least five (5) feet above the pile tip elevation or as ordered by the Engineer. The Contractor shall drive the pile with an impact hammer to a blow count specified by the Engineer. For end-bearing piles on rock or hardpan, the Contractor shall carry drilling to the surface of the rock or hardpan. The Contractor shall tap the planted piles with an impact hammer.

The Engineer will not permit the use of spuds, a short strong driven member to make a hole for inserting a pile.

(4) Blasting. If pile driving or drilling is not possible, the Engineer will decide whether shooting of holes with explosives or a redesign is necessary.

(F) Preparation for Driving.

(1) Excavation. The Contractor shall not drill holes for piles or drive piles until after the Contractor completes the excavation and when accepted in writing by the Engineer. The Contractor shall remove the materials forced up between the piles to the correct elevation without cost to the State before the Contractor places the concrete for the foundation.

The additional material removed is not excavation. The Engineer will not make additional payment.

(2) Splices. The Contractor shall use full length piles unless the contract shows the location of the splice within a given length of pile. The contract will show the splice detail, number and location, if any.

(3) Pile Shoes. The Contractor shall provide and install the pile shoes of the type and dimensions specified when shown in the contract.

The Contractor shall prefabricate the shoes for steel pile from cast steel conforming to ASTM A27.

(4) Collars. The Contractor shall provide collar bands to protect timber piles against splitting and brooming where necessary.

(5) Bituminous Coating. When specified in the contracts, the Contractor shall apply bituminous coating on piles within the limits specified in the contract.

The Contractor shall dry and clean the surfaces to be coated with bitumen thoroughly of dust and loose material. The Contractor shall not apply the primer or bitumen in wet weather or when the temperature is below sixty-five (65) degrees Fahrenheit.

The Contractor shall apply the primer to the surfaces and allow the primer to dry completely before the Contractor applies the bituminous coating. The Contractor shall apply the primer uniformly at the quantity of one (1) gallon per one hundred (100) square feet of surface.

The Contractor shall apply the bitumen uniformly by mopping, brushing or spraying at the project site at a temperature between three hundred (300) to three hundred and fifty (350) degrees Fahrenheit. The Contractor shall apply the bitumen uniformly over the asphalt primer. The Contractor shall fill the holes or depressions in the concrete surface completely with bitumen. The Contractor shall apply the bituminous coating to a minimum dry thickness of one-eighth (1/8) inch and a minimum of eight (8) gallons per one hundred (100) square feet.

The Contractor shall protect the bitumen coated piles from sunlight and heat before driving. The Contractor shall not expose the pile coatings unduly to damage during storage, hauling, or handling. The Contractor shall preserve and maintain the bitumen coating. The Contractor shall repair damages to the coating at no cost to the State. At the time of pile driving the bitumen coating shall have a minimum dry thickness of one-eighth (1/8) inch and a minimum penetration value of 50. If necessary, the Contractor shall recoat the piles at no cost to the State according to the contract.

(6) Compressive Strength of Concrete Piles. The Contractor shall not drive prestressed concrete piles until the concrete has reached a compressive strength of five thousand (5,000) pounds per square inch as resolved by test cylinders not earlier than seven (7) days after casting.

The compressive strength of precast non-prestressed concrete piles for driving shall conform to Subsection 505.03(B) - Constructing Precast Non-Prestressed Concrete Piles.

(G) Pile Test Program.

(1) General. The pile test program includes driving the test piles successfully and doing static and dynamic pile load tests.

The Contractor shall cast test piles full length. Full length piles are piles cast without splice and driven without a follower.

The length of the test piles used as indicator piles and test piles used to do only dynamic load test shall be ten (10) feet longer than the distance measured from the planned pile tip elevation to cut-off elevation shown in the contract.

The lengths of the test pile used to do the static load test shall be ten (10) feet longer than the distance measured from the planned pile tip elevation to the level ground surface on which the base of the cribbing rests or the level platform over water from which the load test is to be done.

The Contractor shall furnish, drive, and jet or place, test piles of the number, length and type specified or ordered. The Contractor shall remove the test piles that are not part of the completed structure. The Contractor shall incorporate the test piles that are part of the completed structure into the structure according to the requirements for production pile of the same type.

