Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
Bonifacio Drive, Port Area, Manila

BAGONG PILIPINAS

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DEPARTMENT ORDER

NO. 103
Series of 2025

SUBJECT: DPWH Standard Specification for Item 400 – Piling

To support the Department's commitment to updating its standard specifications and adopting effective/appropriate solutions for specific project needs, the attached revised Standard Specification for **Item 400 – Piling** is hereby prescribed for adoption in DPWH infrastructure projects.

This revised standard specification shall form part of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II. Likewise, the new pay item subscripts are now included in the Standard Pay Item List and Project and Contract Management Application (PCMA).

This Order shall take effect immediately.

MANUEL M. BONOAN
Secretary

Department of Public Works and Highways
Office of the Secretary
WIN5U02159

Encl: DPWH Standard Specification for Item 400 – Piling

14.1 JDV/AGC

DPWH Standard Specification for
ITEM 400 – PILING

400.1 Description

400.1.1 Scope

This Item shall consist of piling, furnishing, driving, placing, cutting and splicing in accordance with this Specification and Plans.

400.1.2 Test Piles

The Contractor shall drive the test pile at the location indicated on the Plans and it shall be considered as one of the regular piles. The Contractor shall furnish the test piles of the required dimensions and shall be driven up to refusal. Test piles shall be driven with the same hammer to be used for driving regular piles.

When the Engineer requests a load test for timber piles to determine a bearing value, the first load test pile shall be driven to the specified bearing value as determined by the applicable formula for Timber Pile Bearing Value by Formula. Subsequent piles to be load-tested shall be driven to the specified bearing value as determined by the applicable formula modified by the results of prior test loads and foundation data. The ground at each pile shall be excavated to the elevation of the bottom of the footing before the pile is driven or as directed by the Engineer.

400.1.3 Load Tests

Load tests for piles shall be either Static or Pile Testing by Low-Strain Dynamic Method, High-Strain Dynamic Method and Cross-Hole Sonic Logging.

When load tests are specified, the number and location of piles to be tested will be designated by the Engineer or as indicated on the Plans. Load tests shall be done by methods specified in the Plans. The Contractor shall submit to the Engineer for the approval of the detailed Plans of the loading apparatus he intends to use. The apparatus shall allow the various increments of the load to be placed gradually without vibration to the piles to be tested. If the approved method requires the use of tension or anchor piles, the same shall be of the same type and diameter as the permanent piles and shall be driven in the location of permanent piles when feasible. Piles that are not part of the permanent structure shall be removed or cut-off at least 300 mm below the bottom of the footing or finished elevation of the ground upon completion of the test load. Permanent piles used as anchor piles which are raised during the test load shall be re-driven to the original grade and bearing as specified in the Plans.

400.1.3.1 Static Pile Testing

Suitable approved apparatus for determining accurately the load on pile and the settlement of the pile under increment of load shall be supplied by the Contractor.

Test loading shall consist of the application of incremental static loads to a pile and measuring the resultant settlement. The loads shall be applied by a hydraulic jack acting against suitable anchorage, transmitting the load directly to the pile, or other methods designated on the Plans or approved by the Engineer.

The load shall be applied in increments of 5 t or 10 t as directed by the Engineer or as specified in the Plans. Gross settlement readings, loads and other data shall be recorded by the Engineer immediately before and after the applications of each load increment.

Each load increment shall be held for an interval of 2 ½ min. Each succeeding increment shall be as directed by the Engineer or as shown on the Plans and shall be applied immediately after the 2 ½ min interval readings have been made.

When a load-settlement curve obtained from these data shows that the pile has failed; i.e., the load can be held only by the constant pumping and the pile or shaft is being driven into the ground, pumping shall cease. Gross settlement readings, loads and other data shall be recorded immediately after pumping has ceased and again after an interval of 2 ½ min for a total period of 5 min. All loads shall then be removed and the member allowed to recover. Gross settlement readings shall be made immediately after all loads have been removed and at each interval of 2 ½ min for a total period of 5 min.

All load tests shall be carried to failure or to the capacity of the equipment, unless otherwise noted on the Plans.

After the completion of loading tests, the load used shall be removed and the piles including tension piles, shall be utilized in the structure if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilized similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for utilization in the structure, it shall be removed if so ordered by the Engineer or shall be cut-off below the ground line of footings, whichever is applicable.

When diesel or other types of hammers requiring calibration are to be used, the Contractor shall make load tests even though no load tests are called for in the BOQ, except that load tests will not be required when the hammer is to be used only for driving piles to refusal, rock or a fixed tip elevation or the hammer is of a type and model that has been previously calibrated for similar type, size and length of pile, and foundation material. Calibration data shall have been obtained from sources acceptable to the Engineer.

400.1.3.2 Dynamic Pile Testing

Pile testing shall be done by Bearing Capacity Test by means of High-Strain Pile Dynamic Test Method, and Pile Integrity Test by means of Cross-Hole Sonic Logging Test (CSL) Method or Low-Strain Pile Dynamic Test Method.

Bearing Capacity Test shall be conducted at locations of piles to be tested as specified in the Plans or designated by the Engineer to determine/check the actual bearing capacity of the completed bored piles against the required ultimate bearing capacity. For buildings, at least 5% of the total number of bored piles shall be tested. The total number of bored piles to be tested in a particular project shall be indicated on the Plans and included in the summary of quantities. Additional tests may be conducted upon recommendation of the Engineer where deemed necessary. The testing of bored pile foundation shall be undertaken on the first completed pile in a particular foundation. Construction of succeeding similar piles may be allowed only after acceptance of the test pile based on the results of bearing capacity test.

Pile Integrity Test shall be conducted on at least 50% of the total number of bored piles at the entire foundation area of the project to verify and check the actual length and the concrete homogeneity, and to locate/evaluate any irregularity in the completed bored piles.

1. Low-Strain Dynamic Method

Pile integrity testing by Low-Strain Dynamic Method shall conform to ASTM D5882, Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations. It is a so-called Low Strain Method, since it requires the impact of only a small hand-held hammer, and also referred to as a Non-Destructive Test Method.

2. High-Strain Dynamic Testing

Bearing Capacity Testing by High-Strain Dynamic Method using Pile Driving Analyzer (PDA) or equivalent method shall conform to ASTM D4945, Standard Test Method for High-Strain Dynamic Testing of Deep Foundations. High-Strain Dynamic Method shall be applied to confirm the design parameters and capacities assumed for the piles as well as to confirm the normal integrity of testing of the piles. It is considered supplemental to the low-strain and sonic-type integrity testing of the cast-in-place piles. It is a relatively non-destructive quick test and it is intended that the test shaft be left in a condition suitable for use in production. The shaft used for the test shall be instrumented and tested by the testing specialist, as approved by the Engineer, meeting requirements in accordance to ASTM D4945.

3. Cross-Hole Sonic Logging of Bored Holes

Cross-hole Sonic Logging Test (CSL) using Cross-Hole Sonic Analyzer is a downhole variation of the ultrasonic-pulse velocity test. The methodology and equipment shall conform to ASTM D6760, Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross-Hole Testing. This test is recommended for bored piles with embedded length of more than 30 m.

By sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes), the Cross-hole Sonic Logging (CSL) procedure inspects the drilled shaft structural integrity, and extent and location of defects. Defects indicated by late pulse arrival times and significantly lower amplitude/energy signal shall be immediately reported to the Engineer. For equidistant tubes, uniform concrete yields consistent arrival times with reasonable pulse wave speed and signal strengths. Non-uniformities such as contamination, soft concrete, honeycombing, voids, or intrusions of foreign objects exhibit delayed arrival time with reduced signal strength.

400.1.4 Timber Pile Bearing Value by Formula

When load tests are called for in the Bill of Quantities and when diesel or other hammers to be calibrated are used, the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing value of piles shall be determined by load tests, as provided in Subsections 400.1.2 and 400.1.3. In the absence of load tests, the safe bearing value of each timber pile shall be determined by whichever of the following approximate formulas is applicable:

For gravity hammer, $P = \dfrac{1000}{6} \times \dfrac{WH}{S+25.4}$

For single-action steam or air hammers, and for diesel hammers having unrestricted rebound of ram,

$$P = \frac{1000}{6} \times \frac{WH}{S+2.54}$$

For double-action steam or air hammers, and diesel hammers having enclosed ram,

$$P = \frac{1000}{6} \times \frac{E}{S+2.54}$$

For diesel or steam hammers on very heavy piles,

$$P = \frac{1000}{6} \times \frac{E}{S+2.54\ (Wp/W)}$$

Where:

P	=	Safe load per pile in Newton or kg
W	=	Weight of the striking part of the hammer in Newton or kg
H	=	Height of fall of ram in meters
S	=	Average penetration per blow in mm for th e last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammers
E	=	Hammer energy, N.m or kg.m
Wp	=	Weight of pile

The above formula shall be applicable only when:

1. The hammer has a free fall.
2. The head of the pile is free from broomed or crushed wood fiber or other serious impairment.
3. The penetration is reasonably quick and uniform.
4. There is no measurable bounce after the blow.
5. A follower is not used.

If there is a measurable bounce, twice the height of bounce shall be deducted from H to determine its value in the formula.

The bearing power as determined by the appropriate formula listed in this Subsection, will be considered effective only when it is less than the crushing strength of the pile. Other recognized formulas may be used if fully detailed in the Special Provisions.

