
USACE / NAVFAC / AFCEA UFGS-03372 (February 2004)

Preparing Activity: USACE (CW) Superseding
UFGS-03372 (September 2001)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Latest change indicated by CHG tags

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DIVISION 03 - CONCRETE

SECTION 03372

PREPLACED-AGGREGATE CONCRETE

02/04

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SECTION 03372

PREPLACED-AGGREGATE CONCRETE 02/04

NOTE: This guide specification covers the requirements for furnishing, hauling, and preplacing aggregate concrete incidental to the drilling and the grouting.

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.

PART 1 GENERAL

NOTE: The content of this specification is such that guidance given in EM 1110-2-2000, "Standard Practice for Concrete", is applicable.

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 211.1 | (1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete |
| ACI 214R | (2002) Evaluation of Strength Test Results of Concrete |
| ACI 305R | (1999) Hot Weather Concreting |

ASME INTERNATIONAL (ASME)

- | | |
|--------------|---|
| ASME B36.10M | (2001) Welded and Seamless Wrought Steel Pipe |
|--------------|---|

ASTM INTERNATIONAL (ASTM)

- | | |
|---------------------|---|
| ASTM C 1064/C 1064M | (2003) Temperature of Freshly Mixed Portland Cement Concrete |
| ASTM C 1077 | (2003) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation |
| ASTM C 1107 | (2002) Packaged Dry, Hydraulic-Cement Grout (Nonshrink) |
| ASTM C 117 | (2003) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing |
| ASTM C 123 | (2003) Lightweight Particles in Aggregate |
| ASTM C 127 | (2001) Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate |
| ASTM C 128 | (2001e1) Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate |
| ASTM C 131 | (2003) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| ASTM C 136 | (2001) Sieve Analysis of Fine and Coarse Aggregates |
| ASTM C 142 | (1997) Clay Lumps and Friable Particles in Aggregates |

ASTM C 150	(2002ae1) Portland Cement
ASTM C 171	(2003) Sheet Materials for Curing Concrete
ASTM C 231	(2003) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2001) Air-Entraining Admixtures for Concrete
ASTM C 295	(2003) Petrographic Examination of Aggregates for Concrete
ASTM C 309	(2003) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 39/C 39M	(2003) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40	(1999) Organic Impurities in Fine Aggregates for Concrete
ASTM C 441	(2002a) Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction
ASTM C 494/C 494M	(1999ae1) Chemical Admixtures for Concrete
ASTM C 535	(2003e1) Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	(1997) Total Evaporable Moisture Content of Aggregate by Drying
ASTM C 618	(2003) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 666	(2003) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C 87	(2003) Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C 937	(1997) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C 938	(1997) Proportioning Grout Mixtures for Preplaced-Aggregate Concrete
ASTM C 939	(2002) Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C 943	(2002) Making Test Cylinders and Prisms for Determining Strength and Density of Preplaced-Aggregate Concrete in the

Laboratory

ASTM C 989	(1999) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM D 4791	(1999) Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2004) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices
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U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 114	(1997) Test Method for Soundness of Aggregates by Freezing and Thawing of Concrete Specimens
COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 318	(1979) Federal Specification for Cloth, Burlap, Jute (or Kenaf)
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 94	(1966) Specification for Surface Retarders

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-03 Product Data

Grout Mixture Proportioning

Grout mixture proportions shall be determined by the Contractor and submitted for review. The grout mixture quantities of all ingredients per cubic meter yard and grading of the fine aggregate size that will be used in the manufacture of each quantity of concrete shall be stated. Proportions shall indicate that mass of cement, [pozzolan], [slag, Ground Granulated Blast-Furnace Slag (GGBF)], and water; the mass of the fine aggregate in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce preplaced-aggregate concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the new quality of materials and concrete are satisfactory.

Grout Mixer Capacity

The Contractor shall submit grout-mixer data which include the make, type, and capacity of grout mixers, grout agitators, tank, pump, and pipe system proposed for producing the grout for preplaced-aggregate concrete.

Equipment

The pumping equipment and methods for pumping and delivering the grout for preplaced-aggregate concrete shall be submitted for review by the Contracting Officer. The methods for transporting,

handling, and depositing the coarse aggregate, the location, arrangement, and size of the pipe and inserts, sequence of pumping, method of withdrawal of injection pipe, and the rate of grout injection shall be included in the submittal. Methods for venting of air from under embedded projections shall be submitted.

