**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**
**********

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**References are in agreement with UMRL dated January 2021**

SECTION 31 62 13.26

PRESSURE-INJECTED FOOTINGS
**11/20**

**NOTE: This guide specification covers the requirements for the installation, testing, and forming of enlarged concrete footings and cylindrical shafts by ramming the concrete into place under a specific energy of impact.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**

**NOTE: The following information must be shown on the project drawings:**

**1. Plan of Pressure Injected Footings (PIF) (singles and clusters) and cluster configurations**

**2. Batter PIF angle**

**3. Design loads**

**4. Location of test PIF, unless option to allow direction by Contracting Officer is selected.**

## PART 1 GENERAL

### 1.1 DESCRIPTION

Design, furnish, install, and test pressure injected footings (PIF) at the locations indicated on the drawings and as specified herein. Assume test location[s] can be incorporated into the work.

### 1.2 REFERENCES

**********

**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**

**********

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.

AMERICAN CONCRETE INSTITUTE (ACI)

| | |
|---|---|
| ACI 211.3R | (2016) Guide for Selecting Proportions for No-Slump Concrete |
| ACI 214R | (2011) Evaluation of Strength Test Results of Concrete |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM C33/C33M | (2018) Standard Specification for Concrete Aggregates |
| ASTM C143/C143M | (2020) Standard Test Method for Slump of Hydraulic-Cement Concrete |
| ASTM C150/C150M | (2020) Standard Specification for Portland Cement |
| ASTM C172/C172M | (2017) Standard Practice for Sampling Freshly Mixed Concrete |
| ASTM C1077 | (2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates |

| | |
|---|---|
| | for Use in Construction and Criteria for Testing Agency Evaluation |
| ASTM D1143/D1143M | (2007; R 2013) Piles Under Static Axial Compressive Load |
| ASTM D3689 | (2007; E 2013; R 2013) Standard Test Methods for Deep Foundations Under Static Axial Tensile Load |
| ASTM D3966/D3966M | (2007; R 2013; E 2013) Standard Test Methods for Deep Foundations Under Lateral Load |
| ASTM E329 | (2020) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection |

[1.3 SUBSURFACE DATA

Subsurface soil data logs are[ indicated][ appended to the special contract requirements][ provided on the project drawings].[ The subsoil investigation report may be examined at [_____].]

]1.4 BASIS OF BID

**********
**NOTE: Select one of the following options:**

**Use "Lump Sum" paragraph below for lump (principal) sum bidding of PIF. Use this in all projects except those where exact PIF lengths cannot be practically determined prior to the actual work. Clearly show number of PIF, PIF capacity, PIF locations, and tip and cutoff elevations on the drawings.**

**Use "Unit Price" paragraph for unit price bidding of PIF. Specify unit price bid items for PIF only for projects where exact quantities cannot be practically determined prior to the actual work. Lengths of PIF must be determined as accurately as possible, prior to bidding, since the unit price per meter (foot) of the PIF varies as the length increases or decreases.**
**********

1.4.1 Production Acceptance Criteria

Safe design bearing capacity for PIF is [_____] KN [_____] kips. Install PIFs to[ minimum tip elevation][ a minimum depth of [_____] m [_____] feet below foundation level], and to such additional depth as required to obtain a bearing capacity of not less than [_____] KN [_____] kips. The Contractor's Geotechnical Consultant will determine the terminal driving criteria[ based on results of static load tests].

**********
**NOTE: PIF bearing capacity must be computed per formula. In absence of a load test, use K-value from table below: (K-values and Bearing Capacity**

**Formula from "Dynamic Formula for PIF" by Reymond L. Norlund, Proceedings of the American Society of Civil Engineers, Vol. 108, March 1982.)**

| Recommended K-Values | | |
|---|---|---|
| **Recommended K with Compacted Soil Description** | **Recommended K Concrete Shaft** | **With Cased Shafts** |
| **Gravel** | **9** | **12** |
| **Medium to Coarse Sand** | **11** | **14** |
| **Fine to Medium Sand** | **14** | **18** |
| **Coarse Sand** | **18** | **23** |
| **Medium Sand** | **22** | **28** |
| **Fine Sand** | **27** | **35** |
| **Very Fine Sand** | **32** | **40** |
| **Silty Medium to Coarse Sand** | **14** | **18** |
| **Silty Fine to Medium Sand** | **17** | **22** |
| **Silty Fine Sand** | **24** | **30** |
| **Residual Soil Common to Southeast U.S.** | **600 divided by N (but K less than 18)** | **1800 divided by N (but K less than 50)** |
| **Fine Sand with "Limerock" Fragments and/or Shells** | **18** | **25** |
| **Glacial Till, Granular Matrix** | **20** | **27** |
| **Glacial Till, Clay Matrix** | **30** | **40** |
| **N = number of blows from Standard Penetration Test** | | |

