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USACE / NAVFAC / AFCEC / NASA **UFGS-31 68 13 (November 2008)**

Preparing Activity: USACE **Superseding UFGS-31 68 13 (April 2006)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2014
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SOIL AND ROCK ANCHORS

11/08

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2014
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SECTION 31 68 13

SOIL AND ROCK ANCHORS
11/08

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NOTE: This guide specification covers the requirements for soil and rock anchors. This section was originally developed for USACE Civil Works projects.

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 items(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).
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PART 1 GENERAL

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NOTE: This specification is based on, and references, the POST-TENSION INSTITUTE (PTI) recommendations for prestressed rock and soil anchors. The PTI manual is available from:

POST-TENSIONING INSTITUTE.
1717 W. NORTHERN AVE., SUITE 114
PHOENIX, AZ 85021 U.S.A
PHONE: (602) 870-7540 FAX: (602) 870-7541

The designer should carefully investigate the PTI document to ensure that the design conforms to PTI requirements and that conflicts do not occur between the referenced document and this specification. In

the event deviations from the PTI recommendations are necessary, the specification must be edited to clearly identify such deviations. For unusual conditions, the designer should also consult specialty contractorrs during the design process.

Rock and soil anchors may be used for temporary support or for permanent support. This specification must be carefully edited to reflect the design parameters applicable for the intended durability.

For projects requiring specialized methods or experience, particularly those which are primarily for installation of soil or rock anchors, consideration should be given to using a REQUEST FOR PROPOSAL (RFP) Method of procurement instead of an INVITATION FOR BIDS (IFB) Method. Use of RFP permits evaluation of offers on technical criteria in addition to price.

This guide specification is written for new construction where the anchor is installed after the structure is completed or for installing anchors in existing structures. Where the anchors must be installed and/or stressed prior to completion of the structure additional requirements will be necessary. Where pre-installation is required, means must be taken to protect the anchor components during the subsequent construction of the structure. If the anchors are to be stressed prior to completion of the structure, it may be necessary to stress the anchors against casings or other structures and transfer the load to the structure upon completion of construction.

Where the design of the structure to be anchored requires that the anchors be installed and stressed prior to construction of the new structure (i.e. where a new anchored wall is to be constructed to protect or support an existing wall which is not capable of resisting stressing loads), the anchors may be stressed against casings or a waler or thrust blocks may be used to distribute the load. In this case, the casing and rock socket must be designed to prevent deflection or excessive pulling of the casing into the rock during stressing. The design of the casing and rock socket must be included in the design computations. The casing must be seated into the rock socket and remain in place after grouting of the anchors.

Monitoring of stressing should include monitoring of movement of the casing.

Where anchors must be installed prior to construction of the new structure, the Contractor must adequately protect the anchor components during subsequent construction.

The following sentence should be included in paragraph FIELD QUALITY CONTROL, subparagraph GENERAL when the conditions apply or when stressing and testing the anchor is expected to cause significant movement of the structure such as:

a. Highly loaded anchors within the top 1.5 meters (5 feet) of the structure

b. High test loads on passive anchors

c. Anchors designed to support future loads which are much higher than current loads

"Stressing for [performance] [and] proof [and extended creep] tests shall be by a method which does not induce any stressing loads on the existing structure"

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1.1 UNIT PRICES

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NOTE: If Section 01 22 00.00 10 MEASUREMENT AND PAYMENT 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 22 00.00 10.

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1.1.1 Drilling Holes in Soil

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NOTE: This payment item will be used only when a prescriptive specification is desired. It will be deleted when a performance specification is desired.

****

1.1.1.1 Payment

Payment will be made for costs associated with Drilling Holes in Soil.

1.1.1.2 Measurement

Drilling Holes in soil will be measured for payment to the nearest 300 mm foot, based upon the meters linear feet of hole actually drilled in soil in accordance with the specifications.

1.1.1.3 Unit of Measure

Unit of measure: meter linear foot.

1.1.2 Drilling Holes in Rock

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NOTE: This payment item will be used only when a prescriptive specification is desired. It will be

deleted when a performance specification is desired.

****

1.1.2.1 Payment

Payment will be made for costs associated with Drilling Holes in Rock.

1.1.2.2 Measurement

Drilling Holes in Rock will be measured for payment to the nearest 300 mm foot, based upon the meters linear feet of hole actually drilled in rock in accordance with the specifications.

1.1.2.3 Unit of Measure

Unit of measure: meter linear foot.

1.1.3 [Soil] [Rock] Anchors

****

NOTE: This payment item will be used only when a prescriptive specification is desired. It will be deleted when a performance specification is desired.

****

1.1.3.1 Payment

Payment will be made for costs associated with furnishing and installing [Soil] [Rock] Anchors. No payment will be made for anchors which do not meet the acceptance criteria.

1.1.3.2 Measurement

[Soil] [Rock] Anchors will be measured for payment to the nearest 300 mm foot, based upon the meters linear feet of anchor actually installed below the bearing plate in accordance with the specifications.

1.1.3.3 Unit of Measure

Unit of measure: meter linear foot.

1.1.4 Performance Tests

1.1.4.1 Payment

Payment will be made for costs associated with performing Performance Tests on anchors which are accepted.

1.1.4.2 Measurement

Performance Tests will be measured based upon the number of tests performed.

1.1.4.3 Unit of Measure

Unit of measure: each.

1.1.5 Proof Tests

1.1.5.1 Payment

Payment will be made for costs associated with performing Proof Tests on anchors which are accepted.

1.1.5.2 Measurement

Proof Tests will be measured based upon the number of tests performed on anchors which are accepted in accordance with the specifications.

1.1.5.3 Unit of Measure

Unit of measure: each.

1.1.6 Creep Tests

1.1.6.1 Payment

Payment will be made for costs associated with performing Creep Tests on anchors which are accepted. No payment will be made for creep tests on anchors which do not meet the acceptance criteria.

1.1.6.2 Measurement

Performance Tests will be measured based upon the number of tests performed on anchors which are accepted in accordance with the specifications.

1.1.6.3 Unit of Measure

Unit of measure: each.

1.1.7 [Soil] [Rock] Anchors, Complete

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NOTE: This payment item will be used only when a performance specification is desired. It will be deleted when a prescriptive specification is desired.

If significant variation in length and/or type of anchors is anticipated, separate payment items should be considered for different ranges in anchor length.

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1.1.7.1 Payment

Payment will be made for costs associated with furnishing and installing [Soil] [Rock] Anchors, Complete which are accepted. The price shall include installation of anchors and proof testing as specified. No payment will be made for anchors which do not meet the acceptance criteria, except when failure is due to lower than assumed [soil-][rock-]grout bond strength or other information furnished by the Government.

1.1.7.2 Measurement

[Soil] [Rock] Anchors, Complete will be measured based upon the number of anchors installed and accepted in accordance with the specifications.

1.1.7.3 Unit of Measure

Unit of measure: each.

1.1.8 Watertightness Testing

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NOTE: This payment item will be deleted when watertightness testing is not required.
****

1.1.8.1 Payment

Payment will be made for costs associated with Watertightness Testing.

1.1.8.2 Measurement

Watertightness Testing will be measured for payment based upon the number of watertightness tests actually performed at the direction of the Contracting Officer and in accordance with the specifications or as otherwise required.

1.1.8.3 Unit of Measure

Unit of measure: each.

1.1.9 Pregrouting Holes

****
NOTE: This payment item will be deleted when watertightness testing is not required.
****

1.1.9.1 Payment

Payment will be made for costs associated with Pregrouting Holes [which fail] [prior to] watertightness testing.

1.1.9.2 Measurement

Pregrouting Holes will be measured for payment based upon the number of 94-pound bags of cement that were actually injected into the anchor hole as specified.

1.1.9.3 Unit of Measure

Unit of measure: bags (42 kg 94 lbs).

1.1.10 Redrilling Grouted Holes

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NOTE: This payment item will be deleted when watertightness testing is not required.
****

1.1.10.1 Payment

Payment will be made for costs associated with Redrilling Grouted Holes.

1.1.10.2 Measurement

Redrilling Grouted Holes will be measured for payment to the nearest 300 mm foot, based upon the meters linear feet of hole actually drilled in grout in accordance with the specifications.

1.1.10.3 Unit of Measure

Unit of measure: meter linear foot.