When bearing power is determined by a formula, timber piles shall be driven until a computed safe bearing power of each is not less than 18 t.

400.1.5 Concrete and Steel Pile Bearing Values

The bearing values for concrete and steel pile will be determined by the Engineer using the following formulas:

1. Modified Hiley's Formula or any formula from brochures of the equipment used, shall be used when the ratio of weight of ram or hammer to weight of pile is greater than one fourth (1/4).

$$Ru = \frac{2WH\ (W)}{(S+K)\ (W+Wp)}$$

$$Ra = \frac{Ru}{FS}$$

Where:

Ru	=	ultimate capacity of piles (KN)
Ra	=	capacity of pile (KN)–shall be greater than the required
W	=	weight of ram or hammer (KN)
H	=	height of fall of ram (mm)
Wp	=	weight of pile (KN)
S	=	average penetration for the last ten blows (mm)
K	=	10 mm (unless otherwise observed/computed during driving)
FS	=	factor of safety (min. = 3)

Hiley's Formula shall be used when the ratio of the weight of ram or hammer to weight of pile is less than one fourth (1/4).

$$Ru = \frac{efWH\ (W)}{S+1/2\ (C1+C2+C3)} \times \frac{(W + n^2\ Wp)}{(W + Wp)}$$

$$Ra = \frac{Ru}{FS}$$

where:

Ru	=	ultimate capacity of pile (KN)
Ra	=	capacity of pile (KN)
ef	=	efficiency of hammer (refer to table)
W	=	weight of ram (KN)
Wp	=	weight of pile (KN)
H	=	height of fall of ram (mm)
S	=	average penetration for last ten blows (mm)
C1	=	temporary compression allowance for pile head and cap (refer to table)
C2	=	RuL/AEp
C3	=	range from 2.54mm to 5.08mm for resilient soil to 0 for hard pan (rock, very dense sand and gravel)
L	=	length of pile
A	=	cross-sectional area of pile
Ep	=	modulus of elasticity of pile
n	=	coefficient of restitution (refer to table)
FS	=	factor of safety (min. = 3)

Required minimum penetration of all piles shall be 6 m. However, for exposed piles, the embedded length shall be equal or greater than the exposed length but not less than 6 m.

Note:
Formula for other pile hammers with suggested factor of safety shall be as provided/recommended by the manufacturer.

Table 400.1 Values of C1 for Hiley Formula
Temporary Compression Allowance C1 for Pile Head and Cap

Materials to which blow is applied	**Easy Driving: P1 = 3.45 MPa on Pile Butt If no cushion, mm**	**Medium Driving: P1 = 6.90 MPa on Head or Cap. mm**	**Hard Driving: P1 = 10.34 MPa on Head or Cap. mm**	**Very Hard Driving:P1 = 13.88 MPa on Head or Cap. mm**
Head of timber pile	1.27	2.54	3.81	5.08
76–100 mm packing inside cap on head of precast concrete piles	1.27 + 1.778[b]	2.54 + 3.81[b]	3.81 + 5.588[b]	5.08 + 7.62[b]
Concrete Pile	0.635	1.27	1.905	2.54
Steel-covered cap. containing wood packing but steel piling at pipe	1.016	2.032	3.048	4.064
4.76 mm red electrical tuber disk between 2 mm - 10 mm steel plates, for use with severe driving on Monotube pile	0.508	1.016	1.524	2.032
Head of steel piling of pipe	0	0	0	0

Note: [b]The first figure represent the compression of the cap and wood dolly or packing above the cap, whereas the second figure represent the compression of the wood packing between the cap and the pile head.
P1 = Ru/A

Table 400.2 Values of Efficiency of Hammer, ef

Hammer Type	**ef**
Drop Hammer released by trigger	1.00
Drop Hammer actuated by rope and friction winch	0.75
McKiernan-Terry Single-acting hammers	0.85
Warrington-Vulcan Single-acting hammers	0.75
Differential-acting hammers	0.75

Hammer Type	ef
McKiernan-Terry, Industrial B. Ownhoist, National and Union double-acting hammers	0.85
Diesel Hammers	1.00

Table 400.3 Values of Coefficient of Restitution, n

Pile Type	Head Condition	Drop, Single Acting or Diesel Hammer	Double Acting Hammers
Reinforced Concrete	Helmet with composite plastic or green heart dolly on top of pile	0.40	0.50
	Helmet with Timber dolly, and packing on top of pile	0.25	0.40
	Hammer direct on pile with pad only	-	0.50
Steel	Driving cap with Standard plastic or greenheart dolly	0.50	0.50
	Driving cap with Timber dolly	0.30	0.30
Timber	Hammer direct on pile	-	0.50
	Hammer direct on pile	0.25	0.40

The formulas specified in the preceding Subsection for timber piling may be used in determining a rough approximation for the bearing power of precast and cast-in-place concrete piles and of steel piles.

In all cases when the bearing capacity of concrete and steel piles is determined by formula, the piles shall be driven until the safe bearing capacity of each is computed to be not less than 27 t.

400.1.6 Safe Loads

When the safe bearing capacity of any pile is found by test or computation to be less than the design load, longer piles or additional piles shall be driven as ordered in writing by the Engineer or as specified in the Plans.

400.1.7 Jetted Piles

The safe bearing capacity of jetted piles shall be determined by actual tests or by the appropriate methods and formulas given in the preceding Subsections. No jet shall be used during the test blows.

400.1.8 Micropiles

These are cast-in-place piles with maximum diameter of 300 mm or as indicated on the Plans. They are constructed using high strength small diameter casing, grouted, and installed thread bars. The thread on the bars ensures grout to bond with steel as well as to allow the bar to be cut at any point and joined with a coupler to provide full tension/compression capacity. Typically the casing is advanced to the design depth using a drilling technique. Reinforcing steel in the form of an all-thread bar is typically inserted into the micropile casing, however, deformed bars maybe used when the length are commercially available. Further, deformed reinforcing steel bars are threaded to join using a coupling to obtain the designed length. The casing may extend to the full depth with the reinforcement above the bond zone with the reinforcing bars extending to the full depth. The finished micropile shall resist compression, uplift or tension loads and lateral loads.

Micropiles shall be used as alternatives to conventional piles and as anchors in retaining systems and slopes. Particularly, micropiles are suitable for:

1. Supporting structural loads at sites with restricted access or low headroom.
2. Retrofitting/rehabilitating distressed structures.
3. Underpinning.
4. Excavation and retention systems with restricted access.
5. Seismic retrofit.
6. Expansive soils.

The Contractor shall supply, install and test micropiles including all necessary operation requirements as shown on the Plans or specified herein.

400.2 Material Requirements

The kind and type of piles shall be as specified in the Plans and Bill of Quantities (BOQ). No alternative type or kind of piling shall be used.

400.2.1 Untreated Timber Piles

Structural timber, lumber and piling shall conform to the applicable requirements of AASHTO M 168, Standard Specification for Wood Products or equivalent specification. No boxed heart pieces of Douglas fir or redwood shall be used in outside stringers, floor beams, caps, posts, sills or rail posts. Boxed heart pieces are defined as timber so sawed that any point in the length of a sawed piece, the pith lies entirely inside the four faces.

Yard lumber shall be of the kind and grade called for on the Plans. Round poles and posts shall be of the kind indicated on the Plans.

The species shall be specified on the Plans. Unless otherwise noted on the Plans or Special Provisions, only the best grade shall be used. It shall be free from loose knots, splits, wormholes, decay, warp, ring separation or any defect which will impair its strength or render it unfit for its intended use. Any species specified on the Plans may be used for untreated timber and if the species is not available, a species of equivalent strength and durability may be used if authorized by the Engineer.

Round piles shall be cut above the ground swell and shall taper from butt to tip. A line drawn from the center of the tip to the center of the butt shall not fall outside of the cross-section of the pile at any point more than 1% of the length of the pile.

In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4% of the length of the bend or a maximum of 65 mm.

Unless otherwise specified, all piles shall be peeled removing all rough bark and at least 80% of the inner bark. Not less than 80% of the surface on any circumference shall be clean wood. No strip of inner bark remaining on the pile shall be more than 20 mm wide and 200 mm long. All knots shall be trimmed close to the body of the pile.

The pile sizes shall conform to the dimensions shown in Table 400.4.

Table 400.4 Dimension of Piles

Length of Pile	Diameter (1 meter from the Butt)		Minimum Tip Diameter, mm
	Minimum, mm	Maximum, mm	
Less than 12 meters	300	450	200
12 to 18 meters	320	450	200
More than 18 meters	350	500	150

The diameter of the piles shall be measured in their peeled condition. When the pile is not exactly round, the average of three measurements may be used. For any structure, the butt diameters for the same lengths of pile shall be as uniform as possible.

Square piles shall have the dimensions shown on the Plans.

400.2.2 Treated Timber Piles

Structural timber, lumber and piling to be treated shall conform to the applicable requirements of AASHTO M 168, Standard Specification for Wood Products and AASHTO M 133, Standard Specification for Preservatives and Pressure Treatment Processes for Timber or equivalent specification. The minimum penetration of the preservative into the surface of the timber shall be 20 mm. All piles shall retain the minimum amount of preservative specified in Table 400.5.