**********

Determine safe bearing capacity by ramming zero-slump concrete, in batches of 0.14 cubic meter 5 cubic feet, into granular soil stratum by drop hammer in accordance with the following formula:

$$L = \frac{B \times W \times H \times V(^{2/3})}{K}$$

where

L = Safe bearing capacity of PIF in metric tons (tons)

B = Average number of blows of hammer required to inject one cubic meter one cubic foot of concrete in expanded base, during injection of the last batch

W = Weight of drop hammer in metric tons tons

H = Height of fall of drop hammer in meters feet

V = Total volume of concrete in expanded base measured in cubic meters cubic feet, and

K = [Constant determined from the load test] [_____]

[1.4.2 Lump Sum Payment

**********
**NOTE: Use this paragraph for lump-sum contracts, consult with Contracting Officer's Technical Representative (Geotechnical Branch) on applicability of use prior to selection.**
**********

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

| Table 1 | | | | | | |
|---|---|---|---|---|---|---|
| [Location] | Number | Size | [Bearing Capacity] | Length | [Maximum Bending Moment] | [Maximum Shear Force] |

]

Include the cost of all necessary equipment, tools, material, labor, and supervision required to: install, test, and meet the applicable contract requirements. Include mobilization and pre-drilling. If it is found that any PIF 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 PIF to be provided and installed by changing the PIF locations or elevations, requiring the installation of additional PIF, or directing the omission of PIF from the requirements shown and specified. If total number of PIF 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 PIF will be based on successfully installing PIF to both the minimum tip elevation and satisfying the acceptance criteria identified herein. No additional payment will be made for: rejected PIF or other excesses beyond the assumed PIF length indicated for which the Contractor is responsible.[ Include payments for vibration monitoring, sound monitoring and precondition construction surveys.]

]1.4.3 Unit Price

**********
**NOTE: Delete this paragraph for lump-sum contracts.**

**For NAVFAC PAC projects: Where there is unit pricing for PIF, use this paragraph and edit**

**applicable attachments from Section 00 22 13.00 20 SUPPLEMENTARY INSTRUCTIONS TO OFFERORS for inclusion in Standard Form 1442, "Solicitation, Offer and Award" and "Schedule of Bid Items." Select first bracketed text.**

**For NAVFAC Southeast projects, where there is a need for unit pricing of PIF, include this paragraph. Refer to NAVFAC SE Instruction 00010, "Instructions for Preparing Basis of Bid Statement With Unit-Priced Items," for method of specifying unit price bid items. Select first bracketed text.**
**********

[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.]

**********
**NOTE: For NAVFAC LANT projects, use the following paragraph for measurement and payment and subsequent sub-parts.**
**********

Requirements of FAR 52.211-18 Variation in Estimated Quantity do not apply to payment for PIF. Each PIF and test PIF acceptably provided will be paid for at the bid unit price per unit length, which will include items incidental to furnishing and driving the PIF including mobilization and demobilization, and[ jetting][ predrilling]. Payment will be made for production[ and test PIF] at the bid unit price for the length of PIF, from tip to final cut-off, actually provided, excluding buildups directed by the Contracting Officer to be made. If the actual cumulative PIF length driven (tip to cut-off) vary more than 25 percent from the total PIF 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.[ Payments will be made per each at the respective bid unit price for PIF build-ups and loads tests.][ Include payments for vibration monitoring, sound monitoring, construction instrumentation and monitoring, and precondition construction surveys].

## 1.5 PAYMENT

**********
**NOTE: Delete this paragraph for lump-sum contracts.**

**If Section 01 20 00 PRICE AND PAYMENT PROCEDURES is included in the project specifications, this paragraph title (UNIT PRICES) should be deleted from this section and the remaining appropriately edited subparagraphs below should be inserted into Section 01 20 00 PRICE AND PAYMENT PROCEDURES.**
**********

### 1.5.1 Mobilization and Demobilization

#### 1.5.1.1 Payment

Payment will be made for costs associated with mobilization and

demobilization as a separate single lump sum item.

1.5.1.2 Measurement

Lump sum.

1.5.1.3 Unit of Measure

Lump sum.

1.5.2 Installing PIF

1.5.2.1 Payment

Payment will be made for costs associated with installing PIF, which includes costs of installing PIFs and removing excess waste from the work site, compiling and submitting PIF records, and any other items incidental to installing PIF to the required elevation.

1.5.2.2 Unit of Measure

Linear meter.Foot.

[1.5.3 PIF Static Axial Compressive Load Tests

1.5.3.1 Payment

Payment will be made for costs associated with PIF static axial compressive load tests in accordance with ASTM D1143/D1143M, 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 load test reports. No payment will be made for rejected static axial compressive load tests.

