

SECTION 31 62 13.20

PRECAST/PRESTRESSED CONCRETE PILES  
**08/09**

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

JAPANESE STANDARDS ASSOCIATION (JSA)

JIS A 1108	(2018) Method of Test for Compressive Strength of Concrete
JIS A 1132	(2014) Method of Making and Curing Concrete Specimens
JIS A 5373	(2016) Precast Prestressed Concrete Products
JIS A 7201	(2009) Standard Practice for Execution of Spun Concrete Piles

JAPANESE GEOTECHNICAL SOCIETY (JGS)

JGS 1811	(2002) Method for Static Axial Compressive Load Test of Single Piles
JGS 1813	(2002) Method for Static Axial Tensile Load Test of Single Piles
JGS 1816	(2002) Method for Dynamic Load Test of Single Piles
JGS 1831	(2010) Method for Lateral Load Test of Piles

MINISTRY OF THE ENVIRONMENT GOVERNMENT OF JAPAN (MOE)

Notification No.46	(2001) Environmental Quality Standards for Soil Contamination
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[1.2 LUMP SUM PAYMENT

Base bids upon providing the number, size, capacity, and length of piles as indicated on the [drawings.] [following Table I:

Table 1

<u>Location</u>	<u>Number</u>	<u>Size</u>	<u>Capacity</u>	<u>Length (tip to cut-off)</u>
]				

The contract price for piling shall include the cost of all necessary equipment, tools, material, labor, and supervision required to: deliver, handle, install, cut-off, dispose of any cut-offs, and meet the applicable contract requirements. The contract price also includes mobilization, pre-drilling, and redriving heaved piles. If, in redriving, it is found that any pile is not of sufficient length to provide the capacity specified, notify the Contracting Officer, who reserves the right to increase or decrease the total length of piles to be furnished and installed by changing the pile locations or elevations, requiring the installation of additional piles, or directing the omission of piles from the requirements shown and specified. Should total number of piles or number of each length vary from that specified as the basis for bidding, an adjustment in the contract price or time for completion, or both, will be made in accordance with the contract documents. Payment for piles will be based on successfully installing piles to both the minimum tip elevation and satisfying the acceptance criteria identified herein. No additional payment will be made for: damaged, rejected, or misplaced piles; withdrawn piles; any portion of a pile remaining above the cut-off elevation; backdriving; cutting off piles; splicing; build-ups; any cut-off length of piles; or other excesses beyond the assumed pile length indicated for which the Contractor is responsible.

#### 1.2.1 Acceptance Criteria

Safe design capacity for piles is [\_\_\_\_\_] KiloNewtons (KN). Piles shall be driven to a minimum depth of [\_\_\_\_\_] feet below cut-off elevation, and to such additional depth as required to obtain a bearing capacity of not less than [\_\_\_\_\_] KN.

The following formulas are presented only as a guide to aid in establishing the controlling penetration per blow, which, together with the minimum depth of penetration will serve to determine the required minimum depth of penetration of each individual pile:

$$R = (2WH) / (5s \text{ plus } 0.1)$$

Where:

R - is the approximate allowable pile load in KN

W - is the weight of the hammer in KN

H - is the height of fall of hammer in m

S - is the average of penetration for the last ten blows in m

#### ][1.3 MEASUREMENT AND PAYMENT

[ For unit price bid, see SF 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items." ] [Section 00 22 13.00 20 SUPPLEMENTARY INSTRUCTIONS TO OFFERORS.

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Requirements of FAR 52.211-18 Variation in Estimated Quantity shall not apply to payment for piling. Each pile and test pile acceptably provided will be paid for at the bid unit price per unit length, which price shall include items incidental to furnishing and driving the piles including mobilization and demobilization,[ jetting][ predrilling][ probing], redriving uplifted piles, [an additional 1.5 m in furnished length for any test pile not driven beyond estimated pile length,] and cutting off piles at the cut-off elevation. [The cost for additional length for the test piles shall be included in the total unit price cost for the job.] Payment will be made for job [and test piles] at the bid unit price for the length of pile, from tip to final cut-off, actually provided,

excluding buildups and splices directed by the Contracting Officer to be made. Should the actual cumulative pile length driven (tip to cut-off) vary more than 25 percent from the total pile length specified as a basis for bidding, at the direction of the Contracting Officer, the unit price per unit length will be adjusted in accordance with provisions of FAR 52.236-2 Differing Site Conditions.

#### 1.3.1 Pile Cut-Off

Where the tip to cut-off length is less than that calculated from the results of test pile driving [and load testing], payment for that portion of pile not driven will be made at 75 percent of the bid unit price and no other payment will be made for making the cut-off.

#### 1.3.2 Pile Build-ups

Payment for buildups will be made at 125 percent of the bid unit price.

#### 1.3.3 Pile Splices

Payment for splices, as specified, will be made at 25 times the unit price per 300 mm bid for 250 mm piling, 22 times the unit price per 300 mm bid for 300 mm piling, and 18 times the unit price per 300 mm bid for all other piling.

#### 1.3.4 Pulled Piles

Piles required to be pulled at no fault of the Contractor will be paid for at the bid unit price for furnishing and driving the pile in its original position plus 25 percent of the amount to cover the cost of pulling. Such pulled piles when redriven will be paid for at 25 percent of the bid unit price for the length driven.

#### [1.3.5 Pile Load Test

Payment for each acceptably provided complete test loading of a single pile will be made at the contract unit price per test, which price shall include furnishing, placing, and removing testing equipment, and placing and removing test loads. At the direction of the Contracting Officer, load tests may be waived at a credit to the Government of the unit price bid therefore.

### ]]1.4 UNIT PRICES

#### 1.4.1 Furnishing and Delivering Prestressed Concrete Piles

##### 1.4.1.1 Payment

Payment will be made for costs associated with furnishing and delivering the required lengths of permanent prestressed concrete piles, [including H-pile extensions,] which includes costs of furnishing and delivering piles to the work site. No payment will be made for the driving head or lengths of piles exceeding required lengths. No payment will be made for piles damaged during delivery, storage, or handling to the extent that they are rendered unsuitable for the work, in the opinion of the Contracting Officer.