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 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.
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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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 252	(2009) Standard Specification for Corrugated Polyethylene Drainage Pipe

AMERICAN CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 301	(2010; Errata 2011) Specifications for Structural Concrete
ACI 301M	(2010) Metric Specifications for Structural Concrete
ACI 318	(2011; Errata 1 2011; Errata 2 2012; Errata 3-4 2013) Building Code Requirements for Structural Concrete and Commentary
ACI 318M	(2011; Errata 2013) Building Code Requirements for Structural Concrete &

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325	(2011) Steel Construction Manual

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 5CT	(2011; Errata 2012) Specification for Casing and Tubing

ASTM INTERNATIONAL (ASTM)

ASTM A108	(2013) Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A416/A416M	(2012) Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
ASTM A500/A500M	(2013) Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM A572/A572M	(2013a) Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A588/A588M	(2010) Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point, with Atmospheric Corrosion Resistance
ASTM A615/A615M	(2013) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A709/A709M	(2013a) Standard Specification for Structural Steel for Bridges
ASTM A722/A722M	(2012) Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
ASTM A775/A775M	(2007b) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A779/A779M	(2012) Standard Specification for Steel

	Strand, Seven-Wire, Uncoated, Compacted, Stress-Relieved for Prestressed Concrete
ASTM A882/A882M	(2004a; R 2010) Standard Specification for Filled Epoxy-Coated Seven-Wire Prestressing Steel Strand
ASTM A981/A981M	(2011) Standard Specification for Evaluating Bond Strength for 15.2 mm (0.6 in.) Diameter Prestressing Steel Strand, Grade 270, Uncoated, Used in Prestressed Ground Anchors
ASTM C109/C109M	(2013) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM C1107/C1107M	(2013) Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C144	(2011) Standard Specification for Aggregate for Masonry Mortar
ASTM C150/C150M	(2012) Standard Specification for Portland Cement
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D4101	(2011) Standard Specification for Polypropylene Injection and Extrusion Materials

POST-TENSIONING INSTITUTE (PTI)

PTI DC35.1	(2004) Recommendations for Prestressed Rock and Soil Anchors
PTI M10.2	(2000) Specifications for Unbonded Single Strand Tendons
PTI TAB.1	(2006) Post-Tensioning Manual

1.3 DEFINITIONS

The following definitions are in addition to those given in PTI DC35.1, Section 2.0:

1.3.1 Anchored Structure

The wall, foundation or other structure to which the anchor is to transfer force.

1.3.2 Demonstration Test Anchor

An anchor which is performance tested to verify design assumptions and installation practices.

1.4 SYSTEM DESCRIPTION

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NOTE: This guide specification may be used as a performance specification or a prescriptive specification by use of tailoring options. For the performance specification tailoring option, the Government provides the design loads, locations, minimum unbonded length, minimum bond lengths, soil- or rock-grout bond strength, corrosion protection requirements, and limitations on anchor inclination. The Contractor is then responsible for selecting the type of anchor and designing the anchor system to conform with the prescribed design criteria. In order to use the performance specification, sufficient foundation information must be given to permit the Contractor to accurately estimate the design and installation costs.For the prescriptive specification tailoring option, the design of the anchors must be completely shown on the drawings and must include location, design load, unbonded and bonded length, drilling and grouting method, drill hole size, corrosion protection, and anchor inclination.

****

Prior to commencing any work on the anchors, the Contractor, including all field personnel to be involved in drilling and installation of the anchors, shall meet with the Contracting Officer to review the drawings and specifications, work plans, and submittals. Drilling may commence upon approval of the anchor installation plan and procedures described in paragraph SUBMITTALS and after the conduct of the Preparatory Meeting.

1.4.1 General Requirements

Submit drawings and detailed installation procedures and sequences showing complete details of the installation procedure and equipment; anchor fabrication; grouting methods; grout mix designs; anchor [and casing] placement and installation; corrosion protection for bond length, stressing length and anchorage; anchorage and trumpet; stressing and testing procedures with lengths, forces, deformations, and elongations for the approval by the Contracting Officer. Shop drawings for anchors shall include locations and details of the spacers, centralizers, and banding.

If different types of anchors are to be installed, each anchor type shall be readily identifiable. Once reviewed by the Contracting Officer, no changes or deviation from shop drawings will be permitted without further review by the Contracting Officer. The work includes design, fabrication and installation of the [soil] [rock] anchor system. The anchors shall be fabricated and installed as shown on the drawings. Prepare fabrication and installation drawings and an installation plan for approval. [Soil] [Rock] anchors shall be [threaded bar] [or] [strand] type.

1.4.2 Scope of work

Provide the design of the [soil] [rock] anchor system that will be completely the Contractor's responsibility. General design criteria are [shown on the drawings] [given in paragraph Design Requirements]. The materials, design, stressing, load testing, and acceptance shall be in accordance with PTI DC35.1 and these specifications.

a. [Soil] [Rock] anchors may be threaded bar or strand type. The Contractor is responsible for the design of the anchor and bearing plate, [determining top of rock], determining drilling methods, and determining hole diameter and bond length. Submit design computations and data for the [soil] [rock] anchors, bearing plates, and bond zones.

b. The computations shall include drawings, design assumptions, calculations, and other information in sufficient detail to verify the design proposed. The design shall be certified by a registered Professional Engineer with proven experience in design of [soil] [rock] anchor components as stated in paragraph Qualifications. Calculations shall be included for the stressing frames.

c. The Contracting Officer will approve the design calculations. Approval of the design calculations will not relieve the Contractor of responsibility for unsatisfactory performance of the installed [soil] [rock] anchors. All design computations shall be furnished at least [30] [_____] calendar days prior to the proposed commencement of drilling. The complete design, including design computations, fabrication and installation drawings and installation plan, shall be certified by a registered Professional Engineer and shall be submitted for approval.

d. Submit a plan for installing the [soil] [rock] anchors for review and comment. The proposal shall describe the sequence for installation and other restrictions as outlined on the drawings or specified. The anchor [and casing] installation procedures shall be determined by the Contractor as part of the anchor design. The installation plan shall also include descriptions of methods and equipment to be used for alignment checking of anchor holes [and casings]. [Payment for rock anchors, as specified in Section 01 22 00.00 10 MEASUREMENT AND PAYMENT, shall include all costs in connection with designing, fabricating, and installing the anchors.]

1.4.3 Anchor Design

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NOTE: The following information must be provided to the Contractor to facilitate the design of the anchor system. The anchor location, Design Load (capacity) and angle of inclination will be determined by the design of the structure being

anchored. If the design load cannot be determined by the Designer, this determination may be assigned to the Contractor, in which case, the specification must be appropriately modified. The Contractor will also be required to redesign the anchored structure to the extent required to accommodate the anchor design loads. Assumed soil or rock to grout bond strength will be determined from testing of the soil or rock in which the anchors are to be installed. Minimum required bond length will be determined in accordance with PTI DC35.1, Section 6.7. Type of grouting material will be determined by site conditions and the structure being anchored. Type of corrosion protection required will be determined in accordance with PTI DC35.1, Section 5.4

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Design the individual [soil] [rock] anchors to meet the following criteria:

Anchor Location	as indicated
Horizontal [and] [Vertical] Spacing	[_____] m feet minimum, [_____] m feet maximum
Hole Diameter	[_____] mm inches minimum, [_____] mm inches maximum
Design Load	[_____] N kips
Assumed [Soil-][Rock-]Grout Bond Strength	[_____] MPa psi
Minimum Unbonded Length	[4.6] [_____] m [15] [_____] feet
Minimum Required Bond Length	[4.6] [_____] m [15] [_____] feet
Maximum Bond Length	[10.7] [_____] m [35] [_____] feet
Corrosion Protection	Class [I, Encapsulated Tendon] [II, Grout Protected Tendons]
Angle of Anchor Inclination	[_____] rad degrees from vertical [with a tolerance of ± [0.05] [_____] rad [3] [_____] degrees]

1.4.3.1 Design Load

The Design Load shall not exceed 60 percent of the ultimate strength of the prestressing steel. The Lock-off Load shall not exceed 70 percent of the ultimate strength of the prestressing steel. The maximum Test Load shall not exceed 80 percent of the ultimate strength of the prestressing steel. The designer should include consideration of group effect of closely spaced anchors when determining design load and minimum spacing. Design the bearing plates so that the bending stresses in the plate do not exceed the yield strength of the steel when a load equal to 95 percent of the minimum specified ultimate tensile strength of the prestressing steel is applied and so that the average bearing stress on the structure does not exceed [24.1] [_____] MPa [3500] [_____] psi. Design the anchorage assembly connection to the structure in accordance with [AISC 325] [ACI 318MACI 318].

1.4.3.2 Design Schedule

Submit a design schedule for the anchors which includes the following:

(1) Anchor number.
(2) Anchor design load.
(3) Type and size of tendon.
(4) Minimum total anchor length.
(5) Minimum bond length.
(6) Minimum tendon bond length.
(7) Minimum unbonded length.
(8) Details of corrosion protection, including details of anchorage and installation.
(9) Submit the design schedule at least 30 days prior to commencement of work on the anchors covered by the schedule.