1.5.3.2 Measurement

PIF static axial compressive load tests will be measured for payment on the basis of the applicable contract unit price per load test.

1.5.3.3 Unit of Measure

Each.

][1.5.4 PIF Static Tensile Load Tests

1.5.4.1 Payment

Payment will be made for costs associated with PIF static tensile load tests in accordance with ASTM D3689, 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 load test reports. No payment will be made for rejected static tensile load tests.

1.5.4.2 Measurement

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

1.5.4.3 Unit of Measure

Each.

][1.5.5 PIF Lateral Load Tests

1.5.5.1 Payment

Payment will be made for costs associated with PIF lateral load tests in accordance with ASTM D3966/D3966M, 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 load test reports. No payment will be made for rejected lateral load tests.

1.5.5.2 Measurement

PIF lateral load tests will be measured for payment on the basis of the applicable contract unit price per lateral load test.

1.5.5.3 Unit of Measure

Each.

][1.5.6 Vibration Monitoring

1.5.6.1 Payment

Payment will be made for costs associated with vibration monitoring.

1.5.6.2 Measurement

Vibration monitoring will be measured for payment on the basis of the applicable contract unit price per vibration monitoring point.

1.5.6.3 Unit of Measure

Each.

][1.5.7 Sound Monitoring

1.5.7.1 Payment

Payment will be made for costs associated with sound monitoring.

1.5.7.2 Measurement

Sound monitoring will be measured for payment on the basis of the applicable contract unit price per vibration monitoring point.

1.5.7.3 Unit of Measure

Each.

][1.5.8 Preconstruction Condition Survey

1.5.8.1 Payment

Payment will be made for costs associated with preconstruction condition surveys.

1.5.8.2 Measurement

Preconstruction condition survey will be measured for payment on the basis of the applicable contract unit price per structure to be surveyed.

1.5.8.3 Unit of Measure

Each.

][1.5.9 Construction Instrumentation and Monitoring

1.5.9.1 Payment

Payment will be made for costs associated with construction instrumentation and monitoring.

1.5.9.2 Measurement

Construction instrumentation and monitoring will be measured as a single pay item.

1.5.9.3 Unit of Measure

One.

]1.6 SUBMITTALS

**********

**NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the**

District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. **Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

**Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.**

**********

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Designer and Installer's Qualifications; G[, [_____]]

Testing Agency Qualifications; G[, [_____]]

Contractor's Geotechnical Consultant Documentation

SD-02 Shop Drawings

Steel-Shell Shaft Casings

Reinforcement

Dowels

Fabricated Additions and Modifications to Pressure-Injected Footings (PIF)

As-Driven Survey; G[, [_____]]

Load Tests; G[, [_____]]

SD-05 Design Data

**********

**NOTE: Calculations, mix designs, analyses or other data pertaining to a part of work.**

**********

Concrete Mix Design; G[, [_____]]

Design Calculations; G[, [_____]]

SD-06 Test Reports

Aggregates; G[, [_____]]

Concrete Compressive Strength; G[, [_____]]

Load Tests; G[, [_____]]

Fine Aggregate

SD-07 Certificates

PIF Installation Equipment

Load Test Apparatus

SD-11 Closeout Submittals

PIF Records

## 1.7 QUALITY CONTROL

### 1.7.1 PIF Records

Pressure-injected footings (PIF) must consist of an expanded base of concrete, formed by ramming concrete into place, and a [cased ][uncased ][reinforced ]concrete shaft to transmit the superstructure load to the expanded base.

### 1.7.2 PIF Installation Equipment

Submit descriptions of proposed PIF installation equipment before commencing work. Include details of the rig, hammer type, and available energy.

### 1.7.3 Load Test Apparatus

**********
**NOTE: Delete this paragraph if load testing is not required.**
**********

Submit equipment description lists or catalog cuts and a brief description of the load test procedure, including maximum load and modifications in accordance with the procedure required by ASTM D1143/D1143M before commencing tests.

### [1.7.4 Contractor's Geotechnical Consultant Documentation

Hire the services of an independent, Registered Professional Geotechnical Engineer, experienced in soil mechanics to observe test PIF installation and production PIF installation as specified herein. The Contractor's Geotechnical Consultant must be independent of the Contractor and must have no employee or employer relationship which could constitute a conflict of interest.

## ]1.8 QUALIFICATIONS

Installation of PIF must be performed by a specialty Contractor experienced and competent in the installation of PIF as specified herein. Submit evidence that the contractor has had similar type projects. The

projects must demonstrate proficiency of the designer as applicable to the intent of the project. The Designer must be a Professional Engineer registered in the state where the project is located.

Submit Designer and Installer's Qualifications at least 30 calendar days prior to installation.