Vibrators

The Contractor shall submit data which include the size, frequency, and amplitude of the external vibrators for review.

Testing and Quality Verification for Contractor Quality Control

The Contractor shall submit statements that the concrete testing technicians and the concrete inspectors meet the specified requirements.

Curing and Protection[; G][; G, [_____]]

The curing medium and methods to be used shall be submitted for review and approval.

Cold-Weather Placing[; G][; G, [_____]]

If preplaced-aggregate concrete is to be placed under cold-weather conditions, the proposed materials, methods, and protection meeting the requirements of paragraph COLD-WEATHER PLACING OF PREPLACED-AGGREGATE CONCRETE shall be submitted for approval.

Hot-Weather Placing[; G][; G, [_____]] Finishing[; G][; G, [_____]]

If preplaced-aggregate concrete is to be placed under hot-weather conditions, the proposed materials and methods, meeting the requirements of paragraph HOT-WEATHER PLACING OF PREPLACED-AGGREGATE CONCRETE and paragraph FINISHING, shall be submitted for review and approval by the Contracting Officer.

SD-04 Samples

Aggregates[; G][; G, [_____]] Cementitious Materials, Admixtures, and Curing Compound[; G][; G, [_____]]

Samples of materials for Government testing and approval shall be submitted as required in paragraph PRECONSTRUCTION SAMPLING AND TESTING.

SD-06 Test Reports

Quality of Aggregates[; G][; G, [_____]]

Aggregate quality test results shall be submitted at least 30 days prior to start of preplaced-aggregate concrete placement, in accordance with paragraph QUALITY OF AGGREGATES.

Testing and Quality Verification for Contractor Quality Control

Contractor quality control test results and inspection reports shall be submitted daily and weekly as required in paragraph REPORTS.

SD-07 Certificates

NOTE: Delete the requirements for certificates for
air-entraining admixtures, other chemical
admixtures, curing compounds, portland cement, and
pozzolan if the optional parts of paragraph
CEMENTITIOUS MATERIALS, ADMIXTURES, AND CURING
COMPOUND are used.

[Cementitious Materials

Cementitious Materials, including Cement and Pozzolan, and Ground Granulated Blast-Furnace Slag will be accepted on the basis of the manufacturer's certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. Certification and mill test reports shall be from samples taken from the particular lot furnished. No cementitious materials shall be used until notice of acceptance has been given by the Contracting Officer. Cementitious materials will be subject to check testing from samples obtained at the mill, at transfer points, or at the project site, as scheduled by the Contracting Officer, and such sampling will be by or under the supervision of the Government at its expense. Material not meeting specifications shall be promptly removed from the site of work.]

Impervious-Sheet Curing Materials

Impervious-Sheet Curing Materials shall be certified for compliance with all specification requirements.

[Air-Entraining Admixture

Air-Entraining Admixture shall be certified for compliance with all specification requirements.]

Nonshrink Grout

Nonshrink Grout shall be certified for compliance with all specification requirements.

[Grout Fluidifier

Grout Fluidifier shall be certified for compliance with specification requirements.]

[Membrane-Forming Curing Compound

Membrane-Forming Curing Compound shall be certified for compliance with all specification requirements.]

1.3 UNIT PRICES

NOTE: If Section 01270A 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 01270A.

1.3.1 Preplaced-Aggregate Concrete

1.3.1.1 Payment

Payment will be made for all costs associated with unloading, handling, and storage of all aggregate, cement, [pozzolan,] fluidifier, and chemical admixture used in the work, including all costs of labor and the use of all equipment, tools, 150 by 300 mm 6 inch by 12 inch cylinder molds, and other materials required to complete the work, excluding cost of reinforcement and embedded parts which are specified to be paid for separately.

1.3.1.2 Measurement

Preplaced-Aggregate Concrete will be measured for payment based on the actual volume placed within the paylines of the structures as indicated.

1.3.1.3 Unit of Measure

Unit of measure: cubic meter yard.

1.4 GOVERNMENT TESTING AND STUDIES

1.4.1 Preconstruction Sampling and Testing

1.4.1.1 Aggregates

NOTES: The Designer should consult the appropriate DM, identify the sources for aggregates, and include them in the Aggregate Sources Template attached to the end of this section. Contact the Division Laboratory for information to fill in the blanks below.