Table 400.5 Minimum Preservative per Cubic Meter of Wood

Use	Type of Processing	
	Empty Cell Process	Full Cell Process
General Use	195 kg	-
Marine Use	-	320 kg

The Engineer shall inspect the timber prior to the treatment to determine conformance with the Specifications and suitability of conditions for treatment. He shall be permitted free access to the plant in order that temperatures, pressures, quantities and type of treatment materials used may be observed. Samples of the creosote or creosote petroleum mixtures shall be furnished as required for test.

The timber shall be checked to determine penetration of treatment, quantity of free preservative remaining on the timber and any visual evidence that the treatment has been performed in a satisfactory manner. The penetration of treatment shall be determined by boring a sufficient number of well-distributed holes to determine the average penetration. All such holes shall be plugged with plugs approximately 2 mm larger in diameter than the bit used in boring the holes.

If the penetration of preservative is less than the required amount, the entire charge, or such parts thereof shall be retreated. If after treatment the penetration is still insufficient, the treated pieces shall be rejected.

400.2.3 Concrete Piles

Concrete shall conform to the requirements of Item 405, Structural Concrete. Concrete shall be Class "C" unless otherwise specified on the Plans.

Concrete shall be proportioned to achieve a range of 150 mm to 200 mm slump, self-compacting mix.

The use of appropriate plasticizer/additives to assure mix fluidity and consistency shall be allowed upon approval by the Engineer. A retardant of proven adequacy and approved by the Engineer may be used to ensure that early hardening of concrete during operation will not occur.

Reinforcing steel shall conform to the requirements of Item 404, Reinforcing Steel. Prestressing reinforcing steel shall be high-tensile steel wire conforming to AASHTO M 204M, Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete.

400.2.4 Steel Shells

1. Shells Driven Without a Mandrel

Unless otherwise shown on the Plans or Special Provisions, shells for cast-in-place concrete piles shall have a minimum 305 mm diameter at cut-off and a minimum diameter of 203 mm diameter at tip: made from not less than 4.55 mm thick plate stock conforming to ASTM A36M, Standard Specification for Carbon Structural Steel. Shells shall either be spirally or longitudinally welded and shall either be tapered or constant in section. Tips shall be sealed as shown on the Plans.

2. Shells Driven With a Mandrel

The shell shall be of sufficient strength and thickness to withstand driving without injury and to resist harmful distortion and/or buckling due to soil pressure after driven and the mandrel removed. Butt and tip dimension shall be as shown on the Plans or Special Provisions.

400.2.5 Steel Pipes Piles / Steel Pipe Sheet Piles

Filled Steel Pipes (filled with concrete) shall conform to the requirements of ASTM A252, Standard Specification for Welded and Seamless Steel Pipe Piles. Closure Plates for closed piles shall conform to the requirements of ASTM A36M or ASTM A31.

Unfilled Tubular Steel Piles shall conform to the requirements of ASTM A252, with chemical requirements meeting ASTM A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless, Grade B. The wall thickness shall not be less than 4.76 mm.

Reinforcing Bar Stud for connection between top slab concrete and steel pipe piles and steel pipe sheet piles shall conform to Item 404, Reinforcing Steel.

The materials for concrete and grout shall conform to Item 405, Structural Concrete. The Concrete shall be Class P as specified in Subsection 405.1.2, Classes and Uses of Concrete unless otherwise shown on the Plans or specified in the Special Provisions. The grout shall consist of Portland cement, water and an expansive admixture approved by the Engineer.

400.2.6 Steel H-Piles

Steel H-Piles shall be rolled steel sections of the weight and shape shown on the Plans. They shall be structural steel meeting the requirements of ASTM A36M provided that, where the Special Provisions called for copper-bearing structural steel, the steel shall not contain less than 0.2% nor more than 0.35% of copper, except that steel manufactured by the acid bessemer process shall not be used.

400.2.7 Steel Sheet Piles

Steel sheet piles shall meet the requirements of AASHTO M 202 (ASTM A328), Standard Specification for Steel Sheet Piling or ASTM A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel. The joints shall be practically water-tight when the piles are in place.

400.2.8 Polyvinyl Chloride (PVC) Sheet Piles

PVC sheet piles shall meet the requirements of ASTM D638, Standard Test Method for Tensile Properties of Plastics, ASTM D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics, and ASTM D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position. The joints shall be practically water-tight when the piles are in place.

400.2.9 Pile Shoes

Pile shoes shall be as called for on the Plans. Steel pile shoes shall be fabricated from cast steel conforming to ASTM A148, Standard Specification for Steel Castings, High Strength, for Structural Purpose.

When shoes are required by soil conditions, piles shall conform to the approved steel shoes to ensure a firm uniform contact and prevent local stress concentrations.

400.2.10 Splices

Full length piles shall be used when practicable; but if splices cannot be avoided, piles or shells for cast-in-place piles may be spliced in accordance with the requirements of the Plans. Piles shall not be spliced except with the approval of the Engineer.

400.2.11 Paint

Paint shall conform to Item 411, Paint.

400.2.12 Mortar for Steel Pipe Piles/Steel Pipe Sheet Piles

Mortar shall consist of sand, cement, and water conforming to the requirements given under Item 505, Riprap and Grouted Riprap, mixed in the proportion of one-part cement to three-parts sand by volume, and sufficient water to obtain the required consistency.

400.3 Construction Requirements

400.3.1 Location and Site Preparation

Piles shall be driven where indicated on the Plans or as directed by the Engineer.

All excavations for the foundation through which the piles are to be driven shall be completed before the pile driving, unless otherwise specified or approved by the Engineer. After driving is completed, all loose and displaced materials shall be removed from around the piles by manual excavation, leaving clean solid surface to receive the concrete of the foundation. Any requirement for granular fill and lean concrete shall be indicated on the Plans or as directed by the Engineer.

400.3.2 Determination of Pile Length

Pile length and bearing capacity shall be determined by the Engineer from the results of the test piling and load tests.

The criterion for pile length may be one of the following:

1. Piles in sand and gravel shall be driven to a bearing capacity determined by the use of the pile driving formula or as decided by the Engineer.

2. Piles in clay shall be driven to the depth ordered by the Engineer. However, the bearing capacity shall be controlled by the pile driving formula if called for by the Engineer.

3. Piles shall be driven to the allowable bearing capacity or refusal on rock/hard layer when so ordered by the Engineer.

The bottom of piles shall be embedded at least three times the diameter (3D) into hard strata with an N-Value of at least 40 capable of developing the required ultimate bearing capacity, if the above condition cannot be met during construction, the designer shall be notified for adjustment of pile length if necessary.

The Contractor shall be responsible for obtaining the correct pile length and bearing capacity according to the agreed criteria indicated in this Specification.

400.3.3 Pile Driving

All piles shall be driven as shown on the Plans. Piles shall be driven within an allowed variation of 20 mm per meter of pile length from the vertical or batter as shown on the Plans. The maximum allowable variation at the butt end of the pile shall be 75 mm in any direction from the location shown on the Plans. Each pile, after driving, shall be within 150 mm from the theoretical location underneath the pile cap or underneath the superstructure in case of pile bents. All piles pushed up by the driving of adjacent piles or any other cause shall be re-driven.

Piles shall be used only in places where the minimum penetration of 3 m in firm materials, or 5 m in soft materials can be obtained. Whereas soft upper stratum overlies a hard stratum, the piles shall penetrate the hard materials at sufficient depths to fix the ends rigidly.

All pile driving equipment shall be subject to the Engineer's approval. The Contractor shall be responsible for sufficient weight and efficiency of the hammers to drive the piles down to the required depth and bearing capacity. Hammers shall be gravity hammers, single and double acting steam or pneumatic hammers or diesel hammers. Gravity hammers shall not weigh less than 60% of the combined weight of the pile and driving head but not less than 2,000 kg. The fall shall be regulated so as to avoid injury to the pile and shall in no case exceed 4.50 m for timber and steel piles, and 2.50 m for concrete piles unless otherwise specified or approved by the Engineer.

The plant and equipment furnished for steam hammers shall have sufficient capacity to maintain, under working condition, the pressure at the hammer specified by the manufacturer. The boiler or pressure tank shall be equipped with an accurate pressure gauge and another gauge shall be supplied at the hammer intake to determine the drop in pressure between the gauges. When diesel hammers or any other types requiring calibration are used, they shall be calibrated with test piling and/or test loads in accordance with Subsection 400.1.2, Test Piles.

Water jets shall be used only when permitted in writing by the Engineer. When water jets are allowed, the number of jets and the nozzle volume and pressure shall be sufficient to clear the material adjacent to the pile. The ultimate pile capacity shall be determined from the results of driving after the jets have been withdrawn. The pump shall have sufficient capacity to deliver a pressure equivalent to at least 690 KPa for two 19 mm diameter jet nozzles. The jets shall be shut off before the required penetration is reached and the piles shall be driven solely by hammers to final penetration as required by the Engineer.

Piles shall be supported in line and position with leads while being driven. Pile driving leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and shall be held in position by workers or steel braces to ensure rigid lateral support to the pile during driving. The leads shall be of sufficient length to make the use of a follower unnecessary and shall be so designed as to permit proper placing of batter piles. The driving of the piles with followers shall be avoided if practicable and shall be done only under written permission from the Engineer.

The method used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete, injurious splitting, splintering and brooming of the wood or deformation of the steel. Manipulation of piles to force them into proper position if considered by the Engineer too excessive will not be permitted.