1.4.1.2 Measurement

Furnishing and delivering permanent prestressed concrete piles will be measured for payment by the linear meter of piles required below the cut-off elevation as [determined by the Contracting Officer and furnished to the Contractor] [indicated].

1.4.1.3 Unit of Measure

Unit of measure: linear meter.

1.4.2 Driving Prestressed Concrete Piles

1.4.2.1 Payment

Payment will be made for costs associated with driving permanent prestressed concrete piles, which includes costs of handling, driving, [and splicing of piles,] [performing dynamic testing, interpreting data and submitting reports,] measuring heave, redriving heaved piles, removal of [build-ups] driving heads or cutting off piles at the cut-off elevation and removing from the work site, compiling and submitting pile driving records, backfilling voids around piles, and any other items incidental to driving piles to the required elevation.

1.4.2.2 Measurement

Permanent prestressed concrete piles will be measured for payment for driving on the basis of lengths, to the nearest hundredth of a linear meter, along the axis of each pile acceptably in place below the cut-off elevation shown.

1.4.2.3 Unit of Measure

Unit of measure: linear meter.

1.4.3 Pulled Prestressed Concrete Piles

1.4.3.1 Payment

Payment will be made for costs associated with piles pulled at the direction of the Contracting Officer and found to be undamaged. The cost of furnishing and delivering pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Furnishing and Delivering Prestressed Concrete Piles". The cost of driving pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". The cost of pulling pulled and undamaged piles will be paid for at twice the applicable contract unit price for payment item "Driving Prestressed Concrete Piles", which includes backfilling any remaining void. The cost of redriving pulled and undamaged piles will be paid for at the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of piles, including pile driving points, pulled and found to be damaged and backfilling voids. New piles replacing damaged piles will be paid for at the applicable contract unit price for payment items "Furnishing and Delivering Prestressed Concrete Piles" and "Driving Prestressed Concrete Piles".

1.4.3.2 Measurement

Furnishing and delivering pulled and undamaged permanent prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph FURNISH AND DELIVER PRESTRESSED CONCRETE PILES. Pulling undamaged prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. Redriving pulled undamaged prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. New piles replacing damaged piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraphs FURNISH AND DELIVER PRESTRESSED CONCRETE PILES and DRIVING PRESTRESSED CONCRETE PILES.

1.4.3.3 Unit of Measure

Unit of measure: linear meter.

1.4.4 [Prestressed Concrete Pile Driving Tests]

1.4.4.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of driven test piles, [including [pile driving points] [and] [splices]]; conducting pile driving tests; backfilling voids around piles; compiling pile driving test records [; performing dynamic testing; interpreting data; and submitting reports].

1.4.4.2 Measurement

Prestressed concrete pile driving tests will be measured for payment on the basis of the applicable contract unit price per pile driving test.

1.4.4.3 Unit of Measure

Unit of measure: each.

1.4.5 [Prestressed Concrete Piles for Load Tests]

1.4.5.1 Payment

Payment will be made for costs associated with furnishing, delivering, driving, pulling, and disposing of load test piles [including [pile driving points] [and] [splices]]; backfilling voids around piles; compiling pile driving records [; furnishing, fabricating, and mounting of strain rods and protective assembly] [; furnishing, fabricating, and mounting of inclinometer and inclinometer protective assembly] [; performing dynamic testing; interpreting data; and submitting reports]. No additional payment will be made for load test piles incorporated in the permanent work other than as provided.

1.4.5.2 Measurement

Prestressed concrete piles for load tests will be measured for payment on the basis of the applicable contract unit price per load test pile.

1.4.5.3 Unit of Measure

Unit of measure: each.

1.4.6 [Prestressed Concrete Pile Compressive Load Tests]

1.4.6.1 Payment

Payment will be made for costs associated with prestressed concrete pile compressive load tests, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile compressive load tests.

1.4.6.2 Measurement

Prestressed concrete pile compressive load tests will be measured for payment on the basis of the applicable contract unit price per load test.

1.4.6.3 Unit of Measure

Unit of measure: each.

1.4.7 [Prestressed Concrete Pile Tensile Load Tests]

1.4.7.1 Payment

Payment will be made for costs associated with prestressed concrete pile tensile load tests, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing strain rods; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile tensile load tests.

1.4.7.2 Measurement

Prestressed concrete pile tensile load tests will be measured for payment on the basis of the applicable contract unit price per number of tensile load test.

1.4.7.3 Unit of Measure

Unit of measure: each.

1.4.8 [Prestressed Concrete Pile Lateral Load Tests]

1.4.8.1 Payment

Payment will be made for costs associated with prestressed concrete pile lateral load tests, including material and labor for fabricating and furnishing load frames; calibrating load cells and hydraulic jacks; furnishing specified test equipment; installing inclinometers; placing and removing test loads and test equipment; recording, reducing, and submitting test data; and compiling and submitting pile load test reports. No payment will be made for rejected pile lateral load tests.

1.4.8.2 Measurement

Prestressed concrete pile lateral load tests will be measured for payment

on the basis of the applicable contract unit price per lateral load test.

#### 1.4.8.3 Unit of Measure

Unit of measure: each.

#### 1.4.9 [Pulled Load Test Prestressed Concrete Piles]

##### 1.4.9.1 Payment

Payment will be made for costs associated with load test prestressed concrete piles pulled prior to load testing at the direction of the Contracting Officer and found to be undamaged. The cost of furnishing, delivering, driving, and pulling undamaged load test piles will be paid for at the applicable contract unit price for payment item "Prestressed Concrete Piles for Load Tests". The cost of pulling undamaged load test piles the second time after redriving and testing will be paid for at twice the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". The cost of redriving pulled undamaged load test piles will be paid for at the applicable contract unit price for payment item "Driving Prestressed Concrete Piles". No payment will be made for furnishing, delivering, driving, pulling, and disposing of load test piles pulled at the direction of the Contracting Officer and found to be damaged. New load test piles replacing damaged piles will be paid for at the applicable contract unit price for payment item "Prestressed Concrete Piles for Load Tests".