The Contractor shall not order production piles until the Engineer analysis the driving and loading tests and authorizes the pile order list in writing. The Engineer will provide the pile order list within seven (7) working days after completing the pile testing specified in the contract or as decided by the Engineer.

(2) Driving Test Piles. Driving test piles includes the following:

(a) Driving of indicator piles, and

(b) Driving of load test piles.

The Contractor shall drive test piles with impact hammers. The driving equipment used to drive test piles shall be identical with what the Contractor proposes to use on the production piles. Acceptance of the driving equipment shall conform to the contract. The Contractor shall excavate the ground at each test pile location to the elevation of the bottom of the footing before driving the pile.

The Contractor shall drive test piles at the locations shown in the contract and to the depth specified by the Engineer unless the Contractor requests for a new location in writing. In addition, the Contractor shall drive the test piles to the refusal criteria resolved by the Engineer at the estimated pile tip elevation. The Contractor shall base the refusal criteria at the estimated pile tip elevation on the following:

(a) Subsection 505.03(G)(4) - Dynamic Load Test for static and dynamic load test piles, and

(b) Subsection 505.03(J)(2)(b) - Dynamic Analysis for indicator piles.

The Engineer may allow test piles that do not attain the hammer blow count at the plan tip elevation to "set up" for twelve (12) to twenty-four (24) hours or less before redriving. The Contractor shall not use a cold hammer for redriving. The Contractor shall warm up the hammer before driving begins. The Contractor shall apply at least twenty (20) blows of continuous strikes of the hammer to a suitable object that is not part of the structure. If the Contractor cannot attain a specified hammer blow count on redriving, the Engineer may order the Contractor to drive a portion or all the remaining test pile length and repeat the "set up" and redrive procedure. If the Contractor does not have the hammer blow count and drives the test piles to a depth ten (10) feet below plan tip elevation, the Contractor shall splice and redrive test piles until the Contractor gets the required bearing.

(3) Static Load Tests. These tests include the application of a test load placed upon a suitable platform supported by the pile with apparatus for measuring accurately the test load and the settlement of the pile under each increment of load.

Also, the Contractor shall dynamic test the test piles that the Contractor will statically load test according to Subsection 505.03(G)(4) - Dynamic Load Test.

The Contractor shall static load test according to ASTM D 1143. The Contractor shall supply the testing and measuring equipment for the load test. Testing and measuring equipment shall conform to ASTM D 1143 except that the loading system shall apply one hundred fifty (150) percent of the pile bearing capacity or one thousand (1000) tons whichever is less.

The Contractor shall submit to the Engineer for acceptance, detailed plans and design calculations of the proposed loading apparatus. A Hawaii Registered Structural Engineer shall prepare and stamp these plans. Also, the plans shall include soils support values provided by a Hawaii Registered Civil Engineer experienced in Geotechnical Engineering.

The Contractor shall design and construct the loading system properly to allow the various increments of the load that the Contractor will place gradually without causing vibration to the test pile. The Contractor shall design the cribbing or foundation support properly to prevent excessive settlement of the load test. The submittal shall include the method of establishing the reference beam and dial support system for acceptance by the Engineer. The State will require at least three (3) weeks for each submittal or resubmittal for acceptance.

The pile bearing capacity is that load that produces a settlement at failure of the pile head when tested under axial compressive load for piles twenty-four (24) inches or less in diameter or width equal to:

$$SF = S + (0.15 + 0.008D)$$

where:

SF = Settlement at failure in inches
D = Pile diameter or width in inches
S = Elastic deformation of total pile length in inches

The Contractor shall decide the top elevation of the test pile immediately after driving and again just before load testing to check for heave. The Contractor shall redrive or jack the piles that heaves more than quarter (1/4) inch to the original elevation before testing.

Piles shall develop the bearing and attain the pile tip elevations according to contract. The Engineer will estimate the pile bearing capacity by dynamic testing using the dynamic analyzer. The Engineer will use the alternate method of estimating the pile bearing capacity by the wave equation only when specified in the contract.

After completing the load test, the Engineer may require to revise the pile tip elevations to conform to the pile bearing capacity requirements. The Engineer will give the revised pile tip elevations, if required, in writing by according to Subsection 505.03(A)(2) - Order List for Piling.