The pile tops shall be protected by driving heads, caps or cushions in accordance with the recommendation of the manufacturer of the pile hammer and to the satisfaction of the Engineer. The driving head shall be provided to maintain the axis of the pile with the axis of the hammer and provide a driving surface normal to the pile.

Full length piles shall be used where practicable. Splicing of piles when permitted, shall be in accordance with the provisions of Subsection 400.3.7 and 400.3.9. All piles shall be continuously driven unless otherwise allowed by the Engineer.

Piles shall not be driven unless required strength is reached or attained.

400.3.4 Timber Piles

Piles shall be strapped with three (3) metal straps: one about 450 mm from the butt, one about 600 mm from the butt, and the third, about 300 mm from the tip. Additional straps shall be provided at about 4.5 m on centers between tip and butt. Strapping shall encircle the pile once and be tensioned as tightly as possible. Straps shall be 38 mm wide, 0.8 mm thick, cold rolled, fully heat treated, high tensile strapping, painted and waxed. Treated piles shall be strapped after treatment.

Point protection shall be considered for all timber piles. Where timber piles must penetrate dump fill, or may encounter obstructions or be driven to hard strata, point protection shall be used. A boot that encompasses and utilizes the entire end area of the pile is preferred.

400.3.5 Timber Pile Bents

Piles for any one (1) bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. Care shall be exercised in the distribution of piles of various sizes to obtain uniform strength and rigidity in the bents of any given structure. Cut offs shall be made accurately to ensure full being between caps and piles of bents.

400.3.6 Precast/Prestressed Concrete Piles

Precast concrete piles shall be of the design shown on the Plans. The method of prestressing to be used shall be optional with the Contractor subject to all requirements hereinafter specified.

The Contractor, prior to casting any members to be prestressed, shall submit to the Engineer for approval complete details of the methods, materials and equipment he proposes to use in the prestressing operations. Such details shall outline the method and sequence of stressing, complete specifications and details of the prestressing, steel and anchoring devices proposed for use, anchoring stresses, type of enclosures and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, pressure grouting materials and equipment.

The piles shall be caste separately and concrete in each pile shall be placed continuously. The completed piles shall be free from stone pockets, honeycombs, or other defects, and shall be straight and true to the form specified. The forms shall be true to line and built of metal, plywood or dressed lumber. A 25 mm chamfer strip shall be used in all corners. Form shall be water-tight and shall not be removed until at least 24 h after the concrete is placed.

Piles shall be cured and finished in accordance with Subsection 400.3.8, Curing Concrete.

Cylinder specimens shall be made and tested in accordance with Item 405, Structural Concrete. Piles shall not be moved until the tests indicate that the concrete has attained a compressive strength of at least 80% of the design 28-day compressive strength and they shall not be transported or driven until the design 28-day compressive strength has been attained.

If testing equipment is not available, as in isolated areas, piles shall not be moved until after 14 days after casting and shall not be transported or driven prior to 28 days after casting. If high early strength cement is used, piles shall not be moved, transported or driven prior to 7 days after casting.

When concrete piles are lifted or moved, they shall be supported at the points shown on the Plans; if not shown, they shall be supported at the quarter points.

400.3.7 Cast-in-place Concrete Piles

1. Drilled Holes

All holes for concrete piles shall be drilled dry to tip elevation as shown on the Plans. Suitable casings shall be furnished and placed when required to prevent cave-in before concrete is placed.

All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed before placing concrete.

The use of water for drilling operations or for any other purpose where it may enter the hole will not be permitted. All necessary action shall be taken to prevent surface water from entering the hole and all water which may have infiltrated into the hole shall be removed before placing concrete.

Concrete shall be placed by means of suitable tubes. Prior to the initial concrete set, the top 3 m of the concrete filled pile or the depth of any reinforcing cage, whichever is greater, shall be consolidated by acceptable vibratory equipment.

Casing, if used in drilling operations, may be left in place or removed from the hole as concrete is placed. The bottom of the casing shall be maintained not more than 1.5 m nor less than 0.3 m below the top of the concrete during withdrawal and placing operations unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided by vibrating the casing.

2. Steel Shells and Pipes

The inside of shells and pipes shall be cleaned and all loose materials removed before concrete is placed. The concrete shall be placed in one continuous operation from tip to cut-off elevation and shall be carried on in such a manner as to avoid segregation.

The top 3 m of concrete filled shells, or to the depth of any reinforcing cage, whichever is greater, shall be consolidated by acceptable vibratory equipment.

Pipes shall be of the diameter shown on the Plans. The pipe wall thickness shall not be less than that shown on the Plans but in no case less than 5 mm. The pipe, including end closures, shall be of sufficient strength to be driven by the specified methods without distortion.

Closure plates and connecting welds shall not project more than 12.5 mm beyond the perimeter of the pile tips.

No shell or pipe shall be filled with concrete until all adjacent shells, pipes, or piles within a radius of 1.5 m or 4 ½ times the average pile diameter, whichever is greater, have been driven to the required resistance.

After a shell or pipe has been filled with concrete, no shell, pipe or pile shall be driven within 6 m thereof until at least seven (7) days have elapsed.

3. Drilled Shafts

Drilled shafts shall be deep foundations formed by boring a cylindrical hole into soil and/or rock and filling the hole with concrete. Drilled shafts are also commonly referred to as caissons, bored piles or drilled piers.

Drilled shafts, like driven piles, transfer structural loads to bearing stratum well below the base of the structure by passing soils having insufficient strength to carry the design loads.

Drilled shafts shall be classified according to their primary mechanism for deriving load resistance either as floating shafts (i.e., shafts transferring load primarily by side resistance), or end-bearing shafts (i.e., shafts transferring load primarily by tip resistance). Occasionally, the bases of shafts shall be enlarged (i.e., belled or underreamed) to improve the load capacity of end bearing shafts on less than desirable soils, or to increase the uplift resistance of floating shafts.

Effects of ground and ground water conditions on shaft construction operations shall be considered and delineated, when necessary. Because shafts derive their capacity from side and tip resistance which are a function of the condition of the materials in direct contact with the shaft, it is important that the construction procedures be consistent with the material conditions assumed in the design. Softening, loosening or other changes in soil and rock conditions caused by the construction method could result in a reduction in shaft capacity and an increase in shaft displacement. Therefore, evaluation of the effects of shaft construction procedure on load capacity shall be considered an inherent aspect of the design.

Drilled shafts shall be normally sized in 15.24 cm diameter increments with a minimum diameter of 45.72 cm. The diameter of a shaft socketed into rock shall be a minimum of 15.24 cm larger than the socket diameter. If a shaft must be inspected by the entry of a person, the shaft diameter shall not be less than 76.20 cm.

Drilled shafts constructed in dry, non-caving soils can usually be excavated without lateral support of the hole. Other ground conditions where caving, squeezing or sloughing soils are present require installation of a steel casing or use of a slurry for support of the hole. Such conditions and techniques may result in loosening of soil around the shaft, or altering of frictional resistance between the concrete shafts and surrounding soil.

The center-to-center spacing between shafts is normally restricted to a minimum of 3B to minimize the effects of interaction between adjacent shafts during construction or in service. However, larger spacing may be required where drilling operations are difficult or where construction must be completed in very short time frames.

Particular attention shall be given to the potential for deposition of loose or wet material in the bottom of the hole, or the buildup of a cake of soft material around the shaft perimeter prior to concrete placement. Adequate cleaning and inspection of rock sockets shall always be performed to assure good contact between the rock and shaft concrete. If good contact along the shaft cannot be confirmed, it may be necessary to assume that all load is transferred to the tip. If the deposition of soft or loose material in the bottom of the hole is expected, the shaft may have to be designed to carry the entire design load through side resistance.

A number of methods can be used to prevent cave-in during the drilling of holes and the placement of concrete. It is preferred that drilled shafts be constructed in stable non-sloughing soil without excessive ground water. If impossible, consider the following three different construction methods:

1. The construction of the pile or shaft in a wet condition while the walls of the excavation are stabilized by hydrostatic pressure of water or a mineral slurry until the concrete is placed by tremie methods for the full length of the pile.

   Mineral slurry used in the drilling process shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. The level of the slurry shall be maintained at a height sufficient to prevent cave-in of the hole.

   The mineral slurry shall be premixed thoroughly with clean fresh water and adequate time allotted for hydration prior to introduction into the shaft excavation. Adequate slurry tanks will be required when specified. No excavated slurry pits will be allowed when slurry tanks are required on the project without written permission of the Engineer. Adequate desanding equipment will be required when specified. Steps shall be taken as necessary to prevent the slurry from "setting up" in the shaft excavation, such as agitation, circulation, and adjusting the properties of the slurry.

   Control tests using suitable apparatus shall be carried out by the Contractor on the mineral slurry to determine density, viscosity, and pH. An acceptable range of values for those physical properties is shown in Table 400.6.

Table 400.6 Range of Values (At 20°C)

Prperty Units	**Time of Slurry Introduction**	**Time of Concreting (In Hole)**	**Test Method**
Density, KN/m^3	10.10 – 10.86	10.10 – 11.79	Density Balance
Viscosity, sec/liter	28 – 45	28 – 45	March Cone
pH	8 – 11	8 – 11	pH Paper/ Meter

Note: 1. Increase density values by 0.314KN/m^3 in salt water.
2. If desanding is required; sand content shall not exceed 4% (by volume) at any point in the shaft excavation as determined by the American Petrolium Institue sand content test.