##### 1.4.9.2 Measurement

Pulled undamaged load test prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph PRESTRESSED CONCRETE PILES FOR LOAD TESTS. Pulling undamaged load test prestressed concrete piles the second time after redriving and testing will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. Redriving pulled undamaged prestressed concrete piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph DRIVING PRESTRESSED CONCRETE PILES. New load test prestressed concrete piles replacing damaged piles will be measured for payment as specified in paragraph UNIT PRICES, subparagraph PRESTRESSED CONCRETE PILES FOR LOAD TESTS.

##### 1.4.9.3 Unit of Measure

Unit of measure: as specified in paragraph UNIT PRICES, subparagraphs DRIVING PRESTRESSED CONCRETE PILES and PRESTRESSED CONCRETE PILES FOR LOAD TESTS, respectfully.

#### 1.4.10 [Prestressed Concrete Pile Splices]

##### 1.4.10.1 Payment

Payment will be made for costs associated with prestressed concrete pile splices, including all plant, labor, and material required to make the splice.

##### 1.4.10.2 Measurement

Prestressed concrete pile splices will be measured for payment on the basis of the applicable contract unit price per pile splice.

#### 1.4.10.3 Unit of Measure

Unit of measure: each.

#### ]1.5 PILE REQUIREMENTS

Provide precast prestressed concrete piles per JIS A 5373. Production of piles shall be in accordance with JIS A 5373. The Contractor's Geotechnical Consultant will determine and list "calculated" tip elevations or driving resistance for each pile[ from test pile data]. This information will be given to the Contractor no later than 7 days from receipt of complete test data. Use this list as the basis for ordering the piles. Do not order piles until list is provided by the Contractor's Geotechnical Consultant. [Test piles shall be [1.5] [\_\_\_\_\_] meter longer than the bid length.]

#### 1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

##### SD-01 Preconstruction Submittals

Installation Procedures; G[, [\_\_\_\_\_]]

[ Geotechnical Consultant Documentation; G[, [\_\_\_\_\_]]

][ Wave Equation Analysis; G[, [\_\_\_\_\_]]

] Order List; G[, [\_\_\_\_\_]]

Precasting manufacturer's quality control procedures; G[, [\_\_\_\_\_]]

Provide instructions and procedures for the processes of Dynamic Pile Testing, Inspection and Monitoring of piles during installation and testing.

##### SD-02 Shop Drawings

Piles; G[, [\_\_\_\_\_]]

##### SD-03 Product Data

Pile Driving Equipment; G[, [\_\_\_\_\_]]

Submit descriptions of pile driving equipment, including hammers, power packs, driving helmets, cap blocks, pile cushions, leads, extractors, jetting equipment, and preboring equipment at least 30 days prior to commencement of work.

##### SD-05 Design Data

Concrete mix design; G[, [\_\_\_\_\_]]

Submit a concrete mix design before concrete is placed, for each type of concrete used for the piles.

Cement milk mix design; G

SD-06 Test Reports

[ Silica Fume[; G][; G, [\_\_\_\_\_]]]

Concrete Compressive Strength; G[, [\_\_\_\_\_]]

Cement milk Compressive Strength; G

[ Test piles; G[, [\_\_\_\_\_]]]

[ Load tests; G[, [\_\_\_\_\_]]]

Submit concrete cylinder compressive strength test results.  
[Submit test pile records] [and] [load test data].

[ Dynamic Pile Analysis; G[, [\_\_\_\_\_]]]

Submit a summary report of dynamic test results for test piles within [7][\_\_\_\_\_] calendar days of completing field work. [For permanent piles, submit a field summary report within one (1) day of testing. Submit a typed report summarizing the results of dynamic testing of permanent piles on a monthly basis.]

SD-11 Closeout Submittals

Pile records; G[, [\_\_\_\_\_]]

Submit pile [and test pile] records.[ Submit load test data and results.]

1.7 QUALITY ASSURANCE

1.7.1 Piles

Prepare in accordance with JIS A 5373 and JIS A 7201. Indicate placement of reinforcement including tendons. Indicate location of special embedded or attached lifting devices, employment of pick-up points, support points other than pick-up points, and any other methods of pick-up. [Provide certification of a Professional Engineer registered in any jurisdiction of the U. S. or its territories or Japan, that layout and details of reinforcement and tendons conform with that shown on the structural design drawings.]

1.7.2 Quality Control Procedures

Submit the precasting manufacturer's quality control procedures and inspection records established in accordance with JIS A 5373.

1.7.3 Installation Procedures

- a. Submit information on the type of equipment proposed to be used, proposed methods of operation, pile driving plan including proposed

sequence of driving, and details of all pile driving equipment and accessories.

- [ b. Provide details of pile driving equipment and a Wave Equation Analysis of pile drivability for selection of the hammer along with a statement of driving procedures. The Wave Equation Analysis is to be completed by the Contractor's Geotechnical Consultant for each test pile location where different subsurface conditions exist and is to include the following information pertaining to the proposed pile driving equipment:
  - (1) Complete Pile and Driving Equipment Data Form, (which can be downloaded at: <http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf>) for each proposed pile hammer and pile type combination.
  - (2) Copies of computer input and output sheets and graphs showing soil resistance versus blow count as well as maximum tension and compression stresses versus blow count. Analysis shall be run at the estimated tip elevation as well as other required elevations to define maximum stress levels in the pile during driving.
- c. Provide detailed procedures for conducting the dynamic pile load test and equipment to be used for conducting the load test. The detailed description shall explain how specific information of pile performance will be evaluated.

#### ][1.7.4 Geotechnical Consultant Documentation

The services of an independent, Registered Professional Geotechnical Engineer, experienced in soil mechanics and Pile Dynamic Analysis, shall be hired by the Contractor to observe test pile installation and job pile installation as specified herein. The Geotechnical Consultant shall be independent of the Contractor and shall have no employee of employer relationship which could constitute a conflict of interest.

#### ][1.7.5 Concrete Mix Design

Certify, using a Government-approved independent commercial testing laboratory, that proportioning of mix is in accordance with JIS A 5373 for specified strength and is based on aggregate data which has been determined by laboratory tests during last twelve months. Submit a complete list of materials including type; brand; source and amount of cement, fly ash, pozzolan, ground slag, and admixtures; and applicable reference specifications. Submit additional data regarding concrete aggregates if the source of aggregate changes. Submittal shall clearly indicate where each mix design will be used when more than one mix design is submitted.