If the load test piles are too long after driving, the Contractor shall cut the excess portion as ordered by the Engineer. The cost of cutting the piles shall be incidental to the cost of the load tests.

The Contractor shall allow one (1) week after driving piles before placing loads on the piles.

The Engineer will conduct the pile load test within seven (7) working days. The seven (7) working days shall begin the next working day following a satisfactory inspection of the pile test set-up.

(4) Dynamic Load Test. When specified in the contract, the Engineer will dynamic test during the driving of piles designated as dynamic load test piles.

When the contract specifies dynamic testing, the Contractor shall supply instruments, equipment and measurement devices.

The Contractor shall furnish a shelter to protect the dynamic test equipment from the elements. The shelter shall have a minimum floor size of eight (8) feet by eight (8) feet and minimum roof height of seven (7) feet. The Contractor shall maintain inside temperature of the shelter above forty-five (45) degrees and below ninety (90) degrees. The Contractor shall locate the shelter within fifty (50) feet of the test location.

Before driving the load test pile, the Contractor shall make this pile available to the Engineer time to conduct wave speed measurements. The Contractor shall install the anchors with the pile in a horizontal position and not in contact with other piles. The Contractor shall support the pile by level blocking at the pick-up point locations. The pile shall not rest directly on the ground. After the Contractor prepares the pile properly, the Contractor will allow the Engineer a minimum time of one (1) hour to measure the wave speed.

The Contractor may place and secure the pile in the driving lead only after the Contractor has prepared the pile satisfactorily. The Contractor shall then drive the pile five (5) feet. At this time, the Contractor shall attach the transducers, accelerometers and terminal box to the anchors near the head of the pile.

The Contractor shall install these attachments from a safety bucket. The time required to install the attachments is about thirty (30) minutes. The Contractor may then redrive the pile. The Contractor shall install the anchors and attach the transducers, accelerometers and terminal box.

The Contractor shall drive the pile to the depth according to contract or as ordered by the Engineer. The Contractor will monitor the stresses in the pile during driving with the dynamic test equipment. If necessary, the Contractor shall reduce the driving energy transmitted to the pile by using additional cushions or reduce the energy output of the hammer. If the dynamic test equipment measurements show non-axial driving, the Contractor shall realign the driving system immediately.

When the pile head approaches the ground, the Contractor shall stop driving to prevent damage to the instruments and to permit removal of the instruments from the pile.

The Contractor shall wait up to twenty-four (24) hours, reattach the instruments for dynamic testing, and retap the pile. The Contractor shall not use a cold hammer for the redrive. The Contractor shall warm up the hammer by applying at least twenty (20) blows of continuous strikes to a suitable object that is not part of the structure. The maximum amount of penetration required during the redrive shall be six (6) inches or the maximum total number of hammer blows required will be sixty (60) blows whichever occurs first. After retapping, the Engineer will either provide the pile tip elevation or specify additional pile penetration and testing.

(H) Driving Pile.

(1) General. The Contractor shall drive the production and test piles with an impact hammer or a combination of impact hammer type. The Contractor shall use only a single system. Also, the Contractor shall drive the test piles according to Subsection 505.03(G)(2) - Driving Test Piles. Use of driving aids shall be according to Subsection 505.03(E) - Pile Driving Aids.

The Contractor shall drive the piles for a given foundation unit with the same hammer, under the same operating conditions, and with the same cushion material used to drive the test piles.

(2) Installation Sequence. The order of placing individual piles in pile groups shall start from the center of the group and proceed outwards in both directions.

(3) Pile, Hammer and Lead Alignment. Pile driving shall commence with the pile in the vertical or batter position shown in the contract. The Contractor shall continue driving the pile in the specified position without inducing bending stresses on the pile. If the Contractor can no longer bring the pile back to the specified position without inducing bending below the ground and without forcing the pile back to the specified position, the Contractor shall maintain the hammer and leads in alignment with the longitudinal axis of the pile to preclude eccentric blows to the pile.

For vertical piles, the Engineer may require the Contractor to temporarily stop driving and to lift the hammer completely off the pile head. This is to allow the pile freedom to follow its inclination through the ground. During the release of the hammer, the Contractor shall not allow the pile to induce bending stresses. If necessary, the Contractor shall then adjust the leads to come into parallel alignment with the natural inclination of the pile.

