****
USACE / NAVFAC / AFCESA | **UFGS-02466 (August 2004)**

Preparing Activity: NAVFAC | **Superseding UFGS-02466N (September 1999)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004
****

SECTION 02466

PRESSURE-INJECTED FOOTINGS
08/04

****
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.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
****

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

1. Plan of PIF (singles and clusters) and cluster configurations

2. Batter pile angle

3. Safe design loads

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

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

****

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.

ACI INTERNATIONAL (ACI)

ACI 211.3R	(2002) Standard Practice for Selecting Proportions for No-Slump Concrete

ASTM INTERNATIONAL (ASTM)

ASTM D 1143	(1981; R 1994e1) Piles Under Static Axial Compressive Load

1.2 SUBMITTALS

****

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

****

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.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Steel-shell shaft casings

Reinforcement

Dowels

Fabricated additions and modifications to pressure-injected footings (PIF)

SD-06 Test Reports

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

Load tests

SD-07 Certificates

PIF installation equipment

Load test apparatus

SD-11 Closeout Submittals

Pressure injected footing records

1.3 DEFINITION

Pressure-injected footings (PIF) shall 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.

[1.4 BASIS OF BID

****
NOTE: Include this paragraph only if there are one or more test piles and their locations are "to be where directed."
****

Assume test pile[s] will be directed to be placed in [a] location[s] that can be incorporated into the work.

]1.5 QUALITY ASSURANCE

1.5.1 PIF Installation Equipment

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

1.5.2 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 D 1143 before commencing tests.

1.5.3 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 shall 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.

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 inchmaximum coarse aggregate. Concrete for base [and for uncased shaft] shall have minimum 3-day compressive strength of [_____] MPa pounds per square inch. [Cased shaft shall have minimum 3-day compressive strength of [_____] MPa pounds per square inch.] The expanded base shall 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 shall be developed by reducing water in regular-mix concrete in accordance with ACI 211.3R.

2.2 REINFORCEMENT

****

NOTE: Insert the correlated section number and title in paragraph entitled "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.

****

Provide as specified in [_____.]

2.3 CASINGS

****

NOTE: Delete paragraph entitled "Uncased Shaft" if only cased shafts are used. Delete paragraph entitled "Casings" and paragraph entitled "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 feetapart.

****

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 shall be watertight.

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 shall 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 shall 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) shall be approved by the Contracting Officer prior to placement.

3.1.3 Placement Tolerance

Placement tolerance shall be a maximum 38 mm 1.5 inches from plan location for single PIF and 75 mm 3 inches from plan location for PIF in clusters. Except for batter installations, PIF shall be a maximum two percent out of plumb. Batter installations shall be within five percent of the indicated required angle. The required angle shall not exceed 0.44 rad 25 degrees from the vertical.

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.

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.

****

Charge 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 or jet 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 152 mm 6 inches above bottom of tube. [Alternatively, drive tube may be driven into ground with mechanical hammer striking top of drive tube. In this case, close bottom of drive tube with steel plate which

shall later be driven off during forming of base.]

3.3 PIF BEARING CAPACITY

****

NOTE: PIF bearing capacity shall 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 18)	1800 divided by N (but K less 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 mm 5 cubic feet, into granular soil stratum by drop hammer in accordance with the following formula:

$$L = \frac{B \times W \times H \times V2/3}{K}$$

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] [_____]

3.4 SHAFTS

3.4.1 Uncased Shaft

****
NOTE: Delete paragraph entitled "Uncased Shaft" if only cased shafts are used. Delete paragraph entitled "Casings" and paragraph entitled "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 feetapart.
****

Ensure continuous and complete contact between concrete shaft and surrounding soil. Form shaft by compacting charges of zero-slump concrete with hammer blows of 15,000 to 20,000 foot-pounds 20,300 to 27,100 J of energy and withdraw drive tube in not more than 600 mm 2 foot increments. Concrete level inside drive tube shall 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.

3.4.2 Cased Shaft

****
NOTE: Delete paragraph entitled "Uncased Shaft" if only cased shafts are used. Delete paragraph entitled "Casings" and paragraph entitled "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 feetapart.
****

****

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 shall be supported laterally or PIF shall be reinforced. Where a single PIF is used as a foundation and the shaft is cased, shaft shall 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 shall 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 shall 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.

3.5 REINFORCEMENT

****

NOTE: Insert the correlated section number and title in paragraph entitled "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.

3.6 TEST PIF

****

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

****

3.6.1 Load Tests

****

NOTE: 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 D 1143, [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]. [Dial gauges and measurements of deflection or settlement [will] [shall] be the responsibility of the [Contracting Officer] [Contractor].]

3.6.2 Test Measurements

Maintain ultimate test load for a minimum of 24 hours before releasing. Determine safe bearing capacity of test PIF from results of load test as approved by the Contracting Officer. [Safe bearing capacity shall 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.]

3.7 INSPECTION AND SAFETY

PIF [and casings for cased shaft] will be inspected by the Contracting Officer. [Provide sufficient light and access for proper inspection of full length of casings.] Provide safety requirements and access equipment required for proper inspection. [Casing shall be inspected and approved prior to installing shaft.] -- End of Section --