#### [1.7.6 Load Test Supporting Data

Submit Jack calibration records, a testing arrangement description and diagram, and the proposed loading sequence.

#### ][1.7.7 Silica Fume Manufacturer's Representative

Provide statement that the manufacturer's representative will be present at plant to ensure proper mix, including high range water reducer (HRWR), and batching methods.

## 1.8 DELIVERY, STORAGE, AND HANDLING

Piles shall be stored, handled, and transported in accordance with JIS A 5373 except as follows. Methods used for handling and storage of piles shall be such that the piles are not subjected to excessive bending stress, cracking, spalling, or other damage.

### 1.8.1 Damaged Piles

The Contractor shall inspect each pile for sweep and structural damage such as cracking and spalling before transporting them to the project site and immediately prior to placement in the driving leads. Any unusual cracks (cracks other than crazing, surface drying, shrinkage cracks and end cracks) shall be brought to the attention of the Contracting Officer. Piles which are damaged during delivery, storage, or handling to the extent they are rendered unsuitable for the work, in the opinion of the Contracting Officer, shall be rejected and removed from the project site, or may be repaired, if approved, at no cost to the Government.

#### 1.8.1.1 Repairable Cracks

Piles with cracks equal to or greater than 0.15 mm but less than 1.5 mm shall be rejected or repaired. As an alternate to pile rejection, the Contractor may submit a proposal to repair deficient piles, which shall be restored prior to driving to provide its required design capacity, perform its intended function in the structure, and take into consideration long term durability in corrosive environment.

#### 1.8.1.2 Non-Repairable Cracks

Piles with cracks equal to or greater than 1.5 mm shall be rejected.

### 1.8.2 Pile Sweep

Sweep shall be limited to 3 mm per 3 M over the length of the pile. Piles having excessive sweep shall be rejected.

## PART 2 PRODUCTS

### 2.1 MATERIALS

Materials used for manufacturing precast/prestressed concrete piles shall comply with JIS A 5373.

### 2.2 CONCRETE MIX DESIGN

Concrete shall have a minimum compressive strength of 80 MPa at 28 days and a maximum size aggregate of [\_\_\_\_] mm. Concrete shall be air entrained with a minimum of 4.5 percent and a maximum of 7.5 percent. Mix shall contain fly ash, ground iron blast furnace slag or silica fume to meet the requirements specified herein to mitigate Alkali-Silica Reactivity (ASR). [ For marine exposure, ensure a dense concrete free of shrinkage cracks, with a minimum degree of permeability. The maximum water cement ratio shall be 0.40 . ]

## 2.3 FABRICATION

### 2.3.1 Formwork

Formwork and dimensional tolerances shall be in accordance with JIS A 5373 , and as specified herein. Provide forms of metal, braced and stiffened against deformation, accurately constructed, watertight, and supported on unyielding casting beds. Forms shall permit movement of pile without damage during release of prestressing force. Form precast dowel holes with galvanized flexible metal conduit. [Inside forms or void tubes not to be grouted may be treated cardboard, plywood, or other material.]

### 2.3.2 Pretensioning

Pretensioning shall be performed in accordance with JIS A 5373, and as specified herein. Use gage calibrated within last 6 months by a laboratory approved by Contracting Officer. Provide means for measuring elongation of steel to nearest 3 mm. Give tensioning steel a uniform prestress prior to being brought to design prestress. Induce same initial prestress in each unit when several units of prestressing steel in a pile are stretched simultaneously.

### 2.3.3 Casting

#### 2.3.3.1 Conveying

Convey concrete to formwork in accordance with JIS A 5373, and as specified herein. Clean conveying equipment thoroughly before each run. During placing, make any free vertical drop of the concrete less than 0.91 m. Remove concrete which has segregated in conveying or placing.

#### 2.3.3.2 Placing and Casting

Perform concrete casting within 3 days after pretensioning steel; however, do not deposit concrete in forms until placement of reinforcement and anchorages has been inspected and approved by pile manufacturer's quality control representative. Produce each pile of dense concrete straight with smooth surfaces with reinforcement retained in its proper position during fabrication. Use vibrator with heads smaller than the minimum distance between steel for pretensioning. Make surface of pile ends perpendicular to axis of pile. Chamfer, [a minimum of 19 mm,] [[\_\_\_\_\_] mm,] [between 19 mm and 31 mm,] ends of piles and corners of square piles.

### 2.3.4 Curing of Piles

Cure piles using moist or accelerated curing. Curing of piles shall be in accordance with JIS A 5373 except as follows.

## 2.4 PRODUCT QUALITY CONTROL

Where piling is manufactured in a plant with an established quality control program as attested to by a current certification in the PCI "Certification Program for Quality Control" perform product quality control in accordance with JIS A 5373. Where piling is manufactured by specialists or in plants not currently enrolled in the PCI "Certification Program for Quality Control," set-up a product quality control system in accordance with JIS A 5373 and perform concrete and aggregate quality control testing using an independent commercial testing laboratory approved by the Contracting Officer in accordance with the following.

#### 2.4.1 Aggregate Tests

Aggregate tests shall comply with JIS A 5373.

#### 2.4.2 Slump and Strength Tests

Slump and compressive strength tests shall comply with JIS A 5373.

#### 2.4.3 Changes in Proportions

If, after evaluation of strength test results, compressive strength is less than specified compressive strength, make adjustments in proportions and water content and changes in temperature, moisture, and curing procedures as necessary to secure specified strength. Submit changes in mix design to Contracting Officer in writing.