(4) Driving Near Fresh Concrete. Pile driving operations shall cease when:

(a) vibration can be felt in the vicinity of the fresh concrete or

(b) when the concrete is less than seventy-two (72) hours old,

(c) less than two thousand (2,000) pounds per square inch of compressive strength, and

(d) is within one hundred fifty (150) feet measured horizontally.

(5) Accuracy of Driving. The pile tops at the cut-off elevation shall be within two (2) inches of the plan locations for trestle bent caps supported by piles. Also, the as-driven centroid of load of pile groups at the cut-off elevation shall be within five (5) percent of the plan location of the designed centroid load. No piles shall be nearer than four (4) inches from edges of the cap. Increases in size of cap to meet this edge distance requirement shall be at no cost to the State.

The Contractor shall install the piles so that the axial alignment of the top ten (10) feet of the pile is within four (4) percent of the specified alignment. For piles that the Engineer cannot inspect internally after installation, the Contractor shall make an alignment check before installing the last five (5) feet of pile or after completing installation provided the exposed portion of the pile is not less than five (5) feet in length. The Engineer may require the Contractor to stop driving to check the pile alignment. The Engineer will not permit pulling on piles laterally to correct misalignment or splicing a properly aligned section on a misaligned section.

If the location and/or alignment exceeds the tolerances specified, the Engineer will investigate the extent of overloading within ten (10) working days. The Engineer shall then inform the Contractor of the decision in writing. If the Engineer determines that corrective measures are necessary, the Contractor shall redesign, submit for acceptance, and construct that corrective measures. The Contractor shall bear the costs and delays associated with the corrective action.

(6) Heaved Piles. The Contractor shall make level readings at the start of pile driving operations. The Contractor shall continue making level readings until the Engineer decides that the Contractor no longer requires such checking. The Contractor shall take level readings immediately after driving the pile and again after driving the piles within a radius of fifteen

(15) feet. If the Contractor or Engineer observes pile heaving, the Contractor shall take accurate level readings referenced to a fixed datum on piles. The Contractor shall take readings immediately after installation and periodically as the Contractor drives adjacent piles to decide the pile heave range. The Contractor shall redrive piles that have heaved more than 0.25 inches at no cost to the State, and to the required resistance or penetration. If the Contractor or Engineer detects pile heave for pipe piles filled with concrete, the Contractor shall redrive the piles to original position after both the concrete has obtained sufficient strength and after using a proper hammer-pile cushion system according to contract.

(7) Retapping. After the Contractor drives the piles in a footing, and before removing the driving equipment from the footing, the Engineer will select one (1) pile in the footing for retapping. This pile will generally be the pile with the lowest penetration resistance at tip. The Contractor shall retap with the same hammer used to drive the piles. Retapping the pile shall end if the penetration rate is less than or equal to the initial refusal in the same hammer energy setting. Also, during retapping, the Contractor shall not deliver less then sixty (60) blows or move the pile three (3) inches, whichever occurs first.

If the retapping penetration rate is greater than the initial refusal rate, the Contractor shall continue to drive the pile until the Contractor gets the initial refusal rate. The Engineer will select additional piles in the footing for retapping. The Contractor shall not retap additional piles unless ordered by the Engineer.

(8) Furnishing As-Driven Pile Locations. The Contractor shall furnish the Engineer a plan showing the locations of as-driven piles of a pile group including the batter and the direction of the batter. The Contractor shall survey the work under the supervision of the Engineer or its representative. The Contractor shall notify the Engineer in advance when the Contractor will survey the work. The Contractor shall submit a copy of the survey notes locating the piles in a given foundation immediately to the Engineer after the Contractor completes the survey. The Contractor shall follow-up with a submittal of a scaled plan of the as-driven pile location.

The Engineer will use the plan for deciding if a redesign or added pile is necessary. The Engineer will require ten (10) working days from the date the Engineer receives the as-driven pile location plans.

Form work for the footings shall not proceed unless accepted by the Engineer.

Locating the piles, providing the as-driven plans and survey notes shall be incidental to pile driving. The Engineer will not pay for them separately.