The aggregate sources listed at the end of this section have been tested and at the time testing was performed were capable of producing materials of a quality required for this project, provided suitable processing is performed. The Contractor may furnish materials from a listed source or from a source not listed. Samples from any source of coarse aggregate and any source of fine aggregate selected by the Contractor, consisting of not less than [70] [_____] kg [150] [_____] pounds of each coarse aggregate and [35] [_____] kg [75] [_____] pounds taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100 shall be delivered to [_____] within 15 days after notice to proceed. Sampling and shipment of samples shall be at the Contractor's expense. [_____] days will be required to complete evaluation of the aggregates. Testing will be performed by and at the expense of the Government in accordance with COE

CRD-C 114 or ASTM test methods. The cost of testing one source for each size of aggregate will be borne by the Government. If the Contractor selects more than one source for each aggregate size or selects a substitute source for any size aggregate after the original source was tested, the cost of that additional testing will be borne by the Contractor. Tests to which aggregate may be subjected are listed in paragraph QUALITY. The material from the proposed source shall meet the quality requirements of this paragraph. The Government's test data and other information on aggregate quality of those sources listed at the end of this section are included in the Design Memorandum and are available for review in the district office. Quality Assurance testing of aggregates by the Government does not relieve the Contractor of quality control requirements as outlined in paragraph TESTING AND QUALITY VERIFICATION FOR CONTRACTOR QUALITY CONTROL.

1.4.1.2 Cementitious Materials, Admixtures, and Curing Compound

NOTE: When the optional sentence below is deleted, the corresponding manufacturer's certification described in the paragraph SUBMITTALS should be used. EM 1110-2-2000, "Standard Practice for Concrete", provides guidance in selecting the options for Government or for Contractor testing.

At least 60 days in advance of concrete placement, the Contractor shall notify the Contracting Officer of the source of materials, along with sampling location, brand name, type, and quantity to be used in the manufacture and/or curing of the concrete. [Sampling and testing will be performed by and at the expense of the Government except as otherwise specified. No material shall be used until notice has been given by the Contracting Officer that test results are satisfactory. The Government will sample and test other chemical admixtures, curing compounds, and cementitious materials].

a. Chemical Admixtures - Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing shall be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if test results are not satisfactory. Chemical admixtures will be accepted based on compliance with the requirements in paragraph CHEMICAL ADMIXTURES.

[b. Cement and Pozzolan - If cement or pozzolan is to be obtained from more than one source, the initial notification shall state the estimated amount to be obtained from each source and the proposed schedule of shipments.]

NOTE: Delete this paragraph if materials are to be accepted on the basis of a manufacturer's certification of compliance and mill test reports, and the optional submittals under SD-07 Certificates in paragraph SUBMITTALS will be used. See the appropriate DM or consult the Materials Engineer to select prequalified sources, (1) and (2), sealed bins, (3) and (4), or both options, (1), (2), (3), and (4). Selection of the sealed bin method,

subparagraphs (3) and (4), must be fully justified
in the appropriate DM.

[(1) Prequalified Cement Sources

Cement shall be delivered and used directly from a mill of a producer designated as a qualified source. Samples of cement for check testing will be taken at the project site or concrete-producing plant by a representative of the Contracting Officer for testing at the expense of the Government. A list of prequalified cement sources is available from Director, U.S. Army Engineer Waterways Experiment Station (USACE-WES), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, ATTN: CEWES-SC.]

[(2) Prequalified Pozzolan Sources

Pozzolan shall be delivered and used directly from a producer designated as a qualified source. Samples of pozzolan for check testing will be taken at the project site by a representative of the Contracting Officer for testing at the expense of the Government. A list of prequalified pozzolan sources is available from the Director, USACE-WES, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, ATTN: CEWES-SC.]

[(3) Nonprequalified Cement Sources

**NOTE: To fill in the blank for cost of testing
excess cement, contact the Structures Laboratory,
Concrete Technology Division, WES.**

Cement, if not from a prequalified source, will be sampled at the source and stored in sealed bins pending completion of testing. Sampling, testing, and the shipping inspection from the point of sampling, when the point is other than at the site of the work, will be made by or under the supervision of the Government and at its expense. No cement shall be used until notice has been given by the Contracting Officer that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor, at his expense. When the point of sampling is other than at the site of the work, the fill gates of the sampled bin and conveyances used in shipment will be sealed under Government supervision and kept sealed until shipment from the bin has been completed. If tested cement is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing cement excess to project requirements shall also be at the expense of the Contractor. The charges for testing cement at the expense of the Contractor will be deducted from the payments due the Contractor at a rate of [_____] dollars per ton of cement represented by the tests.]