[1.9 DESIGN CALCULATIONS

The installer must submit two sets of detailed design calculations for approval at least 30 calendar days prior to the beginning of construction. A detailed explanation of the design parameters for the calculations must be included in the submittal. Additionally, the quality control test program confirming the design requirements, must be submitted. All calculations and drawings must be prepared and sealed by a Professional Engineer in the State in which the project is constructed.

]PART 2 PRODUCTS

2.1 CONCRETE

**********
**NOTE: Insert the correlated section number and title or include concrete specification in this section in the blank below in the correct format per UFC 1-300-02.**
**********

Provide as specified in [_____] except as specified otherwise herein, for minimum 28-day concrete compressive strength of [_____] MPa pounds per square inch, using 19 mm 3/4 inch maximum coarse aggregate. Concrete for base [and for uncased shaft ]must have minimum 3-day compressive strength of [_____] MPa pounds per square inch.[ Cased shaft must have minimum 3-day compressive strength of [_____] MPa pounds per square inch.] The expanded base must be made of zero-slump concrete. Use [zero-slump concrete for uncased shaft][ 75 mm 3 inch slump concrete for cased or uncased shaft][ 100 to 150 mm 4 to 6 inch slump concrete for cased shaft]. Zero-slump concrete must be developed by reducing water in regular-mix concrete in accordance with ACI 211.3R. Submit concrete mix design for approval at least 30 calendar days prior to installation.

2.1.1 Portland Cement

Portland cement must confirm to ASTM C150/C150M and Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.1.2 Water

Water must be fresh, clean, and free from sewage, oil, acid, alkali, salts, or organic matter.

2.1.3 Fine Aggregate

Fine aggregate must meet the requirements of ASTM C33/C33M. The sand must consist of hard, dense, durable, uncoated rock particles and be free from injurious amounts of silt, loam, lumps, soft or flaky particles, shale, alkali, organic matter, mica, and other deleterious substances. If washed, a washing method must be used that will not remove desirable

fines, and the sand must subsequently be permitted to drain until the residual-free moisture is reasonably uniform and stable. The sand must be well-graded from fine to coarse, with fineness modulus between 1.30 and 3.40.

### 2.1.4 Aggregates

Aggregate must meet the requirements of ASTM C33/C33M, for fine aggregate, except as to gradation. The sand must consist of hard, dense, durable, uncoated rock fragments and must be free from injurious amounts of silt, lumps, loam, soft, or flaky particles, shale, alkali, organic matter, mica, and other deleterious substances. If washed, the method must not remove other desirable fines, and the sand must be permitted to drain until the residual free moisture is reasonably uniform and stable. Sand gradation must be reasonably consistent and must conform to the following requirements as delivered to the grout mixer:

| Sieve Opening U.S. Standard Sieve Number | Cumulative Percent by Weight Passing | Cumulative Percent by Weight Retained |
|---|---|---|
| 2.38 mm 8 | 100 | 0 |
| 1.19 mm 16 | 95-100 | 0-5 |
| 0.600 mm 30 | 55-80 | 20-45 |
| 0.300 mm 50 | 30-55 | 45-70 |
| 0.150 mm 100 | 10-30 | 70-90 |
| 0.075 mm 200 | 0-10 | 90-100 |

The sand must have a fineness modulus of not less than 1.30 nor more than 2.10. The sand gradation shown above may be modified with the approval of the Contracting Officer. Mortar test specimens made with the modified sand must exhibit compressive strength equal to or greater than that exhibited by similar specimens made with sand meeting grading and other requirements shown above.

### 2.1.5 Zero-Slump Concrete Sampling

Various testing agencies have developed special procedures to produce test specimens to mold zero-slump concrete test cylinders. These procedures should be used to mold zero-slump concrete cylinders. One such procedure that has been widely used is described below. Conform to appropriate sections of ASTM C143/C143M and ASTM C172/C172M.

Obtain approximately 0.08 cubic meter 3 cubic feet of concrete from the batch to be placed in the PIF. A fresh, moist sample of concrete must be obtained for each cylinder. Record the mix temperature. Assemble the compaction steel mold 150 mm diameter by 300 mm high 6-inch diameter by 12 inch high and tighten all lugs. Using a US Standard 19 mm 3/4 inch sieve to screen the mix, place sufficient material in the mold to give a loose lift thickness of 50 mm 2 inches. Compact the lift using 20 blows of the Marshall hammer 4.53 Kg falling 457 mm 10-lb weight falling 18 inches, making sure that all blows are evenly spaced over the entire surface. Repeat the procedure for each lift until eight lifts are placed. The material should be passed through a 12.7 mm 1/2 inch sieve for the last

two lifts in order to form a smooth top. The compacted specimen should remain in the reusable mold for 24 hours before removal for additional curing.