(9) Microfilm of Foundation Records. At the completion of the pile driving of each footing, the Contractor shall furnish one (1) set of microfilms of the pile driving reports to the Engineer. The Contractor shall provide a separate and complete set of microfilms of pile driving reports for each pile group. The Contractor shall include a footing layout showing the actual location and identifying each pile in the first exposure in the set of microfilms for each footing. The Contractor shall arrange the pile driving reports in the order as indexed in the footing layout.

The Contractor shall insure that:

(a) the Contractor provides information in the pile driving reports properly,

(b) the piles properly identified, and

(c) the information in the report are legible and fully readable when microfilmed.

The Engineer will reject microfilms that are illegible, and/or incomplete.

Also, the Contractor shall microfilm and furnish the corrected original tracings of the foundation plans and the "Log of Test Borings" plans to the Engineer. The Contractor shall include an index prepared specifically for the drawings for each structure containing sheet numbers and titles in the set of microfilms for each structure.

Microfilms shall be thirty-five (35) millimeter unperforated silver halide camera microfilm (negative type clear line image) having an antihalation undercoat and specifically manufactured for line copying, with a resolution of at least one hundred and twenty (120) lines per millimeter after processing. The average visual diffuse transmission density of the background of the document image area on the processed microfilm shall be 0.90 through 1.30 and a line density of 0.08 or less. The Contractor shall process the films according to the manufacturer's specification.

The edge of the document image shall be clearly visible with the frame and visually parallel with the edges of the frame. The Contractor shall provide a clear, legible symbol on the upper left side of each frame to show the amount of

reduction. The Contractor shall provide a horizontal and vertical scale that the Contractor will photograph on each frame to ease enlargement to original scale.

(I) Defective Piles. The method used in driving piles shall not subject the piles to excessive or undue abuse producing crushing and spalling of the concrete, injurious splitting, splintering and brooming of the wood or deformation of the steel. The Contractor shall not force misaligned piles into position. The Contractor shall correct piles damaged during driving by internal defects, improper driving, driven out of its proper location or driven below the designated cut-off elevation at no cost to the State by the following methods accepted by the Engineer for the piles in question:

(1) The Contractor shall withdraw and replace the pile by a new and if necessary, a longer pile;

(2) The Contractor shall drive a second pile next to the defective pile; or

(3) The Contractor shall splice or build up the pile according to the contract or a sufficient portion of the footing extended to properly embed the portion of the pile. The Contractor shall not splice timber piles without permission by the Engineer.

The Contractor shall drive the piles pushed up by the driving of adjacent piles or by other causes down again to the bearing requirement.

The Contractor may require dynamic testing for pile acceptance. At the option of the Engineer, the Contractor may use the State's pile driving analyzer to evaluate the structural condition of a driven pile. This includes the integrity of pile splice connections. The Contractor shall dynamic test similar to the testing procedure for retapping of the load test pile in Subsection 505.03(G)(4) - Dynamic Load Test. The Engineer may use the information obtained with the dynamic analyzer as a basis for pile rejection. Compliance with the requirements of this contract does not relieve the Contractor from the responsibility of providing piles free of defects and within the specified accuracy of driving. The Engineer will not pay for piles that the Engineer does not accept for furnishing, driving and testing.

(J) Pile Bearing Capacity and Penetration.

(1) General. Piles shall develop the bearing capacity and penetration as required. If refusal occurs before the Contractor reaches the tip elevation shown in the contract, the penetration as specified in Subsection 505.03(J)(3) - Penetration shall apply.

If the Contractor cannot get the specified bearing capacity of piles when the pile tips reach the given elevation, the Engineer will decide if the Contractor shall extend the piles or if redesign of the footing is necessary.

The Contractor shall not use jetting or other methods to ease pile penetration unless accepted in writing by the Engineer. The Contractor shall base the pile bearing capacity of jetted piles on blow count of the impact hammer after the Contractor have removed the jet pipes. The Contractor shall splice jetted piles not attaining the required pile bearing capacity at the ordered length as required at no cost to the State. The Contractor shall drive the jetted piles with an impact hammer until the Contractor gets the required pile bearing capacity according to Subsection 505.03(J)(2) - Determination of Pile Bearing Capacity.