[(4) Nonprequalified Pozzolan Sources

Pozzolan, if not from a prequalified source, will be sampled at the source and stored in sealed bins pending completion of certain tests. Pozzolan will also be sampled at the site when determined

necessary. All sampling and testing will be by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with 7-day lime-pozzolan strength requirements and other physical and chemical and uniformity requirements for which tests can be completed by the time the 7-day lime-pozzolan strength test is completed. Release for shipment and approval for use on the above basis will be contingent on continuing compliance with the other requirements of the specifications. If a bin fails, the contents may be resampled and tested at the Contractor's expense. In this event, the pozzolan may be sampled as it is loaded into cars, trucks, or barges provided they are kept at the source until released for shipment. Unsealing and resealing of bins and sealing of shipping conveyances will be done by or under the supervision of the Government. Shipping conveyances will not be accepted at the site of the work unless received with all seals intact. If pozzolan is damaged in shipment, handling, or storage, it shall be promptly removed from the site of the work. Pozzolan that has not been used within 6 months after testing shall be retested at the expense of the Contractor when directed by the Contracting Officer and shall be rejected if the test results are not satisfactory. If tested pozzolan is rehandled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing excess pozzolan shall be at the Contractor's expense at a rate of [_____] cents per ton of pozzolan represented by the test. The amount will be deducted from payment to the Contractor.]

1.4.2 Construction Testing by Government

The Government will sample and test aggregates, grout, and preplaced-aggregate concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of placement in accordance with COE CRD-C 100. Grout will be sampled after the agitator and tested for flow in accordance with ASTM C 939 and air content in accordance with ASTM C 231. Unconfined compressive strength test specimens will be made and cured in accordance with ASTM C 943 and tested in accordance with ASTM C 39/C 39M.

1.5 RELATED WORK SPECIFIED ELSEWHERE

1.5.1 Concrete Accessories

Steel bars, welded steel wire fabric and accessories for concrete reinforcement shall comply with Section 03201 STEEL BARS AND WELDED WIRE FABRIC FOR CONCRETE REINFORCEMENT.

1.5.2 Concrete Formwork

Concrete formwork shall comply with Section 03100A STRUCTURAL CONCRETE FORMWORK.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

NOTE: See the appropriate DM to select the proper requirements for the Cementitious Materials Options. Other cementitious materials may be added if specifically recommended and approved in the concrete materials DM.

Cementitious materials shall be portland cement or portland cement in combination with pozzolan [or [____]] and shall conform to appropriate specifications listed below.

2.1.1.1 Portland Cement

ASTM C 150, Type I or II, except that the maximum amount of tricalcium aluminate (C3A) in Type I cement shall be 15 percent [including the heat of hydration at 7 days] [including false set requirements] [low alkali when used with aggregates listed at the end of this section which require it.] [In lieu of low-alkali cement, the Contractor may use a combination of portland cement that does not meet the low-alkali requirement with a pozzolan or slag provided the following requirement is met. The expansion of the proposed combination when tested in accordance with ASTM C 441 shall be equal to or less than the expansion of a low-alkali cement meeting the requirements of ASTM C 150 when tested in general conformance with ASTM C 441. The expansion tests shall be run concurrently at an independent laboratory that is nationally recognized to perform such tests. The Government reserves the right to confirm the test results and to adjust the percentage of pozzolan or slag in the combination to suit other requirements.]

2.1.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618, Class [C], [F], [N], with the optional requirements for multiple factor, drying shrinkage, and uniformity of Table 2A. Table 1A requirement for maximum alkalies shall apply when used with aggregates listed at the end of this section to require low-alkali cement.

2.1.1.3 [Ground Granulated Blast-Furnace Slag

Ground Granulated Blast-Furnace Slag shall conform to ASTM C 989, Grade [____].]

2.1.2 Aggregates

2.1.2.1 General

NOTE: The list of sources and required tests and test limits will be taken from the concrete materials DM.