Tests to determine density, viscosity and pH values shall be done during the shaft excavation to establish a consistent working pattern.

Prior to placing shaft concrete, slurry samples shall be taken from the bottom and at intervals not exceeding 3.05 m for the full height of slurry. Any heavily contaminated slurry that has accumulated at the bottom of the shaft shall be eliminated. The mineral slurry shall be within Specification requirements immediately before shaft concrete placement.

Excavation Inspection

1. The Contractor shall provide equipment for checking the dimensions and alignment of each shaft excavation. The Contractor under the direction of the Engineer shall determine the dimensions and alignment of the drilled shaft. Final shaft depth shall be measured prior to concrete pouring.

   The base of the shaft excavation may be cleaned using a cleaning bucket followed by airlifting clean-up method. Reverse circulation techniques may also be used to clean the base of the shaft.

   The shaft excavation shall be cleaned so that a minimum of 50% of the base will have less than 12.5 mm of sediment and at no place on the base more than 37.5 mm of sediment. The Engineer will determine shaft cleanliness.

2. The use of steel casing which is installed during drilling operations to hold the hole open and usually withdrawn during concrete placement.

   Casing, if used in operation, shall be metal, smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified size of the shaft. It shall conform to ASTM A709, Standard Specification for Structural Steel for Bridges, Grade 36 unless otherwise specified.

   Temporary casings shall be removed while the concrete remains workable. Generally the removal of temporary casing shall not be started until concrete placement in the shaft is at or above ground surface. Movement of casing by rotating, exerting downward pressure and tapping to facilitate extraction or extraction with a vibratory hammer shall be permitted. Casing extraction shall be at a slow, uniform rate with the pull in line with the shaft axis.

   A sufficient head of concrete shall be maintained above the bottom of the casing to overcome the hydrostatic pressure of water or drilling fluid outside of the casing.

3. The use of a permanent casing which is left in place within the portion of the pile which is in unstable material.

   A permanent casing is applied as protection from the presence of surface water during drilling and as support later for the installation of the rebar cage and as a concrete form in drilling under water.

Standard weight pipe shall be furnished unless otherwise shown on the Plans or in the Special Provisions.

Reinforcing Steel Cage Construction and Placement

The reinforcing steel cage consisting of the steel shown on the Plans plus cage stiffener bars, spacers, centralizers and any other necessary appurtenances shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted prior to shaft concrete placement.

Where the reinforcing cage length is too long for placement as a single unit, the cage may be placed in separate units such that appropriate means of splicing the longitudinal steel is provided for. The Contractor shall submit his Plans for such splices to the Engineer for approval.

The reinforcing steel in the hole shall be tied and supported so that the reinforcing steel will remain within allowable tolerances until the concrete will support the reinforcing steel. When concrete is placed by suitable tubes, temporary hold-down devices shall be used to prevent uplifting of the steel cage during concrete placement. Concrete spacers or other approved noncorrosive spacing devices shall be used at sufficient intervals not exceeding 1.50 m along the shaft to insure concentric location of the cage within the shaft excavation. When the size of the longitudinal reinforcing steel exceeds 25 mm, such spacing shall not exceed 3 m.

Concrete Placement, Curing and Protection

Concrete shall be placed as soon as possible after reinforcing steel cage placement. Concrete placement shall be continuous in the shaft to the top elevation of the shaft. Placement shall continue after the shaft is full until good quality concrete is evident at the top of the shaft. Concrete shall be placed through a suitable tube.

For piles less than 2.50 m in diameter, the elapsed time from the beginning of concrete placement in the shaft to the completion of placement shall not exceed 2 h. For piles 2.50 m and greater in diameter, the concrete placing rate shall not be less than 9 m of pile height per each 2-hour period. The concrete mix shall be of such design that the concrete remains in a workable plastic state throughout the 2-hour placement limit.

When the top of pile elevation is above ground, the portion of the pile above ground shall be formed with a removable form or permanent casing when specified.

The upper 1.50 m of concrete shall be vibrated or rodded to a depth of 1.50 m below the ground surface except where soft uncased soil or slurry remaining in the excavation will possibly mix with the concrete.

After placement, the temporarily exposed surfaces of the shaft concrete shall be cured in accordance with the provision in Subsection 407.3.8, Curing Concrete.

For at least 48 h after pile concrete has been placed, no construction operations that would cause soil movement adjacent to the shaft, other than mild vibration, shall be conducted.

Construction Tolerances:

The following tolerances shall be maintained in constructing drilled shaft:

1. The drilled shaft shall be within 15.24 cm of the plan position in the horizontal plane at the plan elevation for the top of the shaft.

2. The vertical alignment of the shaft excavation shall not vary from the plan alignment by more than 20.83 mm/m of depth.

3. After all the shaft concrete is placed, the top of the reinforcing steel cage shall be no more than 15.24 cm above and no more than 7.62 cm below plan position.

4. When casing is used, its outside diameter shall not be less than the shaft diameter shown on the Plans. When casing is not used, the minimum diameter of the drilled shaft shall be the diameter shown on the Plans for diameters 60.96 cm or less, and not more than 2.54 cm less than the diameter shown on the Plans for diameters greater than 60.96 cm.

5. The bearing area of bells shall be excavated to the plan bearing area as a minimum. All other plan dimensions shown for the bells may be varied, when approved, to accommodate the equipment used.

6. The top elevation of the shaft shall be within 2.54 cm of the plan top of shaft elevation.

7. The bottom of the shaft excavation shall be normal to the axis of the shaft within 62.5 mm/m of shaft diameter.

8. Drilled shaft excavations constructed in such a manner that the concrete shaft cannot be completed within the required tolerances are unacceptable.

400.3.8 Steel Pipe Piles /Steel Pipe Sheet Piles

Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs) shall be driven to the elevation shown on the Plans/Drawings.-Where, due to subsurface conditions, it is impractical to drive the piles to design depth, the piles may be stopped at a higher elevation with the written permission of the Engineer. Where, due to subsurface conditions, it is necessary to drive the piles to below the design depth, for normal and low headroom working or other site conditions, the piles may be spliced in accordance with Subsection 400.3.12(3), Splicing. Where obstacles to driving exist and the Engineer decides that the obstacles may be removed, the Contractor shall extract the piles, remove the obstacles in an approved manner and re-drive the piles.

400.3.9 Steel H-Pile

Steel H-Pile shall consist of structural steel shapes of the sections indicated on the Plans.

When placed in the leads, the pile shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise damaged shall be rejected.

The loading, transporting, unloading, storing and handling of steel H-pile shall be conducted so that the metal will be kept clean and free from damage.

400.3.10 Unfilled Tubular Steel Piles

The minimum wall thickness shall be as indicated in the following table:

Table 400.7 Minimum Wall Thickness of Unfilled Tubular Steel Piles

Outside Diameter	Less than 355 mm	355 mm and over
Minimum wall thickness	6.5 mm	9.5 mm

Cutting shoes for piles driven open end may be inside or outside of the pipe. They may be high carbon structural steel with a machined ledged for pile bearing or cast steel with a ledge, designed for attachment with a simple weld.

400.3.11 PVC Sheet Piles

All PVC sheet piles shall be driven as shown on the Plans. If it is determined that the soil conditions warrant a mandrel, then holes shall be drilled in the appropriate locations to bolt the sheets to the top of the mandrel. Drive the initial sheet piles with the male lock leading, since the female lock fill up with soil and hinder driving if used as the leading edge. Make certain that the initial sheets are properly positioned, square and plumb, as it will influence the orientation of subsequent sheets. Also ensure that the sheets are placed up against the pile guide as they are positioned for driving. The sheets shall be driven as close to plumb as possible. Deviation in plumbness in any direction shall not be more than 3°.

400.3.12 Splicing

Splicing when permitted shall be made as shown on the Plans and in accordance with this Subsection.

1. Precast Concrete Piles

    a. By using prefabricated joints mounted in the forms and cast together with the piles sections and joined together as specified by the manufacturer and approved by the Engineer. The joints shall be of the design and type as specified or shown on the Plans.

       By cutting away the concrete at the end of the pile, leaving the reinforcing steel exposed for a length of 40 times bar diameters for corrugated or deformed bars and 60 times bar diameters for plain bars. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement of the same size as that used in the pile shall be spliced to the projecting steel in accordance with Item 902, Reinforcing Steel, and the necessary splice box shall be placed, care being taken to prevent leakage along the pile.

    b. By any other method shown on the Plans or approved by the Engineer, curing and finishing of extensions shall be the same as in the original pile.

2. Prestressed Piles

    Splicing of prestressed precast piles will generally not be permitted, but when permitted, it shall be made in accordance with (1) above, but only after driving has been completed. Reinforcement bars shall be included in the pile head for splicing to the extension bars. No additional driving shall be permitted. The Contractor, at his option, may submit alternative plans of splicing for consideration by the Engineer.

3. Steel Piles, Shells or Pipes

    If the length of the steel pile, shell or pipe driven is insufficient to obtain the specified bearing capacity, an extension of the same cross-section shall be spliced to it. Unless otherwise shown on the Plans, splices shall be made by butt-welding the entire cross-sections to form an integral pile using the electric arc method. The sections connected shall be properly aligned so that the axis of the pile shall be straight. Bent and/or damaged piles shall be rejected.