When the Engineer permits followers, the Contractor shall only consider the required pile bearing capacity of piles driven with followers acceptable when the follower driven piles attain the same tip elevation as the full length piles that attained the required pile bearing capacity.

When the Engineer permits non-impact hammers according to 505.03(D)(1)(d) - Non-Impact Hammers, the Contractor shall decide the pile bearing capacity as specified in the contract. The Contractor shall drive the first pile of each group of ten (10) piles with the vibratory hammer to the tip elevation according to the contract. When the Contractor gets tip elevation with the non-impact hammer, the Contractor shall then retap the pile with an impact hammer of suitable energy. The Contractor shall drive the pile with the impact hammer until the Contractor gets the required pile bearing capacity as specified in Subsection 505.03(J)(2) - Determination of Pile Bearing Capacity.

-- The Contractor shall splice the piles not attaining the required pile bearing capacity at tip elevation as required at no cost to the State. The Contractor shall drive such piles with the impact hammer until the Contractor gets the required pile bearing capacity. When the Contractor gets the required pile bearing capacity, the Contractor shall install the remaining nine piles to the same tip elevation as the first pile. The Contractor shall use the same vibratory hammer power consumption and rate of penetration used on the first pile on the remaining nine piles.

(2) Determination of Pile Bearing Capacity.

(a) Load Tests. When the contract specifies load tests, the Engineer will decide the pile bearing capacity based on the results of the static load tests. If the contract specifies only dynamic load tests, the Engineer will decide the pile bearing capacity based on the result of the dynamic load tests.

(b) Dynamic Analysis. When the contract does not specify load tests, the Engineer will decide the pile bearing capacities by dynamic analysis using wave equation of the "WEAP87" Computer Program developed under the sponsorship of the FHWA.

The Contractor shall drive the piles with the accepted driving equipment to the ordered length or other lengths necessary to get the required pile bearing capacity. The Contractor shall not use jetting or other methods to ease pile penetration unless accepted by the Engineer after the Engineer establishes a revised driving resistance from the wave equation analysis. The Contractor shall consider adequate pile penetration when the Contractor gets the specified wave equation resistance criteria within five (5) feet of the tip elevation base on the ordered length. The Contractor shall drive the piles not getting the specified resistance within these limits to the penetrations established by the Engineer.

(c) Dynamic Formula. When specified in the contract, the Contractor shall decide the pile bearing capacity by the dynamic formula according to the contract. The Contractor shall drive the piles to a length necessary to get the pile bearing capacity according to the following:

$$R_U = [(1.75)(E^{0.5})\text{Log}(10N)] - 100$$

Where:

R_U = The pile bearing capacity (kips)

E = The manufacturer's rated hammer energy (foot pounds) at the ram stroke observed in the field

N = The number of hammer blows per inch at final penetration (blows per inch)

Log(10N) = Logarithm to the base 10 of the quality 10 multiplied by N

(3) Penetration. When the contract does not specify a tip elevation, the bearing value of piles shall be not less than the pile bearing capacity shown in the contract. Also, the piles shall be at least ten (10) feet below the bottom of footing or finished grade whichever is lower.

When the contract specifies a tip elevation, the Contractor shall drive the piles to a bearing value of not less than the pile bearing capacity shown in the contract and specified tip elevation.

(K) Finishing of Satisfactorily Driven Piles

(1) Cutting Off and Capping Pile.

(a) General. The Contractor shall cut off the tops of permanent piles and pile castings at the elevation shown in the contract or as ordered by the Engineer. Cut off lengths shall become the property of the Contractor. The Contractor shall remove them from the project site.

(b) Timber Piles. The Contractor shall saw the tops of timber piling to a true plane shown in the contract and at the elevation fixed by the Engineer. The Contractor shall saw the piles that support timber caps or grillage to conform to the plane of the bottom of the superimposed structure. In general, the length of the pile above the elevation of "cut off" shall be sufficient to permit the complete removal of material injured by driving. The Contractor shall adze or free the piles driven to very nearly the cut-off elevation carefully from "broomed", splintered or injured material.

The Contractor shall treat the heads of timber piles not encased in concrete as provided under Subsection 502.03(F) - Treatment of Pile Heads.