### PART 3 EXECUTION

#### 3.1 PILE DRIVING EQUIPMENT

##### 3.1.1 Pile Hammers

Furnish a hammer capable of developing the indicated ultimate pile capacity considering hammer impact velocity; ram weight; stiffness of hammer and pile cushions; cross section, length, and total weight of pile; and character of subsurface material to be encountered. [Use the same pile hammer, operating at the same rate and in the same manner, as that used for driving test piles.] Obtain required driving energy of hammer, except for diesel hammers, by use of a heavy ram and a short stroke with low impact velocity. At final driving, operate pile hammer in accordance with manufacturer's recommendation for driving either end bearing piles or friction piles. At final driving, operate diesel powered hammers at rate recommended by manufacturer for hard driving. Maintain pressure at steam or air hammer so that: (1) for double-acting hammer, the number of blows per minute during and at completion of driving of a pile is equal approximately to that at which hammer is rated; (2) for single-acting hammer, there is a full upward stroke of the ram; and (3) for differential type hammer, there is a slight rise of hammer base during each upward stroke.

##### 3.1.2 Driving Helmets and Cushion Blocks

###### 3.1.2.1 Driving Helmets or Caps and Pile Cushions

Use a steel driving helmet or cap including a pile cushion between top of pile and driving helmet or cap to prevent impact damage to pile. Use a driving helmet or cap and pile cushion combination capable of protecting pile head, minimizing energy absorption and dissipation, and transmitting hammer energy uniformly over top of pile. Provide driving helmet or cap that fits sufficiently loose around top of pile so that pile may be free to rotate without binding within driving helmet. [During test pile installation, demonstrate to satisfaction of Contracting Officer that equipment to be used on project performs specified function.] Use pile cushion of solid wood or of laminated construction using plywood, softwood or hardwood boards with grain parallel to end of pile. Provide pile cushion with thickness of [\_\_\_\_][75] mm minimum and the thickness shall be increased so as to be suitable for the size and length of pile, character of the sub-surface material to be encountered, hammer

characteristics, and the required driving resistance. Replace pile cushion at the start of driving of each pile and when it becomes highly compressed, charred or burned, or has become spongy or deteriorated in any manner. Show details of driving helmets, capblocks, and pile cushions. Submit 2 weeks prior to [test] pile installation.

### 3.1.2.2 Hammer Cushion or Capblock

Use a hammer cushion or capblock between driving helmet or cap and hammer ram consisting of [a solid hardwood block with grain parallel to the pile axis and enclosed in a close-fitting steel housing] [aluminum and micarta (or equal) discs stacked alternately in a steel housing or a suitable polymer designed for this specific purpose as indicated by the hammer manufacturer]. Use steel plates at top and bottom of capblock. [Replace wood capblock when it becomes highly compressed, charred or burned or becomes spongy or deteriorated in any manner]. [Replace aluminum, micarta or polymer discs that have become damaged, split or deteriorated in any manner]. [Do not replace wood capblock during final driving of any pile.] Do not use small wood blocks, wood chips, rope or other materials that permit excessive loss of hammer energy.

## 3.2 PRELIMINARY WORK

### [3.2.1 Wave Equation Analysis of Pile Drivability

- a. Prior to driving any pile, the Contractor shall submit a pile Wave Equation Analysis, performed by his Geotechnical Consultant, for each size pile and distinct subsurface profile condition. These analyses shall take into account the proposed hammer assembly, pile cap block and cushion characteristics, the pile properties and estimated lengths and the soil properties anticipated to be encountered throughout the installed pile length based on static capacity analysis with consideration of driving gain/loss factors. Only one specific model of pile hammer may be used for each pile type and capacity.
- b. The Wave Equation Analysis shall demonstrate that the piles will not be damaged during driving, shall indicate that the driving stresses will be maintained within the limits below and indicate the blow count necessary to achieve the required ultimate static pile capacities.

#### Allowable Driving Stresses

##### Steel Piles

Compression - 0.9 fy (MPa)  
Tension - 0.9 fy (MPa)

Where fy is yield strength of steel

##### Concrete

Compression - 0.85f'c minus UPL (MPa)  
Tension - (0.25 times (the square root of f'c)) plus UPL (MPa)

f'c is compressive strength of concrete (MPa)  
UPL = Unit Prestress after Losses (MPa)  
(Obtain values from pile manufacturer)

- c. Upon completion of the dynamic and static testing programs outlined in this specification section, a refined Wave Equation Analysis shall be performed taking into consideration the evaluated capacities, gain/loss factors and recommended production pile lengths. Production pile driving criteria shall be developed based on the results of the refined Wave Equation Evaluations.
- d. All pile driving equipment furnished by the Contractor shall be subject to the approval of the Contractor's Geotechnical Consultant. Complete the attached pile and driving equipment data form, including hammer information, in full as part of the submittal of the results of the Wave Equation Analyses.
- e. The cost of performing the Wave Equation Analyses shall be paid for by the Contractor and included in the base bid.

#### 3.2.2 Order List

The Contractor shall submit to the Contracting Officer for approval, an itemized list for piles prior to placing the order with the supplier. The list shall indicate the pile lengths required at each location as shown on the plans and the corresponding ordered length of each pile. [ Load testing and refined wave equation analysis shall be completed prior to submission of an order list.]

#### 3.2.3 Pile Length Markings

The Contractor shall mark each pile prior to driving with horizontal lines at 1 m intervals, and the number of feet from pile tip at 1 m intervals.

### 3.3 PILE DRIVING

#### 3.3.1 Driving Piles

Notify Contracting Officer 10 days prior to driving of [test] piles [and load test]. [Foundation excavation shall be stopped at 300 mm above foundation grade before piles are driven. When pile driving is completed, excavation shall be completed to lines and grade shown. ]Piles may be driven when the specified 28-day concrete strength has been achieved but not less than 7 days after casting. Drive piles to [or below "calculated"] [indicated] tip elevation [to reach a driving resistance established by the wave equation analyses (WEAP) in accordance with the schedule which the Government Contractor's Geotechnical Consultant will prepare from the test-pile driving data]. During initial driving and until pile tip has penetrated beyond layers of very soft soil [or below bottom of predrilled or prejetted holes], use a reduced driving energy of the hammer as required to prevent pile damage. Refusal criteria shall be established by the Contracting Officer. If a pile fails to reach ["calculated"] [indicated] tip elevation, [or if a pile reaches ["calculated"] tip elevation without reaching required driving resistance,] notify Contracting Officer and perform corrective measures as directed. Provide hearing protection when noise levels exceed 140 dB. Piles or pile sections shall not be handled or moved in any manner that would result in cracking or permanent damage to the concrete or to the grout surrounding the prestressing cables. Piles may be driven without pile guides or leads providing a hammer guide frame is used to keep the pile and hammer in alignment.