2.1.6 Compressive Strength Test Results

Evaluate compressive strength test results at 28 days in accordance with ACI 214R using a coefficient of variation of 10 percent. Evaluate strength of concrete by averaging test results of each set of standard cylinders tested at 28 days. Not more than 10 percent of individual cylinders tested must have a compressive strength less than specified design strength.

## 2.2 REINFORCEMENT

**********

**NOTE: Insert the correlated section number and title in paragraph REINFORCEMENT or include reinforcement specification in this section, in blank below in proper format per UFC 1-300-02. Shafts are reinforced only when the shaft is required to withstand tension, moment, or shear. Shaft reinforcement may also be required for compression or lateral loads for battered shafts.**

**********

Materials, assembly, and placement of reinforcement must conform to the requirements of Section [03 30 00 CAST-IN-PLACE CONCRETE] [_____].

## 2.3 CASINGS

**********

**NOTE: Delete paragraph UNCASED SHAFT if only cased shafts are used. Delete paragraphs CASINGS and CASED SHAFT if only uncased shafts are used. Do not use uncased shafts in soft clay or silt soils unless:**

**1. Adjacent PIF are installed in previously bored holes equal to the inside diameter of the driving tubes, or**

**2. PIF are located more than 2.7 m 9 feet apart.**

**********

Provide permanent steel casing of sufficient thickness, strength, and rigidity to prevent deformation, collapse, or distortion caused by driving adjacent PIF or by soil or hydrostatic pressure. Casings must be watertight.

## 2.4 MATERIAL SUSTAINABILITY CRITERIA

For materials used, where applicable and to extent allowed by performance criteria, provide and document the following in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING:

a. Recycled content for fly ash and pozzolan

b. Recycled content for Ground Iron Blast-Furnace Slag

c. Recycled content for Silica Fume

d. Minimum [75 percent] [_____] recycled content for steel used for stressed tendon reinforcing

# PART 3 EXECUTION

## 3.1 INSTALLATION

### 3.1.1 General Requirements

Design of the PIF is based upon assumed subsurface elevations to which the PIF must penetrate at various locations and total energy required to drive them.[ Based upon results of PIF test loadings, the Contracting Officer will specify the actual elevation to which PIF must penetrate and the total energy to be applied to drive the last 0.14 cubic meter 5 cubic feet of concrete into the base.]

### 3.1.2 Placement

Do not place PIF until earthwork has been graded to elevation indicated.[ Do not place permanent PIF until load test[s] [have][has] been successfully completed.] Modifications to pressure-injected footings (PIF) must be approved by the Contracting Officer prior to placement.

### 3.1.3 Tolerance

Placement tolerance must be a maximum 50 mm 2 inches from plan location for single PIF and 75 mm 3 inches from plan location for PIF in clusters. Except for batter installations, PIF must be a maximum of two percent out of plumb. Batter installations must be within five percent of the indicated required angle. The required angle must not exceed 0.44 rad 25 degrees from the vertical.

PIFs must be monitored for heave immediately after installation and after adjacent PIFs are installed. If PIFs heave more than 13 mm 1/2 inch notify the Contracting Officer.

### 3.1.4 PIF Damaged, Mislocated, or Out of Alignment

**********

**NOTE: For PIF installed beyond tolerance, determine actual load to be supported. Reject PIF unless determination shows that overloading does not exceed 10 percent where no load test has been conducted, or 20 percent when load test has been conducted, providing that materials are not stressed beyond allowable limits.**

**********

Abandon PIF damaged, mislocated, or out of alignment beyond maximum tolerance and place additional PIF where directed without additional cost to the Owner.

### 3.1.5 As-Driven Survey

After the installation of each PIF group is complete, provide the Contracting Officer with an as-driven survey showing actual location and top elevation of each PIF. Do not proceed with placing concrete until the

Contracting Officer has reviewed the survey and verified the safe load for the PIF group driven. Present a survey in such form that it gives deviation from plan location in two perpendicular directions and elevations of each PIF to nearest 13 mm half inch. Survey must be prepared and certified by a licensed land surveyor.

### 3.1.6 Protection of Existing Structures

**********

**NOTE: Include this paragraph only when protection of existing structures from pile driving activities is required.**

**The designer must indicate on the drawings all structures and facilities for which protection is required. The designer must also provide a project specific document that details design criteria, requirements for preconstruction condition surveys, post construction condition surveys, geotechnical instrumentation to measure ground movements and any other requirements.**

**Add any additional requirements as necessary.**

**********

Mitigate impact on existing facilities due to PIF installation activities in accordance with the [project specific document] [_____].