1.5 SUBMITTALS

****
NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated 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 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, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Fabrication and Installation Drawings[; G][; G, [_____]]

SD-03 Product Data

Equipment
Designer Qualifications[; G][; G, [_____]]
Fabricator Qualifications[; G][; G, [_____]]
Installer Qualifications[; G][; G, [_____]]
Core Logging and Soil Sampling[; G][; G, [_____]]
Installation Plan[; G][; G, [_____]]

SD-05 Design Data

Design Computations[; G][; G, [_____]]
Anchor Design[; G][; G, [_____]]

SD-06 Test Reports

Prestressing Steel
Cement Grout Mixture Proportions

SD-07 Certificates

Prestressing Steel
Epoxy-Coated Steel Bars

SD-08 Manufacturer's Instructions

Polyester Resin Grout
Resin Grouted Anchors

SD-11 Closeout Submittals

Driller Logs
Anchor Records

1.6 QUALITY ASSURANCE

Submit anchor designer, fabricator and installer qualifications for approval in accordance with paragraph SUBMITTALS. The submittals shall, where applicable, identify individuals who will be working on this contract and their relevant experience. No changes shall be made in approved personnel without prior approval of the Contracting Officer.

1.6.1 Designer Qualifications

The anchors shall be designed by Professional Engineers who have designed a minimum [three] [_____] [soil] [rock] anchors projects similar in size and scope to this project within the past ten years. The drawings and calculations shall be signed by the Professional Engineer.

1.6.2 Fabricator Qualifications

The anchors shall be fabricated by a manufacturer that has been in the practice of designing and fabricating [soil] [rock] anchors similar in size and scope to this project for at least [ten] [_____] years.

1.6.3 Installer Qualifications

Submit the qualifications and experience records for approval. Experience records shall identify all the individuals responsible for the anchors and shall include a listing of projects of similar scope performed within the specified period along with points of contact. Qualifications prior to the installation of any anchors specified in this section. The anchors shall be installed by a firm which is regularly engaged in the installation of [soil] [rock] anchors and has at least [ten] [_____] years experience in the installation of similar anchors. The superintendent shall have installed anchors on at least five projects of similar scope and size.

[1.6.4 Core Logging and Soil Sampling

****
NOTE: Core logging and soil sampling should only be required when necessary to verify design assumptions or to provide additional foundation information.
****

Logging of core and preparation of drilling logs and records shall be performed by a [Registered] Geologist or Geotechnical Engineer who has at least [five] [_____] years experience in identifying and logging rock core and soil samples.

]1.7 DELIVERY, STORAGE, AND HANDLING

Materials shall be suitably wrapped, packaged or covered at the factory or shop to prevent being affected by dirt, water, oil, grease, and rust. Protect materials against abrasion or damage during shipment and handling. Place materials stored at the site above ground on a well supported platform and covered with plastic or other approved material. Materials shall be protected from adjacent construction operations. Grounding of welding leads to prestressing steel will not be permitted. Reject and remove from the site prestressing steel which is damaged by abrasion, cuts, nicks, heavy corrosions, pitting, welds or weld spatter. Inspect tendons prior to insertion into anchor holes for damage to corrosion protection. Any such damage shall be repaired in a manner recommended by the tendon manufacturer and approved by the Contracting Officer.

1.8 SITE CONDITIONS

****
NOTE: Where unique site conditions are anticipated, as evidenced by drilling performance such as loss of drill water, the information should be clearly presented on the drilling logs or otherwise made known to the Contractor. Generally, the plans and specifications should provide sufficient information to clearly identify anticipated foundation conditions. If, based on available information and site conditions, it is anticipated that additional foundation exploration will be required by the Contractor, this work should be added to the specifications.
****

A foundation investigation has been made at the site by the Government and data is presented on the foundation exploration drawings. [Logs of core

borings] [Subsurface soil data logs] are shown on the drawings. While the foundation information is representative of subsurface conditions at the respective locations, local variations in the characteristics of the subsurface materials may be anticipated. Local variations which may be encountered include, but are not limited to, classification and thickness of rock strata, fractures, and other discontinuities in the rock structure, and variation in the soil classifications. Such variations will not be considered as differing materially within the purview of the CONTRACT CLAUSES, paragraph Differing Site Conditions. [Core from the borings indicated] [Additional foundation data] are available for inspection as specified in the SPECIAL CONTRACT REQUIREMENTS, paragraph Physical Data. The Contractor is responsible for verifying the location of all utilities that may be affected by construction or the installation of the anchors.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Prestressing Steel

Submit certified test reports for each heat or lot of prestressing steel with materials delivered to the site. [Test reports for strands shall include bond capacity test results in accordance with ASTM A981/A981M.] Submit [5] [_____] copies of mill reports and [5] [_____] copies of a certificate from the manufacturer stating chemical properties, ultimate strengths, yield strengths, modulus of elasticity, and any other physical properties needed for the required computations, for the type of steel furnished.

2.1.1.1 High-Strength Steel Bars

ASTM A722/A722M, Type [I] [or] [II], meeting all supplementary requirements.

2.1.1.2 Epoxy-Coated Steel Bars

Submit written certification for coating material and coated bars with the delivery of the bars. ASTM A722/A722M, Type [I] [or] [II], conforming to the coating requirements of ASTM A775/A775M, 0.3 mm 8 mils minimum thickness. Coating at the anchorage end may be omitted over the length provided for threading the nut against the bearing plate.

2.1.1.3 Steel Bar

[ASTM A615/A615M] [ASTM A108, Grade []].

2.1.1.4 Strand

ASTM A416/A416M, Grade [1725] [1860] [250] [270], low relaxation strand. Strand shall not be welded.

2.1.1.5 Compact Strand

ASTM A779/A779M, Type [1790] [1860] [260] [270], low relaxation strand. Strand shall not be welded.

2.1.1.6 Epoxy Coated Strand

ASTM A882/A882M, Grade [1725] [1860] [250] [270], including Supplementary Requirements S1.

2.1.2 Structural Steel

ASTM A36/A36M [ASTM A572/A572M, Grade 345 50] [ASTM A588/A588M] [ASTM A709/A709M Grade [248] [345] [36] [50]].

2.1.3 Steel Pipe

ASTM A53/A53M, Type E or S, Grade B.

2.1.4 Steel Tube

[ASTM A500/A500M] or [API Spec 5CT, Grade N-80, Oil Field Seconds / Mill Secondary Tubing].

2.1.5 Ductile Iron Castings

ASTM A536.

2.1.6 Polyethylene Tubing

2.1.6.1 Smooth Polyethylene Tubing

[ASTM D3350] [ASTM D1248, Type III].

2.1.6.2 Corrugated Polyethylene Tubing

AASHTO M 252, with average minimum wall thickness of 1.5 mm 0.06 inch.

2.1.7 Smooth Polypropylene Tubing

ASTM D4101, designation PP 210 B5542-11.

2.1.8 Polyvinyl Chloride (PVC) Pipe

ASTM D1785, Schedule 40.

2.1.9 Polyvinyl Chloride (PVC) Tubing

2.1.9.1 Smooth Polyvinyl Chloride (PVC) Tubing

ASTM D1784.

2.1.9.2 Corrugated Polyvinyl Chloride (PVC) Tubing

Manufactured from rigid PVC compounds conforming to ASTM D1784, Class 13464-8 with average minimum wall thickness of 1.0 mm 0.04 inch.

2.1.10 Heat Shrinkable Sleeve

Radiation crosslinked polyolefin tube internally coated with and adhesive sealant.

2.1.11 Corrosion Inhibiting Compound

The corrosion inhibiting compound shall conform to the requirements of Section 3.2.5 of PTI M10.2.

2.2 MANUFACTURED UNITS

2.2.1 Anchor Head

Anchor head shall consist of [steel bearing plate with wedge plate and wedges for strand anchors] [or] [steel bearing plate with nut for bar anchors], trumpet and corrosion protection. Anchorage devices shall be capable of developing 95 percent of the guaranteed ultimate strength of prestressing steel. The anchorage devices shall conform to the static strength requirements of Section 3.1.6 (1) and Section 3.1.8 (1) and (2) of PTI TAB.1. [Wedges shall be designed to not cause premature failure of the prestressing steel due to notching or pinching. Provide special wedges as required for epoxy coated strand. Removal of epoxy coating to permit use of standard wedges will not be permitted.] [Threaded anchorage items for epoxy coated bars shall be designed to fit over the epoxy coating and maintain the capacity of the prestressing steel.] The trumpet used to provide a transition from the anchorage to the unbonded length corrosion protection shall be fabricated from steel pipe or steel tube. The minimum wall thickness shall be 3.0 mm for diameters up to 100 mm and 5.0 mm for larger diameters 0.125 inch for diameters up to 4 inches and 0.20 inch for larger diameters. The trumpet shall be welded to the bearing plate.