### 3.3.2 Protection of Piles

Take care to avoid damage to piles during handling, placing pile in leads, and during pile driving operations. Support piles laterally during driving, but allow rotation in leads. [Where pile or projecting reinforcement orientation is essential, take precautionary measures to maintain the orientation during driving. ][Take special care in supporting battered piles to prevent excessive bending stresses in pile.] Square top of pile to longitudinal axis of pile. Maintain axial alignment of pile hammer with that of the pile. If the Contractor elects to use a pile head with projecting strands or mild steel reinforcement, prevent direct impact forces from being transmitted through the reinforcement, by using a special driving head.

### 3.3.3 Tolerances in Driving

Drive piles with a variation of not more than 2 percent from vertical for plumb piles or more than 4 percent from required angle for batter piles. Maintain and check axial alignment of pile and leads at all times. If subsurface conditions cause pile drifting beyond allowable axial alignment tolerance, notify Contracting Officer and perform corrective measures as directed. Place butts within 100 mm of location indicated. [Manipulation of piles within specified tolerances [will not be permitted.][will be permitted, to a maximum of 1 1/2-percent of their exposed length above ground surface or mudline.]] In addition to specified tolerances, maintain a location to provide a clear distance of at least 125 mm from butt to edge of pile cap. If clear distance can not be maintained, then notify Contracting Officer. Check each pile for heave. Redrive heaved piles to required point elevation.

### 3.3.4 Rejected Piles

Piles damaged or impaired for use during handling or driving, mislocated, or driven out of alignment beyond the maximum tolerance shall be withdrawn and replaced by new piles or shall be cut-off and abandoned and new piles driven as directed. Excess cut-off from piles and unacceptable piles shall be removed from the work site. All work in connection with withdrawing and removing rejected piles from the site shall be done at no additional cost to the Government.

### 3.3.5 Jetting of Piles

Water jets will[ not] be permitted.[ Jetting [may] [shall] be used to assist driving piles through strata that cannot be penetrated practicably by use of the hammer alone. [Driving shall be restricted to a static weight while water is being injected to prevent inducing tensile stresses in the piles which damage the concrete.] After the penetration of the strata requiring jetting has been accomplished, jetting shall be discontinued and hammer driving shall be resumed.][ Discontinue jetting when the pile tip is approximately 1.5 m above the [calculated] [indicated] pile tip elevation. Drive pile the final 1.5 m of penetration.][Adequate measures shall be taken for collecting and disposing of runoff water.][ Jetting method and equipment shall be approved by the Contracting Officer prior to commencing jetting operation.] Before starting final driving, firmly seat piles in place by application of a number of reduced energy hammer blows.[Measures, including use of a silt curtain, shall be employed to contain turbid water created by jetting piles.]

### 3.3.6 Predrilling of Piles

Predrilling to remove soil or other material representing the bulk of the volume of the pile to be driven[ will[ not] be permitted][ shall be provided]. [The diameter of the hole should not exceed two-thirds the width of the pile.][Predrill only to a depth of [\_\_\_\_\_] meters below cut-off elevation prior to setting piles.][Discontinue drilling when the pile tip is approximately 1.5 m above the [calculated] [indicated] pile tip elevation. Drive pile the final 1.5 m of penetration.]

### 3.3.7 Splices

[ Splicing of piles is not permitted.] [Make splices as indicated. Splices shall be capable of developing the full strength of the member in compression, tension, shear, and bending. Detail drawings of splices and design calculations demonstrating the strength of the splice shall be submitted for approval.

### ]3.3.8 Build-Ups

Where required, pile section may be extended to cut-off elevation by means of a cast-in-place reinforced concrete build-up or by adding a new pile segment with same properties of the below pile. Make build-up in accordance with JIS A 5373. Construct build-ups made after completion of driving in accordance with detail, "Build-Up Without Driving." Make build-ups to be driven in accordance with detail "Build-Up With Driving." Have details of means for protecting joints by a suitable mortar or epoxy approved by Contracting Officer. Where build-ups are exposed to water, protect cast-in-place section from water during curing period. Concrete in build-up shall have a minimum compressive strength of [\_\_\_\_\_] MPa. Build-ups will not be permitted on more than [\_\_\_\_\_] percent of total number of piles. If this percent figure is exceeded, or if in the judgment of the Contracting Officer, the clustered location of build-ups is undesirable, withdraw piles of insufficient length and replace with longer piles. Payment for such withdrawal and replacement will be made as an adjustment to the contract price.

### 3.3.9 Pile Cut-Off

Cut-off piles with a smooth level cut using pneumatic tools, sawing, or other suitable methods approved by Contracting Officer. Use of explosives for cutting is not permitted. Cut-off sections of piles shall be removed from the site upon completion of the work.

## 3.4 FIELD QUALITY CONTROL

### 3.4.1 Test Piles

[ Use test piles of type, and drive as specified for piling elsewhere in this section. ][Order test piles [\_\_\_\_\_] meters longer in length than production piles. The additional test pile length shall be driven only at the direction of the Contracting Officer. ]The Contractor's Geotechnical Consultant will use test pile data to determine "calculated" pile tip elevation or necessary driving resistance. Drive test piles [at the locations indicated] [in vicinity of soil boring test holes Nos. [\_\_\_\_\_,] [\_\_\_\_\_,] and [\_\_\_\_\_]]. Drive test piles to [indicated tip elevation] [indicated bidding lengths]. Use test piles, if located properly and offering adequate driving resistance in finished work. [Pre-drilling or jetting is permitted only when test piles clearly establish validity of

its use, or as directed by the Contracting Officer. ] [A pile dynamic analyzer shall be provided and operated as specified in paragraph DYNAMIC PILE ANALYSIS during the driving of each test pile. Modify driving as required based upon recommendation of Contractor's Geotechnical Consultant and approval of the Contracting Officer.