## 3.2 BASE

**********

**NOTE: Use drive tubes from 508 to 610 mm 20 to 24 inches in diameter for loads 72.6 metric tons 80 tons and greater with energy of 189,840 J 140,000 foot-pounds or use drive tubes from 305 to 406 mm 12 to 16 inches in diameter for loads less than 72.6 metric tons 80 tons with energy of 67,800 to 135,600 J 50,000 to 100,000 foot-pounds.**

**********

Load steel drive tube of [ [_____] mm [_____] inch] [appropriate] diameter with a plug of 0.14 cubic meter 5 cubic feet of concrete or gravel and force into ground by drop hammer blows on plug at bottom inside of the steel tube. Pre-bore to assist driving if appropriate. Drive tube to predetermined depth of granular soil stratum suitable for forming expanded base. At this depth, expel plug while preventing further penetration of the tube, with sufficient seal maintained to prevent entry of water or soil. During injection of concrete, level of concrete in tube shall be 150 mm 6 inches above bottom of tube.

## 3.3 SHAFTS

### 3.3.1 Uncased Shaft

**********

**NOTE: Delete paragraph UNCASED SHAFT if only cased shafts are used. Delete paragraphs CASINGS and CASED SHAFT if only uncased shafts are used. Do not use uncased shafts in soft clay or silt soils unless:**

**1. Adjacent PIF are installed in previously bored holes equal to the inside diameter of the driving tubes, or**

**2. PIF are located more than 2.7 m 9 feet apart.**

**********

Ensure continuous and complete contact between concrete shaft and surrounding soil. Form shaft by compacting charges of zero-slump concrete with hammer blows of 20,300 to 27,100 Joules 15,000 to 20,000 foot-pounds of energy and withdraw drive tube in not more than 600 mm 2 foot increments. Concrete level inside drive tube must be higher than bottom of tube at all times. Alternatively, when shaft is reinforced full length, fill drive-tube with 150 to 200 mm 6 to 8 inches of high-slump concrete and withdraw tube, recharging concrete as needed to ensure that final level is at or above cut-off elevation.

3.3.2 Cased Shaft

**********

**NOTE: Delete paragraph UNCASED SHAFT if only cased shafts are used. Delete paragraphs CASINGS and CASED SHAFT if only uncased shafts are used. Do not use uncased shafts in soft clay or silt soils unless:**

**1. Adjacent PIF are installed in previously bored holes equal to the inside diameter of the driving tubes, or**

**2. PIF are located more than 2.7 m 9 feet apart.**

**********

**********

**NOTE: Where soil conditions indicate that it may be impractical or difficult to fill the annular space between the shaft and the soil around a single casing, shaft must be supported laterally or PIF must be reinforced. Where a single PIF is used as a foundation and the shaft is cased, shaft must be supported at the top in at least two directions, perpendicular to each other. Where two PIF are used in a group and their shafts are cased, the groups must be supported laterally at the top in a direction perpendicular to a line drawn between centers of the footings. Insert minimum nominal diameter of casings.**

**********

Concrete shaft must be cased in a permanent steel casing formed by inserting a steel casing with a minimum diameter of [_____] mm inches into drive tube and embedding in expanded base as required to exclude water or other foreign material. Withdraw drive tube and fill steel casing with 75 mm 3 inch slump concrete to cut-off elevation but not until after all PIF within a 2.7 m 9 foot radius have been installed. Place concrete in continuous flow from bottom to top of shaft, and do not drop through water. Fill spaces between steel casing and surrounding soil with sand by a process of washing sand as the drive tube is withdrawn. Allow shaft to cure 24 hours minimum before constructing additional PIF within a 2.7 m 9

foot radius. Remove mud, water, and other foreign matter before filling casing with concrete. Extract and discard distorted, bent, or damaged casings and drive new casings.

## 3.4 REINFORCEMENT

**********

**NOTE: Insert the correlated section number and title in paragraph REINFORCEMENT or include reinforcement specification in this section. Shafts are reinforced only when the shaft is required to withstand tension, moment, or shear. Shaft reinforcement may also be required for compression or lateral loads for battered shafts.**

**********

Assemble, securely tie together, and place in shaft as a unit. Use spacers to center reinforcement in the shaft and maintain alignment.[ Reinforce full length of battered shafts and uncased shafts to resist uplift force.] Connect shaft to superstructure with reinforcement as indicated. Provide necessary dowels. Submit drawings, details and schedules.

## 3.5 FIELD QUALITY CONTROL

**********

**NOTE: Delete these paragraphs if load testing is not required.**

**********

### 3.5.1 Load Tests

**********

**NOTE: This section is applicable to axial compression load tests. Revise accordingly for axial tension load tests (ASTM D3689) or lateral load tests (ASTM D3966/D3966M). The requirement of performing the load test under the direct supervision of a registered professional engineer may be waived at the discretion of the design agency.**

**********

ASTM D1143/D1143M[, measurement method as recommended by the Contractor]; provide [one] [_____] test PIF[s] conforming to requirements for permanent PIF at location[s] [indicated] [directed by the Contracting Officer]. Place test PIF in same manner specified for permanent PIF. Test PIF indicated or directed to be placed in permanent locations may be incorporated into the final work if load testing is satisfactory. Perform tests and recording of data under the direct supervision of a registered Professional Engineer provided by the [Government] [Contractor]. Load frames, jacks, pumps, and dial gauges must be the responsibility of the Contractor.