2.2.2 Prestressing Steel Couplers

[Prestressing steel couplers for bars shall be capable of developing 100 percent of the minimum specified ultimate tensile strength of the prestressing steel.] [Splicing of strand will not be permitted.]

2.2.3 Centralizers and Spacers

Centralizers [and spacers] shall be fabricated from plastic, steel or other approved material which is nondetrimental to the prestressing steel. Wood shall not be used. The centralizer shall be able to support the tendon in the drill hole and position the tendon so a minimum of 13 mm 0.5 inch of grout cover is provided. Centralizers and spacers shall permit grout to freely flow up the drill hole.

2.2.4 Casing

Casing shall be [steel pipe] [or] [steel tube] [selected and sized by the Contractor where required. Casing shall be the necessary type and size to permit proper drilling of anchor holes and placing of anchors as specified herein and shown on the drawings. Straightening of casings and machining of joints may be necessary in order to meet specified alignment tolerances.]

2.2.5 Anchorage Covers

****

NOTE: When the anchorage recess is to remain open, delete the last sentence. If anchor head has 75 mm (3 inches) or more of concrete or non-shrink grout cover, the anchorage cover may be eliminated and the anchorage coated to prevent corrosion.

****

Fabricate anchorage covers from steel or plastic. The material used shall not be subject to attack by cement, corrosion-inhibiting greases or the environment. If plastic is used, it shall not be susceptible to ultraviolet light degradation. Securely attach the cover to the bearing

plate. If the cover is to be grease filled, the cover shall form a permanent watertight enclosure for the anchorage device.

2.3 EQUIPMENT

The Contractor's Quality Control manager shall verify that the equipment used on site is the same as the equipment submitted for approval. Submit catalog cuts, brochures, or other descriptive literature describing the equipment to be used for drilling, grouting, handling, and installing the [soil] [rock] anchors. Submit sketches, drawings or details showing the access and temporary supports where required for the drilling equipment and stressing frames. Provide descriptions of stressing jacks, gages, dynamometers, load cells, or other devices for measuring stressing load, certified calibration records for each set of jacking equipment, and current testing curves for stress measurement gages which show that gages have been calibrated for the jacks for which they are used [30] [_____] days prior to the start of the testing operations.

2.3.1 Drilling Equipment

Provide drilling equipment suitable for advancing the drill tools to the depths and at the alignment [specified][required].

2.3.2 Grouting Equipment

2.3.2.1 Grout Mixer

The grout mixer shall be a high-speed, high-shear, colloidal type grout mixer capable of continuous mechanical mixing that will produce uniform and thoroughly mixed grout which is free of lumps and undispersed cement. The mixer shall be equipped with a suitable water [and admixture] measuring device[s] calibrated to read in cubic centimeters cubic feet and tenths and so designed that after each delivery the hands can be conveniently set back to zero.

2.3.2.2 Grout Pump

The grout pump shall be of the positive displacement type, and shall be capable of pumping at all flow rates below [75] [_____] L/minute [20] [_____] gpm, shall be capable of pumping at the pressure of at least 345 [_____] kPa [50] [_____] psi at zero flow rate. For neat cement grout, the pump shall have a screen with [3] [_____] mm [0.125] [_____] inch maximum clearance to sieve the grout before being introduced into the pump. Screens are not required for shear type mixers. Make available a pump which is capable of pumping both neat cement grout mixes and sanded grout mixes. The pumping equipment shall have a pressure gage capable of measuring pressures of at least 1.0 MPa 150 psi or twice the required grout pressure, whichever is greater.

2.3.3 Stressing Equipment

Stressing equipment shall be hydraulically operated and shall have a capacity sufficient to stress the anchors to the [specified][required] Test Loads within the rated capacity in one stroke. Pumps shall be capable of applying each load increment in less than 60 seconds and shall be capable of maintaining the hydraulic pressure within 345 kPa 50 psi. The equipment shall permit stressing of the tendon in increments and raising or lowering the load in the tendon. [Stressing equipment for strands shall be capable of stressing all elements equally and simultaneously.] The equipment shall

be calibrated with an accuracy of ±2 percent and the calibration certificate and graphs shall be available at the site. The production gage shall have graduations of 500 kPa 100 psi or less. A second certified gage shall be maintained for periodic verification of the production gage. A dial gage or approved device shall be provided to measure total tendon elongation at each load increment to the nearest 0.03 mm 0.001 inch. The dial gage shall be capable of measuring the entire anchor movement without being reset. Calibration of gages shall be verified no more than 30 calendar days prior to commencing work under this contract and at six-month intervals throughout the period of use.

2.3.4 Testing Equipment

Provide testing equipment consisting of a hydraulic jack with calibrated pressure gage for applying the load and a dial gage or vernier scale to measure anchor movement. The ram travel of the stressing equipment shall be not less than the theoretical elastic elongation of the total anchor length at the maximum Test Load. The pressure gage shall be graduated in [500] [_____] kPa [100] [_____] psi increments. The stressing equipment and pressure gage must have been calibrated as a unit no more than 30 calendar days prior to commencing work under this contract and at six-month intervals throughout the period of use. The movement measuring device shall have a minimum travel equal to the theoretical elastic elongation of the total anchor length at the maximum Test Load without resetting the device.[An approved dial gage or vernier scale and stand shall be provided to measure movement of the [wall] [structure].]

2.4 GROUT

2.4.1 Cement

****
NOTE: When the ambient rock temperature is below 10 degrees C (50 degrees F), Type III cement may be necessary.
****

ASTM C150/C150M, Type I, II, III or V.

2.4.2 Water

Provide fresh, clean, potable water free from injurious amounts of sewage, oil, acid, alkali, salts, or organic matter.

2.4.3 Aggregates

Fine aggregate for sand-cement grout shall conform to ACI 301MACI 301 and [ASTM C33/C33M for grout for backfilling holes] [or ASTM C144 for grout for pregrouting]. Aggregates shall not contain substances which may be deleteriously reactive with alkalis in the cement.

2.4.4 Admixtures.

****
NOTE: Accelerators are not permitted because of concern that they may cause corrosion of the prestressing steel. Only plasticizers or retarders should be permitted when necessary for hot conditions or long pumping distances.

****

Admixtures which control bleed, improve flowability, reduce water content and retard set may be used in the grout subject to the approval of the Contracting Officer. Any admixtures used shall be compatible with the prestressing steel and shall be mixed in accordance with the manufacturer's recommendations.

2.4.5 Grout for Anchors

****

NOTE: Ground and rock ambient temperatures may only have an effect on the grout when they are below 10 degrees C (50 degrees F) or when polyester resin grout is used. If unusual ground or rock temperatures are known to exist, this information should be provided to the Contractor

****

2.4.5.1 Cement Grout

Cement grout mixture proportions are the responsibility of the Contractor. Submit the mixture proportions that will produce grout of the quality required, thirty days prior to installation of anchors. Provide applicable test reports to verify that the grout mixture proportions selected will produce grout of the quality specified. Grout for grouting anchors shall consist of a homogenous, pumpable, stable mixture of portland cement and water. Submit the proposed mix design to the Contracting Officer for approval. The water content shall be the minimum necessary for proper placement but the water-cement ratio shall not exceed [0.45] [_____] by weight. Final proportions of materials shall be based on results of tests made on sample mixtures of grout. The minimum compressive strength of two-inch cubes, molded, cured, and tested in accordance with ASTM C109/C109M, shall be [24.1] [_____] MPa [3,500] [_____] psi at the time of stressing. The Contractor is responsible for taking, curing, and breaking of grout test cubes for determining mix design, and all testing shall be done by an independent laboratory approved by the Contracting Officer. [[Soil] [Rock] conditions and temperatures shall be replicated in the curing process.]

2.4.5.2 Polyester Resin Grout

****

NOTE: Polyester resin grout should not be used for anchors installed in wet holes. Single stage grouting can be accomplished with polyester resin grout by using fast setting resin grout in the bond zone and slower setting resin grout in the free stressing zone. The cure times of the resin grout will be affected by ground or rock ambient temperatures.