(c) Precast Concrete Piles. The Contractor shall cut off precast concrete piles at the required elevations. The pile reinforcing steel and prestressing strands shall extend at least twenty-four (24) inches above the top of the pile. The Contractor shall clean the reinforcing steel and prestressing strands so that the Contractor gets a secure bond with the fresh concrete. The Contractor shall not use explosives in cutting off the piles.

After cut off, the tops of the pile shall be at the required elevation and on a plane normal to the pile's axis.

(d) Steel Piles and Steel Shells. The Contractor shall cut off the piles at the required elevation. The Contractor shall cut off the steel shells for cast-in-place piles before the Contractor fills the shells with concrete. If the contract requires capping, the Contractor shall make the connection according to the details shown in the contract.

(2) Build-ups of Piles. The Contractor shall extend, splice or build-up piles only with the acceptance of the Engineer.

(a) Timber and Steel Piles. The Contractor shall extend timber and steel piles according to the details shown in the contract or furnished by the Engineer.

(b) Precast Concrete Piles. After the Contractor completes driving, the Contractor shall cut off the concrete according to the contract. The Contractor shall leave the reinforcing steel exposed for a length of forty (40) diameters of the reinforcing steel. The final cut of the concrete shall be perpendicular to the axis of the pile. The Contractor shall fasten the reinforcement similar to that used in the pile securely to the projecting steel. The Contractor shall place the necessary formwork. The Contractor shall prevent leakage along the pile. Just before placing concrete, the Contractor shall wet and cover the top of the pile thoroughly. The Contractor shall wet the pile with a thin coating of neat cement, retempered mortar or other bond material acceptable to the Engineer.

The forms shall remain in place for not less then seven (7) days and water cured for thirty (30) days before the Contractor continues driving.

(3) Painting Steel Piles. The Contractor shall protect the steel piles that extend above the ground by three (3) coats of paint as specified for the painting of metals in Section 501 - Steel Structures.

(4) Backfilling Around Piles. The Contractor shall backfill the annular space around the pile caused by drilling or driving operations with fine aggregate conforming to Subsection 703.01 - Fine Aggregate for Concrete. The Contractor shall backfill, if required, after the Contractor drives each pile so that the vibrations caused by driving the adjacent piles will further compact the backfill.

505.04 Method of Measurement

(A) Furnished Piles. Except cast-in-place concrete piles cast in shells, the Engineer will measure for furnishing piles by the linear foot. The quantity shall be as itemized in the order list according to Subsection 505.03(A)(2) - Order List for Piling. The Contractor shall stockpile the piles in good condition at the work site acceptable to the Engineer.

(B) Driven Piles. Except cast-in-place concrete piles cast in shells and piles driven through drilled holes, the Engineer will measure for driving piles by the linear foot. The Engineer will compute the quantity from the tip of the driven pile to the head of the pile after cutoff.

The Engineer will compute the quantity of piles driven through drilled holes by the length of pile below the bottom of the drilled holes.

(C) **Cast-In-Place Concrete Piles Cast in Shells.** The Engineer will measure cast-in-place concrete piles cast in shells by the linear foot of piles cast in place in the completed and accepted structure.

(D) **Pile Shoes.** The Engineer will measure pile shoes per each installed on accepted piles.

(E) **Pile Load Tests.** The Engineer will measure load tests per each completed and accepted.

The Engineer will measure anchor and test piles that are a part of the permanent structure, under the appropriate pay item.

(F) **Drilled Holes.** When the contract provides a pay item in the proposal, the Engineer will measure by the linear foot drilled. The pay limit for drilling will be the bottom of footing to the elevation given in the contract or ordered by the Engineer.

When the contract does not provide a pay item for drilled holes in the proposal, the Contractor may drill at no cost to the State.

(G) **Bitumen Coating.** When bitumen coating is specified in the contract, the Engineer will measure bitumen coating by the linear foot of coating in place on the pile surface.

(H) **Retapping.** The Engineer will not measure for retapping one (1) pile per footing for payment.

The Engineer will pay for retapping additional piles per footing requested on a force account basis.

(I) **Build-Ups of Piles.** If the Engineer requests build-ups or extensions of the prestressed concrete piles in writing, the Engineer will measure such build-ups or extensions on a force account basis.