400.3.13 Cutting Off and Capping Piles

The top of foundation piles shall be embedded in the concrete footing as shown on the Plans.

Concrete piles shall, when approved by the Engineer, be cut off at such a level that at least 300 mm of undamaged pile can be embedded in the succeeding structure. If a pile is damaged below this level, the Contractor shall repair the pile to the satisfaction of the Engineer. The longitudinal reinforcement of the piles shall be embedded in the structure above to a length equal to at least 40 times the diameter of the main reinforcing corrugated bars and 60 times diameters for plain bars. The distance from the side of any pile to the nearest edge of the cap shall not be less than 200 mm.

When the cut off elevation for a precast pile or for the steel shell or pile for a cast in place concrete pile is below the elevation of the bottom of the pile cap, the pile may be built-up from the butt of the pile to the elevation of the bottom of the cap by means of reinforced concrete extension constructed in accordance with Subsection 400.3.12 or as approved by the Engineer.

Cut-offs of structural steel piles shall be made at right angles to the axis of the pile. The cuts shall be made in clear, straight lines and any irregularity due to cutting or burning shall be leveled-off with deposits of weld metal prior to placing bearing caps.

400.3.14 Defective Piles

Any pile delivered with defects, or damaged in driving due to internal defects or by improper driving, or driven out of its proper location, or driven below the elevation fixed by the Plans or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question:

1. Any pile delivered with defects shall be replaced by a new pile.

2. Additional pile shall be driven/casted at the location adjacent to the defective pile as directed by the Engineer.

3. The pile shall be spliced or built-up or as otherwise provided herein on the underside of the footing lowered to the properly embedded pile. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, shall not be permitted.

A precast concrete pile shall be considered defective if it has a visible crack, extending around the four (4) sides of the pile, or any defect which, in the opinion of the Engineer, affects the strength or life of the pile.

When a new pile is driven or cast to replace a rejected one, the Contractor at his own expense, shall enlarge the footing as deemed necessary by the Engineer.

400.3.15 Protecting Untreated Timber Trestle Piles

The sawed surface of the heads of untreated piles shall be thoroughly brush-coated with two (2) applications of hot creosote oil or other approved preservative.

400.3.16 Protecting Treated Timber Trestle Piles

All cuts and abrasions in treated timber piles shall be protected by a preservative approved by the Engineer.

400.3.17 Painting Steel Piles

Unless otherwise provided, when required steel piles extend above the ground surface or water surface, they shall be protected by paint as specified for cleaning and painting metal surfaces in accordance with Item 403, Metal Structures. This protection shall extend from the elevation shown on the Plans to the top of the exposed steel.

400.3.18 Pile Records

The Contractor shall keep records of all piles driven or installed. A copy of the record shall be given to the Engineer within 2 days after each pile is driven. The record form to be used shall be approved by the Engineer. The pile records shall not be limited to the following:

Driven Piles	Cast-In-Place Piles
1. Pile type and dimension 2. Date of casting and concrete quality (for concrete piles) 3. Date of driving 4. Driving equipment: type, weight & efficiency of hammer, etc. 5. Description of cushion on pile head 6. Depth driven and tip elevation 7. Final set for the last 20 blows (for every (ten) 10 piles and when the Engineer so requires the penetration along the whole depth driven shall be recorded) 8. For gravity and single-acting hammers: the height of drop 9. For double acting-hammers - the frequency of blows 10. Details of any interruption in driving 11. Level of pile top immediately after driving and the level when all piles in the group are driven 12. Details of re-driving	1. Date of boring or driving (For steel shell) & casting 2. Date of test 3. Pile identification number, elevation and location 4. Pile type and nominal dimension 5. Length of finished pile and tip elevation 6. Details of penetration during boring or driving of steel shell (driving records as for driven piles) 7. Test load achieved 8. Concrete quality and consistency 9. Time interval between boring or driving and concreting 10. Volume of concrete placed in concrete 11. Installation logs with supporting data 12. Instrumentation types and locations 13. Load cell calibrations and instrument calibrations 14. Load vs Displacement graph, plotting load transfer along the length of the pile using instrumentation data 15. The skin friction/adhesion pressure and end bearing shaft bearing pressure at 12 mm displacement of the pile during testing

400.3.19 Micropiles

400.3.19.1 Drilling Operations

1. Boring near recently Cast Piles

   The maximum allowable deviation of center point location for Micropile shall be 40 mm and a verticality of 1:50. Piles shall not be bored next to other piles which have recently been cast within 24 h and contain unset grout.

2. Stability of Drill Holes

   The Contractor shall be responsible in providing materials, labour and plant, to maintain the stability of the sides of boreholes during Micropile installation and successful completion of the piles. The Contractor shall submit his proposed methods for boring operations.

   Considering the existing ground water, the sides of all borehole shall be kept intact and no loose material shall be permitted to fall into the bottom of the boreholes. The Contractor's boring equipment shall be capable in sinking a steel casing to support the sides of all boring.

   If the sides of boreholes are unstable, temporary steel casing shall be driven until the stable stratum is reached. The borehole shall be filled with drilling fluid to a level sufficiently to stabilize the boreholes.

   Depth of anchorage shall be as shown on the Plans.

   Drill holes shall not be exposed longer than is necessary and shall be covered at all times when work is not in progress. Pile shall be casted within 24 h unless otherwise approved by the Engineer.

   In case of a rapid loss of drilling fluid from the borehole excavation causing instability of borehole, the Contractor shall install temporary casing prior to resumption of boring at that location at the expense of the Contractor.

3. Stability of Borehole by Temporary Casing Method

   Where the use of temporary casing is required to maintain the stability of a borehole, the bottom of casing shall be kept at a minimum of 1 m below the unstable strata to prevent the caving-in of soil and the formation of cavities in the surrounding ground.

   Temporary casings shall be thin-walled mild steel. The dimensions and quality of the casing shall be adequate to withstand pressures to which they will be subjected. The casings shall have an internal diameter not less than the specified pile diameter. The joints of casings shall be watertight.

400.3.19.2 Grouting Operations

The Contractor shall provide details of the method and equipment to be used in grout mixing. Further information such as grouting pressure, grouting procedure, grouting equipment and technique employed in grouting underwater shall also be furnished for approval.

Grout shall be mixed on site and shall be free from segregation, clumping and bleeding. Grout shall be pumped into its final position in one continuous operation as soon as possible and in no case more than half an hour after mixing.

Micropile shall be grouted in one continuous process. If there is significant loss of grout, the Contractor may choose to carry out pre-grouting in stages as necessary to prevent further loss of grout for the construction of micropile. Method statement for pre-grouting including details of equipment, materials and procedures shall be reviewed and approved by the Engineer. If after the process of pre-grouting and re-drilling of the hole is required, the Contractor shall bear the cost and time of the pre-grouting and re-drilling.

400.3.19.3 Construction of Pile Heads

When lengthening is required, the pile reinforcement unit shall be connected on site to the details shown on the Plans. Other means of jointing reinforcement shall be to the approval of the Engineer. Pile heads shall be constructed to the details as shown on the Plans.

400.3.19.4 Standard Load Tests

Load test of two (2) times the working loads shall be carried out on piles designated by the Engineers and in accordance with ASTM D 1143, Standard Test Methods for Deep Foundations Under Static Axial Compressive Load. The Contractor shall submit detailed proposal of the load tests to the Engineer for approval prior to commencement on site. Upon completion of the test, the Contractor shall submit to the Engineer complete results including graphs showing load and settlement versus time, and settlement versus load.

The format of the test report shall be approved by the Engineer which shall contain the following:

1. Pile designation, date completed, weather condition, pile length, pile size, volume of grout intake, time of drilling at intervals not greater than 4 m and time to grout the pile
2. Designation of the apparatus used for testing, loading system and procedure for measuring settlement
3. Field data
4. Time vs Settlement Curve
5. Load vs Settlement Curve
6. Remarks containing unusual event or data and movement of piles
7. Calibration certificates of dial gauges and pressure gauges
8. The format of record shall be approved by the Engineer

400.3.19.5 Damaged or Displaced Piles

Should the deviation exceed the tolerance provided in the specification, the Contractor shall submit his remedial proposal subject to approval of the Engineer. The faulty pile shall be replaced by additional piles as necessary in position as determined by the Engineer at the expense of the Contractor.

Where piles have not been positioned within the specified limits, no method of forcible correction shall be permitted.

1052.3.19.6 Piling Records

Complete piling records shall be kept by the Contractor during piling works. The Contractor shall submit the following in duplicate copy to the Engineer.

1. Records of all piles as the work proceeds.
2. Upon completion, a record of the work as carried out and as-built drawing.

The format of the record shall be approved by the Engineer and shall contain the following where applicable:

1. Reference number and position of pile
2. Type and dimension
3. Date of boring and nature of strata where each pile is bored
4. Details of the equipment used
5. Ground level and base of excavation level
6. Total penetration
7. Length and position of cavity/cavities in each pile
8. Penetration in rock
9. Time of drilling at intervals not exceeding 5 m
10. Details of all splicing or jointing operations, locations of sleeves, etc.
11. Details of grouting operation for tremie grouting and time tables
12. Weather
13. Top level of pile immediately after completion
14. Errors in position and inclination
15. Amount of grout and the pressure used
16. Size and position of boulder/s in each pile
17. Detailed drilling speed (m/min)
18. Description of drilled material

400.4 Method of Measurement

In determining lengths of piles for ordering and to be included for payment, the lengths given in the order list shall be based on the lengths which are assumed to remain in the completed structure. The Contractor shall, without added compensation, increase the lengths to provide for the fresh heading and for such additional length as maybe necessary to suit the Contractor's method of operation.