****

Polyester resin grout shall consist of high strength, unsaturated polyester resin filled with nonreactive, inorganic aggregate and a separated catalyst contained in a tube of polyester film or glass. Gel time and cure time shall be appropriate for the installation procedures. The polyester resin grout shall have the following minimum properties:

Compressive Strength	83 MPa 12000 psi
Tensile Strength	27.6 MPa 4000 psi
Shear Strength	20.7 MPa 3000 psi

Resin cartridges with expired shelf life are not allowed.

2.4.6 Sand-Cement Grout

****
NOTE: Where an excessive volume of neat cement grout is required for pregrouting holes or grouting holes which fail watertightness tests, sand-cement grout may be used. The first option for grout mix is suitable for normal applications. When a specific strength grout is required, the second option should be used.
****

Grout for waterproofing holes, grouting holes which fail the watertightness test, and for backfilling holes which are abandoned shall consist of a mixture of portland cement, [fine aggregate][masonry sand] and water. [The grout shall consist of one part portland cement and two parts fine aggregate by volume, mixed with sufficient water to provide a uniform consistency.] [The grout mix proportions are the responsibility of the Contractor. Submit the proposed mix design to the Contracting Officer for approval. The water content shall be the minimum necessary for proper placement. Final proportions of materials shall be based on results of tests made on sample mixtures of grout. The minimum compressive strength of two-inch cubes, molded, cured, and tested in accordance with ASTM C109/C109M, shall be [27.6] [_____] MPa [4,000] [_____] psi.] The Contractor is responsible for taking, curing, and breaking of grout test cubes for determining mix design, and all testing shall be done by an independent laboratory approved by the Contracting Officer. [[Soil] [Rock] conditions and temperatures shall be replicated in the curing process.]

2.4.7 Grout for Anchor Pads

Use nonshrink grout conforming to ASTM C1107/C1107M for leveling bearing plates.

2.5 TENDON FABRICATION

****
NOTE: The tendon consists of the prestressing steel, anchorage, corrosion protection, centralizers and spacers, and sheathing where required. For fully bonded anchors, the free stressing length is grouted after stressing. For unbonded anchors, the free stressing length is provided with bond breaker to prevent bonding with the grout or two-stage grouting is performed.
****

2.5.1 General

Fabrication of the anchors shall be as recommended by the suppliers.

Anchors shall be completely assembled with all [centralizers], [spacers], grout and vent tubes and corrosion protection prior to insertion into the hole. Fabricated anchors shall be protected, transported and stored in a manner to prevent contamination or damage to any components.

2.5.2 Tendon

All spacers for multiple element tendons shall be located as indicated on the approved shop drawings. Furnish strands full length with no splicing or coupling permitted. Tendon material shall be unblemished and free of pitting, nicks, grease, or injurious defects. When required to maintain the tendon location within the hole, provide centralizers at a maximum of [3] [_____] meter [10] [_____] foot intervals center-to-center throughout the bond length. [Spacers shall be provided at a maximum [3] [_____] meter [10] [_____] foot intervals center-to-center throughout the bond length.] The entire bond length of the tendon shall be free of dirt, lubricants, loose rust, corrosion-inhibiting coatings or other contaminants.

2.5.3 Bond Breaker

Bond breaker for free stressing length of unbonded anchors shall consist of smooth polyethylene tubing, minimum wall thickness 1 mm 0.04 inch, or smooth PVC tubing, minimum wall thickness 1.0 mm 0.04 inch.

2.5.4 Vent Tubes

Vent tubes used during grouting operations, if necessary, shall be any appropriate type for the job, as recommended by the supplier of the anchors.

2.5.5 Grout Tubes

Grout tubes shall be polyethylene tubing or as recommended by the anchor manufacturer and approved by the Contracting Officer. Inside diameter of grout tubes shall be adequate to fully grout the entire hole.

2.5.6 Corrosion Protection

****
NOTE: Type of corrosion protection required will be determined in accordance with PTI DC35.1, Paragraph 5.3. Fusion bonded epoxy coatings may contain holidays and may be damaged during fabrication and installation, therefore epoxy coating should not be relied on to provide adequate corrosion protection. The grout or encapsulation must be included in the corrosion protection design. The paragraphs on encapsulation will be included for Class I (Encapsulated Tendon) corrosion protection. Additional corrosion protection may not be required for temporary anchors.
****

Corrosion protection shall be as indicated. Corrosion protection shall be provided for the entire anchor and shall include anchorages covers and trumpets filled with corrosion inhibiting compound or grout and encapsulation of the free stressing length and bond length.

2.5.6.1 Anchorage Protection

****
NOTE: Compound filled trumpets should only be used for restressable anchors or anchors with permanent load cells.
****

The trumpet shall be sealed to the bearing plate and shall overlap the free stressing length encapsulation by at least 100 mm 4 inches. The trumpet and anchorage cover shall be completely filled with corrosion inhibiting compound or grout. Compound filled trumpets shall have a permanent seal between the trumpet and the free length corrosion protection.

2.5.6.2 Free Stressing Length Encapsulation

****
NOTE: Encapsulation of the free stressing length is intended to provide corrosion protection in the free stressing length. If corrugated tubing or heat shrinkable sleeve is used for encapsulation for unbonded anchors, a separate bond breaker must be used.
****

Encapsulation for free stressing length shall consist of a sheath of smooth polyethylene tubing, minimum wall thickness 1.5 mm 0.06 inch; smooth polypropylene tubing, minimum wall thickness 1.5 mm 0.06 inch; smooth PVC tubing, minimum wall thickness 1.0 mm 0.04 inch; steel pipe or tube with minimum wall thickness 5.0 mm 0.20 inch or corrugated tubing conforming to paragraph Bond Length Encapsulation. Sheath for bars and strands may be heat shrinkable sleeve with a minimum thickness of 0.6 mm 0.024 inch. Free stressing length encapsulation shall extend at least 100 mm 4 inches into the trumpet, but shall not contact the bearing plate during testing and stressing of the tendon. [Where corrugated tubing is used for sheath for unbonded anchors, a separate bond breaker shall be provided.]

2.5.6.3 Bond Length Encapsulation

****
NOTE: Encapsulation of the bond length for Class I (Encapsulated Tendon) corrosion protection is intended to provide corrosion protection in the bond zone and transfer stresses from the prestressing steel through the grout. For Class II (Grout Protected Tendons) corrosion protection, the grout provides the only corrosion protection in the bond zone, and separate encapsulation will not be specified.
****

Bond length encapsulation shall consist of corrugated polyethylene tubing, minimum wall thickness 1.5 mm 0.060 inch or corrugated PVC tubing, minimum wall thickness 1.0 mm 0.040 inch.

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

Perform required material tests, on prestressing steel and accessories, by an approved laboratory to demonstrate that the materials are in conformance

with the specifications. Test grout in accordance with ASTM C109/C109M. These tests shall be at the Contractor's expense. Furnish to the Contracting Officer prestressing steel test results prior to beginning fabrication of any anchors and within 24 hours of testing.

PART 3 EXECUTION

3.1 DRILLING HOLES

3.1.1 General

****

NOTE: If redesign of anchored structures due to relocation of anchors is to be performed by the Contractor, the appropriate design criteria must be furnished by the Government.

Limitations on distance between grout holes and holes being drilled is based on prevention of washout of fresh grout by drill water. The actual distance, if required, should be determined on the basis of integrity of the rock and whether or not the hole was pregrouted.

When environmental considerations require containment and disposal of waste water, the last two sentences should be included and the work should be coordinated with Section 01 57 20.00 10 ENVIRONMENTAL PROTECTION.

****

The [top of bond zone elevations] [and other] physical conditions indicated on the drawings are the result of [soil sampling] [and] [core borings]. (See also paragraph "PROJECT SITE CONDITIONS"). Holes shall be drilled at the locations and inclinations shown and to the depths and diameters determined by the Contractor to provide the design bond length and capacity indicated on the drawings. The locations of the holes may be changed only as approved by the Contracting Officer. Any redesign of the [anchored structure] [_____] due to relocation of anchor holes [will be performed by the Government] [shall be performed by the Contractor]. Unless otherwise specified, theThe Contractor shall determine the drilling method to be used. No holes shall be drilled within [15] [_____] meters [50] [_____] feet of a grouted hole until the grout has set at least 24 hours. [Pressure grouting and drilling shall not be simultaneously performed within a distance of [15] [_____] meters [50] [_____] feet.] Care shall be taken while drilling to avoid damage of any kind to the existing structures. Damages of any nature will be evaluated by the Contracting Officer and repairs or replacements shall be made as required. Holes shall be drilled a maximum of [1] [_____] meter [3] [_____] feet beyond the required anchor bond length. Provide a temporary plug for all holes drilled more than 10 days prior to installation of the anchor. [Waste water from drilling operations shall be collected and recycled or treated; it shall not be discharged directly into the [river] [water] or on the ground. See also Section 01 57 20.00 10 ENVIRONMENTAL PROTECTION].