(J) **Repair or Replacement of Engineer's Equipment.** The Engineer will measure for repair or replacement of the Engineer's Equipment on a force account basis.

(K) **Microfilm of Pile Driving Records.** The Engineer will not pay for microfilms of Pile Driving Record when contracted on a lump sum basis.

505.05 Basis of Payment.

(A) Furnished Piles. The Engineer will pay for the accepted quantities of production and test piles furnished at the contract unit price per linear foot. *

The price shall be full compensation for the lengths required for fresh heads; additional lengths as may be necessary to suit its operation; damaged piles, including test piles, that the Engineer accepted previously; furnishing labors, material, tools, equipment, and incidentals to complete the work. *

(B) Driven Piles. The Engineer will pay for the accepted quantities of production and test piles driven at the contract unit price per linear foot. *

The price shall be full compensation for cutoffs; pile splices; pile collars; furnishing labors, material, tools, equipment, and incidentals to complete the work. *

(C) Cast-In-Place Concrete Piles Cast in Shells. The Engineer will pay for the accepted quantities of cast-in-place concrete piles cast in shells at the contract unit price per linear foot. *

The price shall be full compensation for steel shells; furnishing labors, material, tools, equipment and incidentals to complete the work. *

(D) Pile Shoes. The Engineer will pay for the accepted quantities of pile driving shoes furnished and installed on accepted piles at the contract unit price per each. *

(E) Pile Load Tests. The Engineer will pay for the accepted quantities of pile load tests at the contract unit price per each. *

The price shall be full compensation for anchor and test piling that are not a part of the permanent structure, furnishing labors, material, tools, equipment, and incidentals to complete the work. *

The Engineer will not include load tests made at the convenience or the option of the Contractor or made to evaluate the suitability of the Contractor's equipment, methods or work. *

The Engineer will pay for anchor and test piles that are a part of the permanent structure, under the appropriate pay item. *

(F) Drilled Holes. When the contract provides a pay item in the proposal, the Engineer will pay for the accepted quantities of drilled holes at the contract unit price per linear foot.

The unit price shall be full compensation for furnishing labors, material, tools, equipment, and incidentals necessary to complete the work.

When the contract does not provide a pay item for drilled holes in the proposal, the Contractor may drill at no cost to the State. The Engineer will not make separate payments.

(G) Bitumen Coating. The Engineer will pay for the accepted quantities of bitumen coating at the contract unit price per linear foot.

The price shall be full compensation for applying the bituminous coating and primer; and furnishing labors, materials, tools, equipment and incidentals necessary to complete the work.

(H) Retapping. The Engineer will not pay for retapping one (1) pile per footing.

The Engineer will pay for retapping additional piles per footing requested on a force account basis according to Subsection 109.04 - Extra and Force Account Work. The actual amount that the Engineer will pay the Contractor for authorized work will be the sum shown on the force account sheets.

(I) Build-Ups of Piles. If the Engineer requests build-ups or extensions of the prestressed concrete piles in writing, the Engineer will pay for such build-ups or extensions on a force account basis according to Subsection 109.04 - Extra and Force Account Work.

The actual amount that the Engineer will pay the Contractor for authorized work will be the sum shown on the force account sheets.

(J) Repair or Replacement of Engineer's Equipment. The Engineer will pay for the repair or replacement of the Engineer's Equipment on a force account basis according to Subsection 109.04 - Extra and Force Account Work. The actual amount that the Engineer will pay the Contractor for authorized work will be the sum shown on the force account sheets.

The Contractor shall repair or replace the Engineer's Equipment damaged by the Contractor at no cost to the State.

(K) Microfilm of Pile Driving Records. The Engineer will pay for microfilms of Pile Driving Record on a lump sum basis.

The Engineer will make payment under:

Pay Item	Pay Unit
_____, Furnished	Linear Foot
Cast-In-Place Concrete Piles Cast in Shells	Linear Foot
_____, Driven	Linear Foot
_____ Pile Load Test	Each
Pile Driving Shoe	Each
Bitumen Coating	Linear Foot
Drilled Holes	Linear Foot
Retapping of Additional Piles	Force Account
Repair or Replacement of Engineer's Equipment	Force Account
Build-Ups of Piles	Force Account
Microfilm of Pile Driving Records	Lump Sum