### 3.5.2 Test Measurements

Maintain ultimate test load as per ASTM D1143/D1143M. Determine safe bearing capacity of test PIF from results of load test as approved by the Contracting Officer.[ Safe bearing capacity must be the lesser of two values computed as follows: (a) one-half the load at which the load vs.

total settlement curve exhibits a slope of 1.3 mm per 907 kg 0.05 inches per ton of test load; or (b) one-half the load that causes net settlement after rebound of not more than 25.4 mm one inch.]

## 3.6 INSPECTION AND SAFETY

Engage an independent testing agency qualified according to ASTM C1077 and ASTM E329 for testing indicated. Submit testing agency qualifications to the Contracting Officer for approval at least 30 calendar days prior to installation.[ Provide sufficient light and access for proper inspection of full length of casings.] The Contractor must provide safety requirements and access equipment required for proper inspection.[ Casing must be inspected and approved prior to installing shaft.]

### 3.6.1 Pressure Injected Footing Records

Maintain daily records and make available to the Contracting Officer at all times. Within 15 days after completion of PIF, furnish to the Contracting Officer a complete and accurate record of all PIF installed. Records must include, as a minimum, the following information for each PIF:

a. Reference or identification number

b. Shaft type and method of reinforcing used

c. Diameter, length, location, and elevation of finished concrete at top of shaft

d. Elevation of bottom of base

e. Type and volume of concrete in base

f. Number and magnitude of blows required to drive the last 0.14 cubic meter 5 cubic feet of base concrete

g. Unusual or unexpected conditions encountered during installation

h. Date of construction drilling, driving, concrete placing, high and low temperatures, and weather conditions for each PIF

i. For PIF closer than nine shaft diameters, elevations at adjacent PIF, recorded before and after driving

j. Sequence of placing PIF in groups.

## 3.7 SPECIAL INSPECTION AND TESTING FOR SEISMIC-RESISTING SYSTEMS

**********

**NOTE: Include this paragraph only when special inspection and testing for seismic-resisting systems is required by the International Building Code (IBC).**

**This paragraph will be applicable to both new buildings designed and to existing building seismic rehabilitation designs done according to UFC 1-200-01, "General Building Requirements", UFC 3-301-01 "Structural Engineering", and UFC 3-301-02 "Design of Risk Category V Structures, National Strategic Military Assets".**

**The designer must indicate on the drawings all locations and all features for which special inspection and testing is required in accordance with Chapter 17 of the IBC. This includes indicating the locations of all structural components and connections requiring inspection.**

**Add any additional requirements as necessary.**
**********

Perform special inspections and testing for seismic-resisting systems and components in accordance with Section 01 45 35 SPECIAL INSPECTIONS.

[3.8 VIBRATION CONTROL

**********
**NOTE: Include this paragraph when vibration monitoring is required. Add any additional criteria or requirements as necessary to the particular project.**
**********

Perform vibration monitoring at the locations[ shown in the plan][ decided by the Contracting Officer] during the PIF installation operations. Perform vibration monitoring [using] [seismographs] [and geophones] within a distance of [61] [_____] meters [200] [_____] feet from the PIF installation activity.[ Engage the services of a qualified, independent vibration consultant, acceptable to the Government, to conduct the vibration monitoring. The vibration consultant must have minimum of [five] [_____] years of experience in vibration monitoring. A minimum of [28] [_____] days before the installation of vibration monitors, submit to the Government the name of the vibration consultant and a list of at least [three] [_____] previously completed projects of similar scope and purpose.]

Prior to the PIF installation activities, obtain baseline readings of ambient vibrations. The vibration during the PIF installation activities must be limited to[ a peak particle velocity of not more than [5] [_____] cm [2.0] [_____] inches per second][ the limits mentioned in the [contract documents] [_____]].[ Determine appropriate vibration limits as per [US Bureau of Mines ][American Association of State Highway and Transportation Officials (AASHTO) ]guidelines.] During PIF installation activities, monitor the vibrations to ensure the limits are not exceeded. If the limits are exceeded, cease the PIF installation activity causing the vibration until [the Vibration consultant and the Contracting Officer] [_____] are on site to observe the structures nearest to the vibration monitor which has exceeded the limits.

The Contractor must be responsible for all damages resulting from the PIF installation operations and must take whatever measures necessary to maintain peak particle velocity within the specified limit. After completion of the project, remove the vibration monitors off the site and off Government property and restore the monitoring locations back to their original condition.