3.1.2 Drilling Through Existing Structures

****

NOTE: Core drilling through existing structures

should only be required where close tolerances are required or where vibrations from other drilling methods might be objectionable.

****

Holes through existing structure shall be drilled by [core drilling equipment to prevent][any method which does not cause] damage to the surrounding structure. The Contractor is advised that foreign material, including metals and other materials remaining from original construction of the existing structure, may be encountered during drilling through existing structures.

3.1.3 Drilling In Soil

****

NOTE: Where loss of surrounding material could endanger nearby structures, the casing should be advanced by methods which preclude removal of material surrounding the casing, such as use of duplex method with annular flow of drill water or fluid between the inner drill string and the casing.

****

Holes in soil may be drilled by rotary drilling, rotary percussive, or vibratory driven casing. Holes in soil shall be provided with steel casing where required for support of the surrounding material. [Casing shall be removed [prior to] [during] anchor grouting.] [Hollow-stem augers which are used for installation of the tendon shall be removed during anchor grouting.] Where soil is susceptible to caving, holes through soil shall be drilled by the duplex method using an inner and outer casing with return water flow between the casings.

3.1.4 Casing

****

NOTE: Casing may also be required to span voids when drilling through existing structures.

****

Casing shall be utilized for drilling through unstable soil formations [and] [_____]. The casing shall be advanced by [rotary drilling] [or] [driving].

[3.1.5 Drilling in Rock

****

NOTE: Core drilling is more expensive and slower than other drilling methods and should be specified only where excessive vibration could endanger existing structures or would otherwise be objectionable, where it is expected that embedded items will be encountered in an existing structure, or as otherwise determined by the designer to be necessary. Anchor holes which are core drilled may require overdrilling with a roller bit or other approved means to roughen the circumference of the hole to promote bond with the grout. Where existing foundation information is not complete, e.g. when anchoring existing structures, it may be advisable

to require core drilling for initial (demonstration test) anchor holes in each area to determine the nature of the rock material and permit determination of actual hole depths. If sufficient foundation information cannot be provided to permit the Contractor to estimate design and installation of the anchors prior to bidding, the prescriptive tailoring option should be used.

****

Unless otherwise specified, holesHoles in rock may be drilled by core drilling, rotary drilling, percussion drilling or down-the-hole hammer using equipment suitable for the intended purpose. [The drilling method shall not cause structural damage to existing structures. If damage is observed, the drilling method shall be modified.][Core drilling shall be performed with rotary drilling equipment using diamond-matrix coring bits.] [Core from holes shall be furnished to the Contracting Officer in core boxes at the site for information. Additional drilling may be required based on the quality of the rock encountered. Rock core from demonstration test anchor holes only shall be retained by the Contractor for the duration of the contract as specified in paragraph "Retention of Core". Retention of core from other holes, after evaluation and release by the Contracting Officer, is not required.] Overdrilling of holes by a maximum of one meter three feet beyond the required elevation will be permitted if complete removal of cuttings and other material cannot be accomplished. If the hole is overdrilled, the tendon must be supported so that the free length corrosion protection extends the required length into the trumpet and so that the anchor can be stressed.

]3.1.6 Records

****

NOTE: If core recovery and logging is required to verify design assumptions or to provide additional foundation information, Section 02 32 00 SUBSURFACE DRILLING, SAMPLING, AND TESTING should be included in the project, or applicable portions should be inserted into this specification.

****

Submit driller logs and records as specified in paragraph Driller Logs. The presence of a Government inspector or the keeping of separate drilling records by the Contracting Officer shall not relieve the Contractor of the responsibility for the work specified in this paragraph. Payment will not be made for any work for which the required records have not been furnished by the Contractor.

3.1.7 Alignment

****

NOTE: The specifier should consult PTI DC35.1, paragraph 7.3.5. Tolerances are governed by project-specific requirements. The practical lower bound is 0.01 rad (0.5 degree).

****

3.1.7.1 Tolerances

The anchor hole shall be located within [300] [_____] mm [12] [_____] inches

of the plan location. The entry angle shall be within [0.05] [_____] rad [3] [_____] degrees of the specified inclination. The alignment of the drilled hole shall be within [0.05] [_____] rad [3] [_____] degrees of the theoretical alignment. If the hole alignment is not within these tolerances, the hole shall be backfilled with cement or sand-cement grout and a new hole drilled adjacent to the rejected hole.

[3.1.7.2 Alignment Check

****
NOTE: Alignment checks are rarely performed for soil anchors. Alignment check should only be required when the actual alignment of the anchor is critical to the design of the structure. Situations where alignment is critical include: anchors through structures with voids or embedded items, where there is a possibility that anchors could intersect each other, and where the purpose of the anchors is overturning resistance.
****

Check each drilled hole for alignment as specified herein upon completion of drilling and before commencement of any other work. Check direction and inclination of all anchor holes for each [3-meter 10-foot] [_____] intervals throughout the hole. Checking the alignment of each anchor hole shall be done by measuring the inclination of the actual drilled anchor hole center line in place with respect to the specified anchor center line. The specified anchor center line shall consist of a single, straight, continuous line extending from the top of the hole to the required bottom elevation of the hole. Specified anchor centerlines shall slope at the inclinations shown on the drawings. The Contracting Officer shall have access to holes for alignment surveys that may include, but not be limited to, slope indicators or other down-the-hole equipment. Drill rods may be required to be removed from the hole or left in place as directed by the Contracting Officer. Holes, or portions of holes, which are out of alignment shall be corrected or filled with cement grout having a water-cement ratio of 0.40 or sand-cement grout, and a new hole drilled as directed by the Contracting Officer. Slight adjustments to inclinations indicated on the drawings may be required, as directed by the Contracting Officer. The Contractor is responsible for all drilled holes until accepted by the Contracting Officer. Holes to replace incorrectly drilled holes shall be drilled at no additional cost to the Government. All equipment for checking alignment of anchor holes shall be operated by personnel experienced in the operation of such equipment.

][3.1.7.3 Alignment Checking Equipment

****
NOTE: Because of the expense involved, the down-hole gyrocompass should only be used when there is a reasonable anticipation that embedded metal will be encountered within the structure in sufficient mass to affect the magnetic compass. In such case, an appropriate payment item for a cost per day should be included.
****

Check alignment of holes by means of a magnetic single shot survey instrument, or equal equipment. The camera and plumb-bob assembly shall be

selected based on the maximum expected range of angle deviation to be measured. [If embedded metal within the structure is reasonably believed to have affected the standard magnetic compass, then a down-hole gyrocompass may be required. Payment for use of the gyrocompass will be made at the contract unit price per day.]

][3.1.8 Watertightness Testing

****
NOTE: Anchor holes should be watertight to prevent loss of grout from the rock zone, prevent dilution of grout prior to setting, and prevent corrosion of the tendon. Watertightness testing should be performed where any of the following conditions are known to occur or where sufficient data is not available to adequately determine the integrity of the rock:

a. the rock formation has open fractures which would permit loss of grout from around the prestressing steel after initial placement.
b. artesian water flow or seepage exists in the strata where the rock anchor is located.
c. interconnection exists between drilled holes.

Watertightness testing may be performed after drilling the hole or after pregrouting the hole. Where the rock is known to be highly fractured, pregrouting and redrilling should be considered prior to watertightness testing.
****

The rock portion of all drilled holes shall be watertightness tested in accordance with the procedures of PTI DC35.1, paragraph 7.4. A packer shall be used where necessary to facilitate pressure testing of the bond zone. Holes which have a water loss in excess of [9.5] [_____] liters [2.5] [_____] gallons in ten minutes shall be grouted as specified in paragraph Waterproofing Anchor Holes, and redrilled.

][3.1.9 Waterproofing Anchor Holes

****
NOTE: Where the rock is known to be fractured or have interconnections, pregrouting of the hole prior to watertightness testing may be required. Where the rock in the free stressing zone is fractured and where the anchor is installed through unconsolidated material, a packer will be required to properly grout the rock. Waterproof grouting of anchor holes should only be done with a Government representative present to avoid overruns in the amount of grout used. When cement grout take is excessive, a sand-cement grout should be used.
****

The rock portion of anchor holes which fail the watertightness test shall be [tremie] [pressure] grouted with cement grout as specified in paragraph Grout for Waterproofing or Backfilling Holes. [A packer shall be installed at the top of rock.] Grouted holes shall be redrilled while the grout

strength is considerably less than that of the surrounding rock, but not less than [24] [_____] hours after grouting. [If the grout take for the hole exceeds [_____] bags of cement, grouting with cement shall be stopped and the hole shall be grouted with a sand-cement grout.]