Concrete aggregates may be furnished from any source capable of meeting the quality requirements as stated in paragraph QUALITY. The sources listed at the end of this section were evaluated during the design phase of the project in [] and were found at that time capable of meeting the quality requirements when suitably processed. No guarantee is given or implied that any of the listed sources are currently capable of producing aggregates that meet the required quality stated in paragraph QUALITY. A Design Memorandum containing the results of the Government investigation and test results is available for review in the [] district office. Contact [] at [] to arrange for review of the memorandum. The test results and conclusions shall be considered valid only for the sample tested and shall not be taken as an indication of the quality of all material from a source nor for the amount of processing required.

2.1.2.2 Fine-Aggregate Grading

The grading and uniformity of the fine aggregate shall conform to the following requirements as delivered to the grout mixer:

U. S. STANDARD SIEVE SIZE	PERCENT BY MASS, PASSING
2.36 mm (No. 8)	100
1.18 mm (No. 16)	95 - 100
600 μ m (No. 30)	55 - 80
300 μ m (No. 50)	30 - 55
150 μ m (No. 100)	10 - 30
75 μ m (No. 200)	0 - 10

In addition to the grading limits specified above, the fine aggregate shall have a fineness modulus of not less than 1.30 nor more than 2.10. The grading of the fine aggregate shall also be controlled so that the fineness moduli of at least four of any five consecutive test samples shall not vary more than 0.15 from the average fineness modulus of all samples previously taken.

2.1.2.3 Coarse-Aggregate Grading

The grading of the coarse aggregate shall conform to the following requirements:

U. S. STANDARD SIEVE SIZE	PERCENT BY MASS, PASSING	
	19.0 mm (3/4 in.) to 37.5 mm (1-1/2 in.)	37.5 mm (1-1/2 in.) to 75 mm (3 in.)
75 mm (3 in.)		95 - 100
50 mm (2 in.)	100	20 - 55
37.5 mm (1-1/2 in.)	95 - 100	0 - 5
25.0 mm (1 in.)	40 - 80	0 - 2
19.0 mm (3/4 in.)	20 - 45	
12.5 mm (1/2 in.)	0 - 5	
9.5 mm (3/8 in.)	0 - 2	

2.1.2.4 Coarse-Aggregate Particle Shape

The quantity of flat and elongated particles of the coarse aggregate, as defined and determined by ASTM D 4791, shall not exceed 25 percent.

2.1.2.5 Concrete Aggregate Sources

NOTE: If an aggregate source is provided by the
Government, the appropriate paragraphs from
UFGS-03700 MASS CONCRETE should be used.

- a. List of Sources - The concrete aggregates sources may be selected from sources listed at the end of this section.
- b. Selection of Source - After the award of the contract, the Contractor shall designate in writing only one source or combination of sources from which he proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or from sources not listed at the end of this section, he may designate only a single source or single combination of sources for aggregates. Regardless of the source, selected samples for acceptance testing shall be provided as required by paragraph GOVERNMENT TESTING AND STUDIES. If a source for coarse or fine aggregates so designated by the Contractor does not meet the quality requirements stated in paragraph QUALITY, the Contractor may not submit for approval other nonlisted sources but shall furnish the coarse or fine aggregate, as the case may be, from sources listed at the end of this section at no additional cost to the Government.

2.1.2.6 Coarse-Aggregate Quality

NOTES: The tests selected should be those which are
applicable to the concrete to be used in the
project. These tests may include those listed below
in addition to others not listed. See Chapter 2 of
EM 1110-2-2000 for discussion of tests.

A list of properties and test values are unique to
each project and should be taken from the concrete
materials design memorandum. Delete the quality
tests not required in the DM.

The petrographic examination shall be used to
identify deleterious substances in aggregates.
Deleterious substances shall be listed individually
with respective limits.

Depending upon the quality of aggregates available,
some tests may not be required. Refer to EM
1110-2-2000 for the purpose of each test.

Aggregates delivered to the mixer shall meet the following requirements:

PROPERTY	TEST LIMITS		TESTS
	FINE AGGREGATE	COARSE AGGREGATE	
Specific Gravity	[_____]	[_____]	ASTM C 127 ASTM C 128

PROPERTY	TEST LIMITS		TESTS
	FINE AGGREGATE	COARSE AGGREGATE	
Absorption	[_____]	[_____]	ASTM C 127 ASTM C 128
[Durability Factor	[_____]	[_____]	COE CRD-C 114 ASTM C 666]
[Clay Lump and Friable Particles	[_____]	[_____]	ASTM C 142]
[Material Finer than 75- μ m (No.200) Sieve	[_____]	[_____]	ASTM C 117]
[Organic Impurities	Not darker than No. 3 Not less than 95 percent	[_____]	ASTM C 40 ASTM C 87]
[L.A. Abrasion	[_____]	[_____]	ASTM C 131 ASTM C 535]
[Soft Particles	[_____]	[_____]	COE CRD-C 130]
[Petrographic Examination	List unwanted deleterious materials and their limits	[_____]	ASTM C 295]
[Chert, less than 2.40 specific gravity]	[_____]	[_____]	ASTM C 123
[Coal and Lignite, less than 2.00 specific gravity]	[_____]	[_____]	ASTM C 123