][3.9 NOISE CONTROL

**********

**NOTE: Include this paragraph when noise monitoring is required. Add any additional criteria, references or requirements as necessary to the particular project.**
**********

Perform noise monitoring at the locations [shown in the plan] [decided by the Contracting Officer] [at noise sensitive public areas] during the PIF installation operations.[ Perform noise monitoring using [noise meters][, and] [_____].][ Engage the services of a qualified, independent noise consultant, acceptable to the Government, to conduct the noise monitoring. The noise consultant must have minimum of [five] [_____] years of experience in noise monitoring. A minimum of [28] [_____] days before the installation of noise monitors, submit to the Government the name of the noise consultant and a list of at least [three] [_____] previously completed projects of similar scope and purpose.]

Prior to the PIF installation activities, obtain baseline readings of ambient noise levels.[ The noise limits are mentioned in the [plan] [contract documents].][ Determine appropriate noise limits as per [local agency] [Occupation Safety and Health Administration] guidelines.] During PIF installation activities, monitor the noise to ensure the limits are not exceeded. If the limits are exceeded, cease the PIF installation activity and install noise mitigation measures.

The Contractor must be responsible for all damages resulting from the PIF installation and must take whatever measures necessary to maintain noise within the specified limit. After completion of the project, remove the noise monitors off the site and off Government property and restore the monitoring locations back to their original condition.

][3.10 PRECONSTRUCTION CONDITION SURVEY

**********
**NOTE: Add any additional criteria, references or requirements as necessary to the particular project.**
**********

Perform preconstruction condition survey of [structures] [and utilities] [within [61] [_____] meters [200] [_____] feet of the PIF installation activity] [specified in the plans] [decided by the Contracting Officer]. Perform outreach to the owner of the structures [28] [_____] days before performing the preconstruction condition survey. The Contractor must obtain written permission from the owner of the structure prior to accessing the structure. The preconstruction condition survey must include video and photographic documentation of the exterior and interior of above ground structures and of the interior of underground structures. Video documentation must be in high definition, and show existing conditions and highlight, where possible, existing cracks, deteriorated concrete, exposed and corroded reinforcement, cracked or broken brick or mortar, and other signs of distress. For utilities, perform the survey when the greatest extent of the interior is exposed. Provide supplementary artificial lighting as needed. The video must include annotation with location and structure nomenclature which describes any areas of distress over the video and time code superimposed on the video. Photographs must be accompanied by sketches or descriptions that indicate the location and direction of each photograph. For each structure surveyed, provide a Pre-Construction Condition Survey Report following completion of the survey. The report must contain all documentation

associated with the survey including DVD copies. In the report, include notes, sketches, photographs, and videos. Provide general information, such as location details and structure type, as well as particular information on materials, condition, existing damage, aperture and persistence of cracks, and disrepair observed during visual survey. Provide a graphical depiction of locations of damage or other features of concern. Submit the Preconstruction Condition Survey Reports no later than [28] [_____] days before the commencement of PIF installation activity. Accept responsibility for damages to existing adjacent or adjoining structures created by PIF installation work, and repair any damages to these structures without cost to the Government.

][3.11 CONSTRUCTION INSTRUMENTATION AND MONITORING PROGRAM

**********

**NOTE: Include this section if instrumentation is to be installed due to concerns about vibration, settlement, lateral movement, etc. during PIF installation activities. Instrumentation should be specified and included in the specification. This section can be deleted if there are no instrumentation requirements.**

**Add any additional criteria or requirements as necessary for the particular project.**

**********

Prepare a geotechnical instrumentation program to monitor settlement [and lateral movement] of temporary and permanent structures, utilities, [embankments] [and excavations] during PIF installation. The design and distribution of instrumentation must demonstrate an understanding of the need, purpose and application of each proposed type.[ Perform noise and vibration monitoring in accordance with NOISE CONTROL and VIBRATION CONTROL sections.]

Monitoring must extend before, during and for a period after completion of construction activities related to PIF installation when long-term performance issues are a concern. The monitoring plan must be designed to protect adjacent structures and utilities against damage due to the PIF installation activities. Establish limiting values of vertical [and horizontal] movement [and angular distortion] [and vibration] for each structure and utility within the zone of influence, subject to review by the Government.

Prepare a report detailing the proposed program of instrumentation and monitoring, establishing threshold values of monitored parameters, and describing the response plans that will be implemented when threshold parameters are exceeded. The report must include details about instrumentation consultant's experience, appropriate types, quantities, locations and monitoring frequencies of the instruments.

Upon acceptance of the instrumentation and monitoring program, provide, install and monitor the instrumentation and interpret the data. Submit instrumentation data reports not less than every [_____] days after the monitoring program has begun. Take corrective actions, as necessary, based on the field instrumentation data and as defined in the instrumentation and monitoring program.

] -- End of Section --