400.4.1 Steel, Precast Concrete Piles, Micropile, and Timber Piles

1. Piles Furnished

   The quantity to be paid for shall be the sum of the lengths in meters of the piles of the several types and lengths ordered in writing by the Engineer, furnished in compliance with this Specifications and stockpiled in good condition at the project site by the Contractor and accepted by the Engineer. The length to be paid for shall include test and tension piles ordered by the Engineer, but not those furnished by the Contractor at his option. No allowance shall be made for piles, including test piles, furnished by the Contractor to replace piles previously accepted by the Engineer that are subsequently lost or damaged while in stockpile, or during handling or driving, and are ordered by the Engineer to be removed from the site of work.

In case extensions of piles are necessary, the extension length shall be included in the length of pile furnished, except for cut off lengths used for extensions and already measured for payment.

2. Piles Driven

The quantity to be paid for shall be the sum of the lengths in meters of the piles driven in the completed work measured from the pile tip elevation to the bottom of pile caps, footings or bottom of concrete superstructure in the case of pile bents. Measurement shall not include additional piles or test piles driven that may be necessary to suit the Contractor's method of construction and were driven at his option.

Unless otherwise provided for, preboring, jetting or other methods used for facilitating pile driving operations shall not be measured directly but will be considered subsidiary to Pay Items.

400.4.2 Steel Pipes/Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs)

The quantity to be paid for shall be the sum of actual lengths in meters of the steel pipes/ Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs) left in-place in the completed and accepted work. Measurements shall be by linear meter of installed as Permanent Works as the approved working Plans/drawings and measurement from the design pile tip elevation or higher elevation allowed by the Engineer to the design top level after cut off complete in place and accepted work.

Measurement shall not include additional piles, rejected piles or test piles installed that may be necessary to suit the Contractor's method of construction and installed at his option. All necessary methods of installation and pre-boring, jetting or other methods used for facilitating pile driving operations shall not be measured directly but shall be considered subsidiary to Pay Items.

Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs) to be installed as Temporary Works for the purpose of forming cofferdams or as temporary supports to bridges or staging etc. shall be measured as a Lump Sum and included in the Item B.24 General Scaffolding and Shoring (including Cofferdamming) in Part B. Other General Requirements and strictly in accordance with the requirements, Standard Specifications and Special Specifications included in Part 2 - Works Requirements.

400.4.3 Cast-In-Place Concrete Piles

The quantity to be paid for shall be the sum of actual lengths in meters of the piles cast and left in-place in the completed and accepted work. Measurements shall be from the pile tip to the bottom of cap or footing. Portions of piles cast deeper than the required length through over-drilling shall not be measured for payment.

400.4.4 PVC Sheet Piles

The quantity to be paid for shall be the sum of actual lengths in meters of the PVC sheet piles furnished and driven in the completed and accepted work measured from the pile tip elevation to the bottom of pile caps. Measurement shall not include additional PVC sheet piles or test piles driven that may be necessary to suit the Contractor's method of construction and were driven at his option.

400.4.5 Pile Shoes

The quantity to be paid for, including test pile shoes, shall be the number of pile shoes driven shown on the Plans or as ordered in writing by the Engineer, furnished by the Contractor in accordance with this specification and accepted by the Engineer. Pile shoes furnished by the Contractor at his option or to replace those that are lost or damaged in stockpile or handling shall not be measured for payment.

400.4.6 Load Tests

The quantity of the load tests to be paid for shall be the number of tests completed and accepted except that load tests made to calibrate different types of hammers, if not included in the Bill of Quantities, shall not be measured for payment.

Anchor and test piling which are not part of the completed structure, shall be included in the unit bid price for each "Load Test". Anchor and test piling or anchor and test shafts which are a part of the permanent structure will be paid for under the appropriate Item.

400.4.7 Splices

The quantity to be paid for shall be the number of splices which may be required to drive the pile in excess of the estimated length shown on the Plans for cast-in-place steel pipes or shells or in excess of the order length furnished by the Engineer for all other types of piling. Splices made for the convenience of the Contractor or to fabricate piles cut offs shall not be paid for.

400.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 400.4, Method of Measurement shall be paid for at the Contract Unit Price for each of the particular item listed below that is included in the Bill of Quantities, which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment tools and incidentals as well as temporary works, staging areas or craneway necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
400 (1)	Untreated Timber Piles, Furnished	Meter
400 (2)	Treated Timber Piles, Preservative, Furnished	Meter
400 (3)a	Steel H-Piles, furnished, 305 mm x 305 mm, 79 kg/m	Meter

Pay Item Number	Description	Unit of Measurement
400 (3)b	Steel H-Piles, Furnished, 305 mm x 305 mm, 94 kg/m	Meter
400 (3)c	Steel H-Piles, Furnished, 305 mm x 305 mm, 110 kg/m	Meter
400 (3)d	Steel H-Piles, Furnished, 305 mm x 305 mm, 125 kg/m	Meter
400 (3)e	**Steel H-Piles, Furnished, 360.7 mm x 378.5 mm, 174.2 kg/m**	**Meter**
400 (4)a1	Precast Concrete Piles, Furnished (400 x 400 mm)	Meter
400 (4)a2	Precast Concrete Piles, Furnished (450 x 450 mm)	Meter
400 (5)a1	Precast, Prestresssed Concrete Piles, Furnished (400 x 400 mm)	Meter
400 (5)a2	Precast, Prestresssed Concrete Piles, Furnished (450 x 450 mm)	Meter
400 (6)	Structural Steel Sheet Piles, Furnished	Meter
400 (7)	Precast Concrete Sheet Piles, Furnished	Meter
400 (8)	Untreated Timber Piles, Driven	Meter
400 (9)	Treated Timber Piles, Driven	Meter
400 (10)	Steel H-Piles, Driven	Meter
400 (11)	Steel Pipes Piles	Meter
400 (12)	Structural Steel Sheet Piles, Driven	Meter
400 (13)	Precast Concrete Sheet Piles, Driven	Meter
400 (14)	Precast Concrete Piles, Driven	Meter
400 (15)	Precast, Prestresssed Concrete Piles, Driven	Meter
400 (17)a	Concrete Piles cast in Drilled Holes (0.80 m dia.)	Meter
400 (17)b	Concrete Piles cast in Drilled Holes (0.90 m dia.)	Meter
400 (17)c	Concrete Piles cast in Drilled Holes (1.00 m dia.)	Meter
400 (17)d	Concrete Piles cast in Drilled Holes (1.10 m dia.)	Meter
400 (17)e	Concrete Piles cast in Drilled Holes (1.20 m dia.)	Meter
400 (17)f	Concrete Piles cast in Drilled Holes (1.30 m dia.)	Meter
400 (17)g	Concrete Piles cast in Drilled Holes (1.40 m dia.)	Meter
400 (17)h	Concrete Piles cast in Drilled Holes (1.50 m dia.)	Meter
400 (17)i	Concrete Piles cast in Drilled Holes (1.60 m dia.)	Meter
400 (17)j	Concrete Piles cast in Drilled Holes (1.70 m dia.)	Meter
400 (17)k	Concrete Piles cast in Drilled Holes (1.80 m dia.)	Meter
400 (17)l	Concrete Piles cast in Drilled Holes (1.90 m dia.)	Meter

Pay Item Number	Description	Unit of Measurement
400 (17)m	Concrete Piles cast in Drilled Holes (2.00 m dia.)	Meter
400 (17)n	Concrete Piles cast in Drilled Holes (2.10 m dia.)	Meter
400 (17)o	Concrete Piles cast in Drilled Holes (2.20 m dia.)	Meter
400 (17)p	Concrete Piles cast in Drilled Holes (2.30 m dia.)	Meter
400 (17)q	Concrete Piles cast in Drilled Holes (2.40 m dia.)	Meter
400 (17)r	Concrete Piles cast in Drilled Holes (2.50 m dia.)	Meter
400 (17)s	Concrete Piles cast in Drilled Holes (2.60m dia.)	Meter
400 (17)t	Concrete Piles cast in Drilled Holes (2.70 m dia.)	Meter
400 (17)u	Concrete Piles cast in Drilled Holes (2.80 m dia.)	Meter
400 (17)v	Concrete Piles cast in Drilled Holes (2.90 m dia.)	Meter
400 (17)w	Concrete Piles cast in Drilled Holes (3.00 m dia.)	Meter
400 (17)x	Concrete Piles cast in Drilled Holes (3.50 m dia.)	Meter
400 (17)y1	Concrete Piles cast in Drilled Holes (3.0 m x 6.50 m), Oval	Meter
400 (17)y2	Concrete Piles cast in Drilled Holes (3.0 m x 7.00 m), Oval	Meter
400 (17)y3	Concrete Piles Cast in Drilled Holes (3.5 m x 7.00 m), Oval	Meter
400 (17)z	Concrete Piles cast in Drilled Holes, Rectangular	Meter
400 (17)aa	Concrete Piles cast in Drilled Holes (0.60 m dia.)	Meter
400 (18)a	Concrete Piles cast in Steel Shells (400 mm dia.)	Meter
400 (18)b	Concrete Piles cast in Steel Shells (500 mm dia.)	Meter
400 (19)a	Concrete Piles cast in Steel Shells (400 mm dia.)	Meter
400 (19)b	Concrete Piles cast in Steel Shells (500 mm dia.)	Meter
400 (20)	Pile Shoes	Each
400 (21)	Splices, Splice Can	Each
400 (22)	Load Tests	Each
400 (23)a1	Permanent Casing (0.80 m dia.; 10 mm thick)	Meter
400 (23)a2	Permanent Casing (0.80 m dia.; 12 mm thick)	Meter
400 (23)a3	Permanent Casing (0.80 m dia.; 16 mm thick)	Meter
400 (23)b1	Permanent Casing (0.90 m dia.; 10 mm thick)	Meter
400 (23)b2	Permanent Casing (0.90 m dia.; 12 mm thick)	Meter
400 (23)b3	Permanent Casing (0.90 m dia.; 16 mm thick)	Meter
400 (23)c1	Permanent Casing (1.00 m dia.; 10 mm thick)	Meter
400 (23)c2	Permanent Casing (1.00 m dia.; 12 mm thick)	Meter