2.1.3 Chemical Admixtures

Chemical admixtures to be used, when required or permitted, shall conform to the appropriate specification listed.

2.1.3.1 Air-Entraining Admixture

The air-entraining admixture shall conform to ASTM C 260.

2.1.3.2 Grout Fluidifier

Grout fluidifier shall conform to ASTM C 937.

2.1.3.3 Water-Reducing or Retarding Admixtures

Water-reducing or retarding admixtures shall meet the requirements of ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived.

2.1.4 Curing Materials

2.1.4.1 Impervious-Sheet Curing Materials

Impervious-sheet curing materials shall conform to ASTM C 171, type optional, except polyethylene film shall not be used.

2.1.4.2 Membrane-Forming Curing Compound

Membrane-forming curing compound shall meet the requirements of ASTM C 309, Type 1-D or 2, except a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted. The curing compound selected shall be compatible with any subsequent paint specified. Nonpigmented compound shall contain a fugitive dye and shall have the reflective requirements in ASTM C 309 waived.

2.1.4.3 Burlap

Burlap used for curing shall conform to COE CRD-C 318.

2.1.5 Water

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that nonpotable water may be used if it meets the requirements of COE CRD-C 400.

2.1.6 Nonshrink Grout

Nonshrink grout shall conform to ASTM C 1107 and shall be a commercial formulation suitable for the application proposed.

2.2 GROUT MIXTURE PROPORTIONING

Grout mixture proportioning shall meet the following requirements.

2.2.1 Quality of Mixture

For each portion of the structure, mixture proportions shall be selected so that the strength and water-cement ratio requirements listed in paragraph DESIGN REQUIREMENTS are met. The source of materials and proportions of portland cement, [pozzolan], fluidifier, fine aggregate, and water shall be stated. The grout proportions for the preplaced-aggregate concrete shall be determined in accordance with ASTM C 938. The grout proportions for the preplaced-aggregate concrete shall meet the specified strength as determined by specimens molded in accordance with ASTM C 943 and tested in accordance with ASTM C 39/C 39M. The maximum water-cement ratios required in paragraph MAXIMUM WATER-CEMENT RATIO (W/C) shall be converted to a ratio by mass of water to cement plus pozzolan or GGBF slag by mass equivalency as described in ACI 211.1. In the case where GGBF slag is used, the mass of the slag shall be included in the equations for the term P, which is used to denote the mass of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent of the total cementitious material.

2.2.2 Air Content

The air content of the grout mixture as determined by ASTM C 231 within 15 minutes after mixing shall be 9.0 plus or minus 1.0 percent.

2.2.3 Grout Flow

The grout flow shall be 18.0 plus or minus 2.0 seconds when sampled from the agitator and tested in accordance with ASTM C 939.

2.3 DESIGN REQUIREMENTS

2.3.1 Preplaced Aggregate

**NOTE: Consult the Structural Design Engineer and
the appropriate DM to fill in the blanks.**

Specified compressive strength shall be as follows:

COMPRESSIVE STRENGTH (MPa)	STRUCTURE OR PORTION OF STRUCTURE
[[34.5 MPa] @ [] days	[]]
[[27.6 MPa] @ [] days	[]]
[[20.7 MPa] @ [] days	[]]
[[17.2 MPa] @ [] days	[]]

COMPRESSIVE STRENGTH (PSI)	STRUCTURE OR PORTION OF STRUCTURE
[[5,000 psi] @ [] days	[]]
[[4,000 psi] @ [] days	[]]
[[3,000 psi] @ [] days	[]]
[[2,500 psi] @ [] days	[]]

2.3.2 Maximum Water-Cement Ratio (W/C)

**NOTE: Consult EM 1110-2-2000 and the appropriate DM
to fill in the blanks and to select the appropriate
W/C. When cementitious materials other than
portland cement are used, see paragraph GROUT
MIXTURE PROPORTIONING for definitions of W/C.**

Maximum W/C shall be as follows:

WATER-CEMENT RATIO, BY MASS	STRUCTURE OR PORTION OF STRUCTURE
[0.40	[]]
[0.45	[]]
[0.50	[]]
[0.55	[]]
[0.60	[]]
[0.65	[]]

These W/Cs may cause higher strengths than that required by paragraph PREPLACED AGGREGATE.