] [3.4.2 Dynamic Pile Analysis

The purpose of dynamic testing is to provide supplemental information for evaluating pile hammer performance, driving stresses, and bearing capacities. Dynamic testing shall be conducted during the entire time piles are initially driven or redriven and during pile restrike testing. Use test piles of type as specified elsewhere in this section. Equipment to obtain dynamic measurements, record, reduce and display its data shall be furnished and meet the requirement of JGS 1816. The equipment shall have been calibrated within 12 months thereafter throughout the contract duration. Drive test piles at the locations indicated. The contractor shall employ an independent inspection firm, hereinafter referred to as the "Contractor's Geotechnical Consultant", experienced in the pile driving process, monitoring of test pile installation, and in the use of the Pile Driving Analyzer and its related equipment. Dynamic pile analysis shall be performed as follows:

a. Each dynamic pile analysis shall be performed in two steps. The first step is to check the hammer, pile and soil performance, and to determine the suitability of the proposed hammer for the size, length and type of pile being installed for the soil types encountered as the piles are driven. This initial monitoring shall determine whether pre-augering or jetting is appropriate, efficiency of the hammer relative to specified efficiency, effectiveness of cushion, level of compressive and tensile stress in pile and extent/location of any pile damage caused by the initial driving. With each blow of the pile the information listed below shall be electronically recorded and analyzed by the Pile Driving Analyzer:

- (1) Blow number
- (2) Blow rate per minute and/or stroke.
- (3) Input and reflected values of force and velocity.
- (4) Value of upward and downward traveling force wave with time.
- (5) Maximum and final transferred energy to pile, hammer system efficiency.
- (6) Maximum compressive stress, velocity, acceleration and displacement.
- (7) Maximum tensile stress in pile.
- (8) Pile structural integrity, damage detection, extent and location.
- (9) Bearing capacity of pile by Case method.

If the pile, hammer and soil performance evaluation recommends changes to the hammer stroke, pile cushioning, augering or any other aspect for the pile driving operation these changes shall be

incorporated into production pile driving in an effort to control excessive stresses and pile damage. Test piles damaged or broken during installation shall be replaced, incorporating driving modifications as determined by the Contractor's Geotechnical Consultant and reviewed and approved by the Contracting Officer. This procedure shall be repeated until allowable tensile and compressive stresses are achieved in the pile and/or pile damage is minimized. Selected initial driving records shall be subjected to rigorous computer analysis based on the Case Method for determination of resistance distribution, soil resistance and properties, and estimation of anticipated gain/loss factors.

- b. Upon completion of test pile driving the piles shall be allowed to set-up for at least 72 hours. After evaluation of pile, hammer and soil performance by the Contractor's Geotechnical Consultant, the second step of the dynamic pile analysis may proceed. This portion of the evaluation requires striking the set-up piles a minimum of 20-50 times, or as directed by the Contractor's Geotechnical Consultant using the same hammer which was used for the test pile driving and which will be used for production pile driving. The hammer shall be "warmed up" and in optimal readiness prior to restriking, in order to avoid capacity losses during evaluation of restrike data. Maximum hammer energy shall be applied during restrike in order to fully mobilize the soil resistance. However, care should be exercised as to not overstress the pile. In addition to those items listed above, selected restrike driving records (as directed by the Contractor's Geotechnical Consultant) are to be subjected to rigorous computer analysis based on the Case method for determination of resistance distribution, soil resistance and properties, and plot of applied load vs. average pile displacement based on the calculated soil properties.
- c. Performance Report:
  - (1) Upon satisfactory completion of each dynamic load test a minimum of three copies of a Pile Performance Report shall be submitted for the Contractor by the Contractor's Geotechnical Consultant. The submittal shall be prepared and sealed by a Professional Engineer registered in any jurisdiction of the U.S. or its territories or Japan and shall be made within three working days of the completion of the dynamic load test.
  - (2) The report for the Dynamic Pile Analysis shall contain the following information:
    - (a) Bearing capacity of pile. Information resulting from analysis of a selected restrike blow.
    - (b) Maximum and final transferred energy, hammer system efficiency during pile installation.
    - (c) Maximum compressive stress, velocity, acceleration and displacement.
    - (d) Maximum tensile stress in pile.
    - (e) Pile structural integrity, damage detection, extent and location.
    - (f) Blows per minute and blow number.

- (g) Input and reflection values of force and velocity, upward and downward traveling force wave with time.
  - (h) Pile skin friction and toe resistance distribution.
  - (i) Maximum energy transferred to pile.
- (3) The maximum allowable pile design load will be proposed by the Contractor's Geotechnical Consultant based upon the results of a satisfactory pile load test conducted on a pile driven as specified herein and shall include the effects of load transfer to the soil above the foundation stratum.
- d. The equipment to be used for dynamic testing of the pile hammer and soil performance and for dynamic load testing of the test pile shall meet the requirements of JGS 1816.
- e. All services of the Contractor's Geotechnical Consultant shall be paid for by the Contractor. The Contractor's Geotechnical Consultant shall be available throughout the pile driving operation to consult with the Contracting Officer when required by the Contracting Officer. The cost of changes in the Contractor's procedure, as required by evaluation of the results of the Pile Driving Analysis, shall be at the Contractor's expense.

#### 13.4.3 Static Load Tests

Perform compressive load tests on [\_\_\_\_\_] test piles in accordance with JGS 1811 as modified herein. [Allow a minimum of 72 hours following final test pile driving for pile set-up prior to load testing. ][Do not use anchor piles.] Provide apparatus for applying vertical loads as required by method, using load from weighted box or platform [or reaction frame attached to sufficient uplift piles to safely take required load] applied to pile by hydraulic jack. Increase load in increments until rapid progressive settlement takes place or until application of total compressive load of [\_\_\_\_\_] metric tons for compressive load tests. Consider load test satisfactory when [after one hour at full test load gross settlement of pile butt is not greater than gross elastic pile compression plus 4 mm plus one percent of pile tip diameter or width in [\_\_\_\_\_] mm,] [slope of gross load-settlement curve under full test load does not exceed 1.5 mm per metric ton,] [net settlement after removal of test load does not exceed 19 mm.] Perform load tests at locations[ as proposed by the Contractor's Geotechnical Consultant and] as directed by the Contracting Officer. Additional load tests, at Government expense, may be required by the Contracting Officer. Loading, testing, and recording and analysis of data shall be under the direct supervision of a Registered Professional Engineer, registered in the state of project location, and provided and paid for by the Contractor.