Pay Item Number	Description	Unit of Measurement
400 (23)c3	Permanent Casing (1.00 m dia.; 16 mm thick)	Meter
400 (23)d1	Permanent Casing (1.10 m dia.; 10 mm thick)	Meter
400 (23)d2	Permanent Casing (1.10 m dia.; 12 mm thick)	Meter
400 (23)d3	Permanent Casing (1.10 m dia.; 16 mm thick)	Meter
400 (23)e1	Permanent Casing (1.20 m dia.; 10 mm thick)	Meter
400 (23)e2	Permanent Casing (1.20 m dia.; 12 mm thick)	Meter
400 (23)e3	Permanent Casing (1.20 m dia.; 16 mm thick)	Meter
400 (23)f1	Permanent Casing (1.30 m dia.; 10 mm thick)	Meter
400 (23)f2	Permanent Casing (1.30 m dia.; 12 mm thick)	Meter
400 (23)f3	Permanent Casing (1.30 m dia.; 16 mm thick)	Meter
400 (23)g1	Permanent Casing (1.40 m dia.; 10 mm thick)	Meter
400 (23)g2	Permanent Casing (1.40 m dia.; 12 mm thick)	Meter
400 (23)g3	Permanent Casing (1.40 m dia.; 16 mm thick)	Meter
400 (23)h1	Permanent Casing (1.50 m dia.; 10 mm thick)	Meter
400 (23)h2	Permanent Casing (1.50 m dia.; 12 mm thick)	Meter
400 (23)h3	Permanent Casing (1.50 m dia.; 16 mm thick)	Meter
400 (23)i1	Permanent Casing (1.60 m dia.; 12 mm thick)	Meter
400 (23)i2	Permanent Casing (1.60 m dia.; 16 mm thick)	Meter
400 (23)j1	Permanent Casing (1.70 m dia.; 12 mm thick)	Meter
400 (23)j2	Permanent Casing (1.70 m dia.; 16 mm thick)	Meter
400 (23)k1	Permanent Casing (1.80 m dia.; 12 mm thick)	Meter
400 (23)k2	Permanent Casing (1.80 m dia.; 16 mm thick)	Meter
400 (23)l1	Permanent Casing (1.90 m dia.; 12 mm thick)	Meter
400 (23)l2	Permanent Casing (1.90 m dia.; 16 mm thick)	Meter
400 (23)m1	Permanent Casing (2.00 m dia.; 12 mm thick)	Meter
400 (23)m2	Permanent Casing (2.00 m dia.; 16 mm thick)	Meter
400 (23)n1	Permanent Casing (2.10 m dia.; 12 mm thick)	Meter
400 (23)n2	Permanent Casing (2.10 m dia.; 16 mm thick)	Meter
400 (23)o1	Permanent Casing (2.20 m dia.; 12 mm thick)	Meter
400 (23)o2	Permanent Casing (2.20 m dia.; 16 mm thick)	Meter
400 (23)p1	Permanent Casing (2.30 m dia.; 12 mm thick)	Meter
400 (23)p2	Permanent Casing (2.30 m dia.; 16 mm thick)	Meter
400 (23)q1	Permanent Casing (2.40 m dia.; 12 mm thick)	Meter
400 (23)q2	Permanent Casing (2.40 m dia.; 16 mm thick)	Meter

Pay Item Number	Description	Unit of Measurement
400 (23)r1	Permanent Casing (2.50 m dia.; 16 mm thick)	Meter
400 (23)r2	Permanent Casing (2.50 m dia.; 20 mm thick)	Meter
400 (23)s1	Permanent Casing (2.60 m dia.; 16 mm thick)	Meter
400 (23)s2	Permanent Casing (2.60 m dia.; 20 mm thick)	Meter
400 (23)t1	Permanent Casing (2.70 m dia.; 16 mm thick)	Meter
400 (23)t2	Permanent Casing (2.70 m dia.; 20 mm thick)	Meter
400 (23)u1	Permanent Casing (2.80 m dia.; 16 mm thick)	Meter
400 (23)u2	Permanent Casing (2.80 m dia.; 20 mm thick)	Meter
400 (23)v1	Permanent Casing (2.90 m dia.; 16 mm thick)	Meter
400 (23)v2	Permanent Casing (2.90 m dia.; 20 mm thick)	Meter
400 (23)w1	Permanent Casing (3.00 m dia.; 16 mm thick)	Meter
400 (23)w2	Permanent Casing (3.00 m dia.; 20 mm thick)	Meter
400 (23)x1	Permanent Casing (3.50 m dia.; 16 mm thick)	Meter
400 (23)x2	Permanent Casing (3.50 m dia.; 20 mm thick)	Meter
400 (23)y	Permanent Casing (0.60 m dia.; 6 mm thick)	Meter
400 (24)	Permanent Casing	Kilogram
400 (25)	Splicing of RC Piles with Epoxy	Each
400 (26)a	Pile Integrity Testing (Crosshole-Sonic)	Each
400 (26)b	Pile Integrity Testing (Low-Strain)	Each
400 (27)	High-Strain Dynamic Testing (PDA)	Each
400 (34)a	Permanent Casing (Micro Piles), 0.20 m	Kilogram
400 (34)b	Permanent Casing (Micro Piles), 0.25 m	Kilogram
400 (34)c	Permanent Casing (Micro Piles), 0.30 m	Kilogram
400 (35)a1	Steel Pipe Piles, Furnished and Driven, Normal Headroom, Press-In Method (318.5 mm dia. x 10.3 mm thick)	Meter
400 (35)a2	Steel Pipe Piles, Furnished and Driven, Normal Headroom, Press-In Method (800 mm dia. x 8 mm thick)	Meter
400 (35)a3	Steel Pipe Piles, Furnished and Driven, Normal Headroom, Press-In Method (1200 mm dia. x 16 mm thick)	Meter
400 (35)a4	Steel Pipe Piles, Furnished and Driven, Normal Headroom, Press-In Method (1200 mm dia. x 19 mm thick)	Meter
400 (35)b1	Steel Pipe Piles, Furnished and Driven,	Meter

Pay Item Number	Description	Unit of Measurement
	Low Headroom, Press-In Method (318.5 mm dia. x 10.3 mm thick)	
400 (35)b2	Steel Pipe Piles, Furnished and Driven, Low Headroom, Press-In Method (800 mm dia. x 8 mm thick)	Meter
400 (35)b3	Steel Pipe Piles, Furnished and Driven, Low Headroom, Press-In Method (1200 mm dia. x 16 mm thick)	Meter
400 (35)b4	Steel Pipe Piles, Furnished and Driven, Low Headroom, Press-In Method (1200 mm dia. x 19 mm thick)	Meter
400 (36)a1	Steel Pipe Sheet Piles, Furnished and Driven, (800 mm dia. x 8 mm thick)	Meter
400 (36)a2	Steel Pipe Sheet Piles, Furnished and Driven, (1200 mm dia. x 19 mm thick)	Meter
400 (36)a3	Steel Pipe Sheet Piles, Furnished and Driven, (800 mm dia. x 9 mm thick)	Meter
400 (37)a	Micro Piles, 0.20 m	Meter
400 (37)b	Micro Piles, 0.25 m	Meter
400 (37)c	Micro Piles, 0.30 m	Meter
400 (38)a	**Test Pile, Furnished, 305 mm x 305 mm**	**Meter**
400 (38)b	**Test Pile, Furnished, 360.7 mm x 378.5 mm**	**Meter**
400 (38)c	**Test Pile, Furnished, 400 mm x 400 mm**	**Meter**
400 (38)d	**Test Pile, Furnished, 450 mm x 450 mm**	**Meter**
400 (39)a	**Test Pile, Driven, 305 mm x 305 mm**	**Meter**
400 (39)b	**Test Pile, Driven, 360.7 mm x 378.5 mm**	**Meter**
400 (39)c	**Test Pile, Driven, 400 mm x 400 mm**	**Meter**
400 (39)d	**Test Pile, Driven, 450 mm x 450 mm**	**Meter**