]3.2 INSTALLATION OF ANCHORS

3.2.1 General

****

NOTE: Demonstration test anchors should be designated to verify the Contractor's installation methods and design assumptions. Demonstration test anchors should be installed and approved prior to drilling for other anchors represented by the anchor to facilitate changes which may be required in anchor depth or drilling techniques. Demonstration test anchors must be performance tested to verify capacity. The last sentence should only be included when verification of anchor bond length is needed prior to installation of production anchors.

****

The Contractor is responsible for each drilled hole until the anchor has been installed, grouted, stressed and accepted. Holes in rock and casings shall be cleaned by pressurized air and/or water to remove drill cuttings and mud. [The anchors designated as demonstration test anchors shall be installed and tested prior to drilling the bond zone for other anchors within the area represented by the demonstration test anchor.]

3.2.2 Placing

All the equipment used in handling and placing the anchors shall be such that it does not damage or deteriorate the prestressing steel, corrosion protection, or the anchorages. Each anchor shall be inspected prior to insertion into the hole. Any damage to corrosion protection shall be repaired prior to insertion or, if determined by the Contracting Officer to be not repairable, the anchor shall be replaced. Insertion of anchors shall be in accordance with PTI DC35.1.

[3.2.3 Resin Grouted Anchors

Insertion of resin-grouted anchors shall be in accordance with the resin manufacturer's written recommendations and recommendations for hole diameter, cartridge selection, and tendon installation and rotation prior to installing the anchors. Tendons shall be inserted until contact is made with the first cartridge. The tendon shall then be rotated and advanced at the rate recommended by the resin grout manufacturer. After reaching its final position, the tendon shall be rotated as recommended by the resin grout manufacturer to ensure complete mixing of the resin.

]3.2.4 Cement Grouted Rock Anchors

****

NOTE: Single stage grouting requires the use of a bond breaker on the tendon in the free stressing zone to prevent bonding of the grout to prestressing steel in the stressing zone. When two-stage grouting is required, the specification must be

modified to reflect the additional grouting step. [Second stage grouting shall be performed after the anchor is stressed, tested, and locked off.]

Rock anchors are normally gravity grouted, however, in weak or weathered rock pressure grouting may be used to increase rock-grout bond, to consolidate the foundation or to provide a grout curtain to restrict flow of water through the rock. When pressure grouting is required, the specification shall include the required grouting pressure. This grouting would normally take place during the waterproofing of the holes.

When the ambient rock temperature is known to be below 10 degrees C (50 degrees F), the provisions of ACI 306R should be added.

****

Grouting equipment shall be of type and capacity required for successful installation of the rock anchors. All anchors shall use single stage grouting to encase the anchor. Grouting shall be performed by a method in accordance with PTI DC35.1, paragraph 7.6. Grouting shall commence at the bottom of the grout zone and proceed to the top of the zone. Grouting shall be gravity flow. [The casing shall be withdrawn as the grouting proceeds.]

3.2.5 Grouting of Soil Anchors

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NOTE: Soil anchors in cohesive soils will have somewhat higher bond strengths when pressure grouted. Soil anchors in cohesionless soils may have significantly higher bond strengths depending on the type of soil. Since the installation and grouting procedures for soil anchors are highly dependent on the specific soil conditions, the procedure should be left to the discretion of the Contractor to meet the performance criteria. When a specific grouting procedure is required to develop the design capacity, the procedure should be included in this paragraph.

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Within the bond length, grout placement shall proceed such that the hole is filled in a manner to prevent air voids. The soil anchor hole shall be progressively filled with grout and maintained completely full from bottom to top of the zone until the grout has set. Grouting of a soil anchor hole shall be performed within 48 hours of the time the hole is drilled. Grouting may be accomplished through the casing pipe, grout tubes, hollow-stem augers or hollow drill rods. The grouting procedure used shall provide soil anchors which meet the specified design capacity. Post-grouting will normally result in higher bond values.

3.2.5.1 Gravity Grouting

Gravity grouting shall proceed from the bottom of the hole to the top of the [bond zone] [hole].

3.2.5.2 Pressure Grouting

The method of pressure grouting shall be determined by the Contractor and proven in the demonstration anchor. Production anchors shall be grouted using the methods and target pressures that were used on the acceptable demonstration anchor. Grouting pressures and pumping rates shall be controlled to prevent ground surface heave or fracturing. Grouting pressures shall be incrementally increased until a refusal is reached or an acceptable amount of grout is pumped.

3.2.5.3 Post-Grouting

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NOTE: Post-grouting is performed using grout tubes with special check valves in the grouting zone which are installed with the tendon. Post-grouting may be utilized as additional pressure grouting after initial grout has set to increase the bond values for anchors. It may also be used, when post-grouting tubes have been installed, for increasing the bond values of anchors which fail load tests. The maximum grouting pressure is determined by the pressure-volume characteristics of the soil. Three phases of post-grouting is considered to be the practical limit.
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The number of phases of post-grouting shall be determined by the Contractor and proven in the demonstration anchor. Production anchors shall be grouted using the methods and target pressures that were used on the acceptable demonstration anchor. Grouting pressures and pumping rates shall be controlled to prevent ground surface heave or fracturing. Grouting pressures shall be incrementally increased until a refusal is reached or an acceptable amount of grout is pumped.

3.2.6 Anchorage Installation

The bearing plate and [anchor head] [nut] shall be installed perpendicular to the tendon, within [0.05] [_____] rad [3] [_____] degrees, and centered on the tendon without bending of the stressing steel. [Wedges, wedge holes and tendons shall be free of dirt, grout or other contaminants.] [Corrosion protection shall be maintained intact at the anchorage and any damage shall be repaired prior to stressing.]

3.3 STRESSING

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NOTE: The lock-off loads should be a function of the structure being anchored and tolerable or anticipated movements for loading changes on the structure that will cause load changes on the anchor. Typically, lock-off loads are equal to or slightly higher than design loads. The last sentence should only be included when verification of anchor length is needed prior to installation of production anchors.
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3.3.1 General Requirements

After the anchor grout [in the bond zone] has reached sufficient strength in accordance with the Contractor's designthe specified strength, as verified by grout cube break, the anchors shall be stressed. Prior to stressing, surfaces upon which the stressing equipment is resting must be clean and the stressing equipment shall be aligned as nearly with the center of the hole as possible. An Alignment Load of [10] [_____] percent of the Design Load shall be applied to the anchor prior to setting dial gauges. Stress the anchor in accordance with the anchor manufacturer's recommendation, subject to the approval of the Contracting Officer. Design and Lock-off loads are given on the drawings. Determine the lock-off procedure so that the lift-off results meet the acceptance criteria specified in paragraph Acceptance. The maximum stress shall never exceed 80 percent of the guaranteed ultimate strength of anchor steel. The process of stressing the anchors shall be so conducted that accurate elongation of the anchor steel can at all times be recorded and compared with the computations submitted to, and accepted by the Contracting Officer. [Stressing elements of strand anchors shall be stressed simultaneously.] Safety precautions shall be taken to prevent workers from being [behind] [or in front of] the stressing equipment during stressing. Stressing of the anchors shall be performed in a sequence submitted by the Contractor for review by the Contracting Officer. All stressing shall be done in the presence of a representative of the Contracting Officer. At no time during the stressing and testing of an anchor shall the stressing equipment be disconnected from the temporary stressing head or anchor. [Each anchor to be performance tested shall be declared acceptable before proceeding with drilling for other anchors within the section [type] represented by that anchor.]

3.3.2 Lock-off

After completion of the all required tests, the load shall be returned to the Alignment Load and the specified Lock-off Load shall be applied to the anchor. A lift-off test shall be made to verify the load in the anchor tendon before the tendon is locked-off and the stressing equipment is removed. The lift-off reading shall be within five percent of the specified lock-off load. If the lift-off reading is not within five percent of the specified lock-off load, the anchorage shall be reset and another lift-off reading shall be made. This procedure shall be repeated until a satisfactory lift-off reading is obtained. After lock-off, the trumpet shall be filled with [grout] [corrosion inhibiting compound] and [the anchor head protective cap shall be installed][the anchorage recess shall be fully grouted flush with the adjacent surfaces].