#### 3.4.3.1 Safe Design Capacity

The safe design capacity of a test pile as determined from the results of load tests shall be the lesser of the two values computed according to the following:

- a. One-half of that load which causes a net settlement after rebound of not more than 0.28 mm per metric ton of total test load.

- b. One-half of the load that causes a gross settlement of not more than 25 mm, provided the load settlement curve shows no sign of failure.

[3.4.4 Tensile Load Test

Perform tensile load tests on [\_\_\_\_\_] test piles in accordance with JGS 1813, as modified [and] in paragraph LOAD TESTS. A tensile load of [\_\_\_\_\_] kN shall be applied to each tensile load test pile. In performing the tension load test, the ultimate load to be applied shall be one and one-half times the safe tension capacity, and the Standard Loading Procedure shall be employed.

] [3.4.5 Lateral Load Test

Perform lateral load tests on [\_\_\_\_\_] piles in accordance with JGS 1831, as modified [and] in paragraph LOAD TESTS. Lateral load tests shall consist of jacking two piles apart with a hydraulic jack, with one pile serving as the reaction pile for the other. A lateral load of [\_\_\_\_\_] kN shall be applied to each pair of lateral load test piles. Required movement readings shall be made and recorded for each pile.

] 3.4.6 Pile Records

Keep a complete and accurate record of each pile driven. Indicate the pile location, deviations from pile location, cross section shape and dimensions, original length, ground elevation, tip elevation, cut-off elevations, [batter alignment,] number of blows required for each 300 mm of penetration and number of blows for the last 150 mm penetration or fraction thereof [as required] for the "calculated" [driving resistance]. Include in the record the beginning and ending times of each operation during driving of pile, type and size of hammer used, rate of operation, stroke or equivalent stroke for diesel hammer, type of driving helmet, and type and dimension of hammer cushion (capblock) and pile cushion used. Record retap data and unusual occurrences during pile driving such as redriving, heaving, weaving, obstructions, [jetting,] and any driving interruptions. A preprinted pile driving log for recording pile driving data[ and pile driving equipment data form], which can be downloaded at: <http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf>. For piles installed by the Cement-Milk Method, provide the actual grout amount pumped into the predrilled hole on the Pile Record.

[3.5 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

Special inspections and testing for seismic-resisting systems and components shall be done in accordance with Section 01 45 35 SPECIAL INSPECTIONS.

] 3.6 PILE INSTALLATION BY PLACING METHODS ("Cement-Milk" Method)

Pile installation by placing methods consists of pre-drilling with earth auger system and filling with cement grout ("cement milk").

If required, use borehole stabilizing liquid during pre-drilling operations. Excavation liquid shall be Bentonite plus cement plus water with following standard mixing quantities

Bentonite (kg)	Cement (kg)	Water (l)
25 - 50	80 - 160	450 - 500

The cement milk compressive strength at 28-Days shall be greater than 20 MPa. The cement milk mix design that can provide the required compressive strength shall be submitted before concrete is placed. Piles shall be open-end piles.

### 3.6.1 PILE INSTALLATION PROCEDURES

- (1) Conduct pre-drilling operations as indicated in drawings.
- (2) Earth auger head diameter is approximately pile diameter plus 100 mm.
- (3) The electric current of earth auger motor shall be recorded continuously.
- (4) Drilling and Pile Erection
  - (a) Perform drilling in a vertical direction aligned with the pile centerline and prevent soil on the lateral surface of a borehole from collapsing by using soil stabilizing liquid. Do not rotate the earth auger in a reverse direction when it is pulled out.
  - (b) After the earth auger reaches the specified bearing ground and subsequently cement milk for condensation is injected, pull out the earth auger while injecting perimeter condensation liquid, place a pile into the borehole while being careful of not damaging the lateral surface of the borehole, either applying pressure with the pile equipment or by slightly driving the pile with a hammer.
  - (c) After placing the pile into the borehole, allow for curing process for approximate 7 days while keeping it as it is aligned with the pile centerline.
- (5) Stabilizing Liquid, Cement Milk for Condensation, and Perimeter Condensation Liquid
  - (a) Use borehole stabilizing liquid for preventing the lateral surface of a borehole from collapsing.
  - (b) Cement milk for condensation is a cement-grout material that is injected at the pile top zone.
  - (c) Perimeter condensation liquid is a cement-grout material injected to fill the gap between the pile and the borehole.
- (6) Perform supervision tests for cement milk for condensation and perimeter condensation liquid as follows:
  - (a) The number of samples per test shall be three.
  - (b) Collect samples as follows: 1) Collect the amount of cement milk for condensation for one test from a grout plant at one time. 2) Collect the amount of perimeter condensation liquid from the cement milk flown over a drilled hole at one time after inserting a pile into it.

- (c) Collect samples by using polyethylene bags and make cylindrical samples with the approximate diameter of 50 mm and the approximate height of 100 mm.
- (d) Cure samples in accordance with the standard cure method which is in the water curing at 20+2 degrees C specified in JIS A 1132.
- (e) Strength test shall be in accordance with JIS A 1108 (Method of Test for Compressive Strength of Concrete).
- (f) The compressive strengths of cement milk for condensation and perimeter condensation liquid are those determined on the 28th day of curing. Required compressive strengths are listed below.

Compressive Strength (Unit: N/mm<sup>2</sup>)

Type	Compressive Strength
Cement Milk for Condensation	20 or greater
Perimeter Condensation Liquid	0.5 or greater

### 3.6.2 FIELD QUALITY CONTROL

Tests indicated in Section 3.4.2, 3.4.3, 3.4.4 and 3.4.5 may also be applicable to piles installed by the "cement-milk" method.

### 3.6.3 ENVIRONMENTAL CONSIDERATIONS

The Soil Mixing Contractor shall use cement materials in order to comply with the regulations from the Japanese Ministry of the Environment indicated in Notification No.46 (i.e. limits for Hexavalent Chromium Leachate in Soils) or other applicable local environmental regulations.

-- End of Section --