3.4 FIELD QUALITY CONTROL

The first three anchors and a minimum of 2 percent of the remaining anchors shall be designated as demonstration test anchors. designated demonstration test anchors shall be used to verify [top of rock elevation,] [rock] [soil] quality and the adequacy of the Contractor's anchor design and installation procedures. Demonstration test anchors shall pass the performance test prior to placing other anchors within the the section represented by the respective demonstration test anchor. All other anchors shall be proof tested. During the stressing of each anchor, a record shall be kept of gage pressure and of anchor elongation at each stage of stressing to the specified test or Lock-off Load, as applicable. The Test Load shall not be exceeded. Provide a qualified engineer to evaluate the anchor test results and determine the acceptability of the anchors in

accordance with the criteria indicated hereunder. Final acceptance of each anchor will be made by the Contracting Officer. All tests shall be run in the presence of the Contracting Officer or his representative.

3.4.1 Performance Test

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NOTE: Performance tests cannot be performed on fully-grouted resin-grouted anchors. The slow setting resin cartridges can not be installed for resin-grouted anchors which are to be performance tested and provision must be made for grouting the free stressing length if the anchors are to be used as production anchors.
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Performance test shall consist of cyclically and incrementally loading and unloading the anchor, and shall be conducted in accordance with PTI DC35.1, Paragraph 8.3.2. During the testing of each anchor, a record shall be kept of gage pressure and of anchor elongation at each stage of stressing to each Test Load required by PTI DC35.1. Measurements of the elongation of prestressing steel shall be made in accordance with PTI DC35.1. If the total movement at the end of 10 minutes at the Test Load exceeds 1 mm 0.040 inch, the Test Load shall be held an additional 50 minutes and the movement readings shall be taken at the interval specified in PTI DC35.1, Paragraph 8.3.2. Test records, including plots and graphical analysis of test data, shall be furnished upon acceptance of each performance tested anchor in accordance with paragraph SUBMITTALS.

3.4.2 Proof Test

Proof test shall consist of incrementally loading the anchor and shall be conducted in accordance with PTI DC35.1, Paragraph 8.3.3. During the testing of each anchor, a record shall be kept of gage pressure and of anchor elongation at each stage of stressing to the Test Load required by PTI DC35.1. Measurements of the elongation of prestressing steel shall be made in accordance with PTI DC35.1. If the total movement at the end of 10 minutes at the Test Load exceeds 1 mm 0.040 inch, the Test Load shall be held an additional 50 minutes and the movement readings shall be taken at the interval specified in PTI DC35.1, Paragraph 8.3.3. Test records, including plots and graphical analysis of test data, shall be furnished upon acceptance of each proof tested anchor in accordance with paragraph SUBMITTALS. The proof test results shall be compared with similar anchors in which performance tests have been performed. If any significant variation from the proof tests occurs, the Contracting Officer may require additional performance tests.

3.4.3 Supplementary Extended Creep Test

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NOTE: Rock anchors installed in competent rock normally do not exhibit time-dependent movement and do not require extended creep test. However, decomposed or weak argillaceous rock may exhibit creep, and extended creep test should be considered. At least 2 extended creep tests should be performed on permanent anchors in soils with a Plasticity Index greater than 20.
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Where specified, anchors shall have an extended creep test performed. Creep test shall consist of cyclically and incrementally loading and unloading the anchor, and shall be conducted in accordance with PTI DC35.1, Paragraph 8.3.4. Each maximum load shall be held in accordance with PTI TAB.1, Table 8.3.4. A plot of each family of creep curves shall be submitted along with the recorded readings taken at time of the test.

3.4.4 Driller Logs

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NOTE: This paragraph should be used when a record of the drilling is desired for verification of design assumptions or to document the actual conditions encountered. The list of information must be edited to reflect the work involved (rock or soil anchor, core drilling, drilling methods, etc.

This paragraph includes a reference to DRILLING LOG, ENG FORM 1836 and 1836A. The forms, or appropriate local equivalent, must be added by the specifier.
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Submit the original handwritten log and three (3) copies in typed format within two days of the completion of each hole. Keep accurate driller logs and records of all work accomplished under this contract and deliver complete, legible copies of these logs and records to the Contracting Officer upon completion of the work or at such other time or times as he may be directed. All such records shall be preserved in good condition and order by the Contractor until they are delivered and accepted, and the Contracting Officer shall have the right to examine such records at any time prior to their delivery. Separate logs shall be made for each hole. Use DRILLING LOG, ENG FORM 1836 and 1836A [or other approved form which provides the required information] for his logs. The following information shall be included on the logs or in the records for each hole:

a. Hole number or designation and elevation of top of hole.

b. Inclination of the hole.

c. Make and manufacturer's model designation of drilling equipment.

d. Dates and time when drilling operations were performed.

e. Time required for drilling each run.

f. Elevation of top of rock.

g. Steel casing seat elevation.

h. Depths and elevations at which core was recovered or attempts made to core including top and bottom depth of each run.

i. Geologic classification or description by depths of each stratigraphic unit cored. This classification or description shall be made immediately following the taking of the core.

j. Percentage of core recovered and rock quality designation per run.

k. Depth and elevation of rod drops and other unusual occurrences.

l. Depth and elevation at which groundwater is encountered.

m. Depths and elevations at which drill water is lost and regained and amounts.

n. Depth and elevation of bottom of hole, determined by measuring the drill steel length.

3.4.5 Anchor Records

Upon completion of installation of each anchor, the anchor records shall be furnished to the Contracting Officer with [watertightness test results and report of remedial action taken,] [top of bond zone elevation,] bond length, free stressing length of anchor, grout mix, grouting pressure, bags of cement injected, [and] a report of performance test or proof test [and extended creep test] results, [and hole alignment surveys]. The performance test, proof test [and extended creep test] results shall include measured lengths of drill holes and anchors, the loads and elongations recorded during testing, monitoring and stressing of the anchors, and graphs of test results.as specified in paragraph SUBMITTALS. In addition as-built drawings showing the completed installation of the anchors shall be furnished upon completion of installation of all anchors.

3.5 ACCEPTANCE

3.5.1 General

Acceptance of anchors shall be determined by the Contracting Officer. The following criteria will be used in determination of the acceptability of each anchor:

3.5.1.1 Creep

Creep movement shall not exceed 1 mm 0.040 inch at maximum Test Load during the first 10 minutes of the performance or proof test. If the creep movement exceeds this limit, it shall not exceed 2 mm 0.080 inch at the maximum Test Load at the end of 60 minutes. If the creep movement exceeds 2 mm 0.080 inch at the maximum Test Load at the end of 60 minutes, the anchor shall be rejected.

3.5.1.2 Movement

Apparent free length shall be calculated from the observed elastic movement in accordance with PTI DC35.1, Section 8.3.2.

3.5.1.2.1 Minimum Apparent Free Length

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NOTE: If the anchor is not returned to the Alignment Load after testing, only total movement data will be available. In this case, only the minimum apparent free length criteria will apply.
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The calculated free length shall be not less than [80] [_____] percent of the designed free tendon length plus the jack length. If the anchor does not meet this criteria, the anchor shall be restressed from the Alignment

Load to the Test Load and the apparent free length shall be recalculated. If the anchor does not meet this criteria after 3 attempts (original plus 2 restresses), the anchor shall be rejected.

3.5.1.2.2 Maximum Apparent Free Length

The calculated free length shall be not more than 100 percent of the designed free tendon length plus 50 percent of the bond length plus the jack length. If the anchor does not meet this criteria, and the cause of the behavior is not investigated and explained to the satisfaction of the Contracting Officer, the anchor shall be rejected.

3.5.1.3 Initial Lift-Off Reading

The initial lift-off reading shall be within 5 percent of the specified Lock-off Load. If the anchor does not meet this criteria, the anchor shall be adjusted as necessary and the lift-off reading shall be repeated.

3.5.2 Replacement of Rejected Anchors

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NOTE: For redesign of anchored structure due to relocation of anchor, see note at paragraph DRILLING HOLES, General.
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Any anchor that fails the performance or proof test or is rejected by the Contracting Officer shall be replaced. A replacement anchor, including a new anchor hole, shall be provided by the Contractor at no expense to the Government. The location of the replacement anchor shall be as [directed by the Contracting Officer] [determined by the Contractor in accordance with the redesign of the anchored structure]. Provide all materials, supplies, equipment, and labor necessary to provide a new anchor assembly to the satisfaction of the Contracting Officer. No drilling shall be performed for a replacement anchor until the grouting of all rock anchors within [15] [_____] meters [50] [_____] feet of the replacement anchor location has been allowed to set for at least 24 hours. Payment will not be made for rejected or failed anchors. Either remove failed anchors and thoroughly ream and clear the anchor hole or remove the load and cut the anchor and casing flush.

-- End of Section --