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

NOTE: Refer to the appropriate DM for the capacity.
Guidance is also found in EM 1110-2-2000.

The mixing and pumping equipment shall have a capacity of at least [_____] cubic meters yards per hour.

3.1.2 Batching Equipment

All materials shall be mechanically batched by mass except the water and admixture which may be batched by volume.

3.1.2.1 Scales

The equipment used for determining mass shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test reference masses and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. The tests shall be made at the frequency required in paragraph TESTING AND QUALITY VERIFICATION FOR CONTRACTOR QUALITY CONTROL in the presence of a Government representative.

3.1.2.2 Batching Tolerances

a. Tolerances on Mass

MATERIAL	PERCENT OF REQUIRED MASS
Cementitious materials	0 to plus 2
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	0 to plus 6

b. Volumetric Tolerances

For volumetric batching equipment, the following tolerances shall apply to the required volume of material being batched:

Water: plus or minus 1 percent.
Chemical admixtures: Zero to plus 6 percent.

3.1.2.3 Grout Mixer

The grout mixer shall be a machine especially designed for the mixing of grout and shall be capable of mixing grout mechanically to a uniform consistency. The mixer shall be maintained in satisfactory operating condition and kept free of hardened grout. Should any grout mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until the condition is corrected. The grout mixer shall be provided with an acceptable device to lock the discharge mechanism until the required

mixing time has elapsed. Use of revolving-drum concrete mixers will not be permitted.

3.1.2.4 Agitator Tank

The agitator tank shall have at least the same capacity as the mixer and shall be equipped to agitate the grout effectively and continuously. All grout entering the tank shall be passed through a wire sieve. The sieve size shall not be less than 4.75 mm (No. 4) and not greater than 9.5 mm (3/8 inch).

3.1.2.5 Grout Pump

The grout pump shall operate by positive displacement or progressive cavity. The pump shall be equipped with a by-pass line connecting the discharge and inlet or provide circulation into the agitator for continuous operation if line blockage or temporary shutdown of grouting operation occurs. A pressure gauge shall be installed on the pump discharge line to indicate incipient line blockage or a plugged insert pipe. Standby pumping equipment shall be provided.

3.1.3 Grout Pipe System

3.1.3.1 Delivery Pipes

The main delivery line carrying grout from the grout pump to the vicinity of the insert pipes shall be of such diameters that grout velocity at the planned operating rate will range between 0.6 and 1.2 meters 2 and 4 feet per second. All pipe fittings shall be watertight. Unions shall be provided for quick disconnect to facilitate pipe cleanup when required. A manifold system in which more than one grout insert is operative at the same time will not be permitted.

3.1.3.2 Grout Insert Pipes

The pipes shall be [19] [25] [40] mm [3/4] [1] [1-1/2] inch in diameter conforming to ASME B36.10M Schedule 40. Standard pipe couplings may be used if the couplings are to be withdrawn not more than 4.5 m 15 feet through the preplaced aggregate. Where pipe couplings are required for greater depths of preplaced aggregate, flush-coupled pipe conforming to ASME B36.10M Schedule 160 shall be used. Connections between grout delivery hoses and insert pipes shall be by means of quick-opening fittings. Quick-disconnect pneumatic fittings will not be permitted for this purpose. All valves in the pipe system shall be plug or ball type, quick-opening, and which can be easily taken apart and cleaned. Valves over 25 mm 1 inch in diameter shall be stem lubricated.

3.1.3.3 Sounding Wells

The sounding wells shall be 50 mm 2 inch diameter steel pipe provided with milled (not burned) 13 mm 1/2-inch open slots 150 mm 6 inches long with 300 mm 12 inches between slots. The pipe shall be reamed and burrs removed before installation. The sounding line shall be equipped with a 25 mm 1 inch diameter float having a mass so as to sink in water, yet float on the grout surface within the slotted pipe.

3.2 PREPARATION FOR PLACEMENT

3.2.1 Embedded Items

Before placement of coarse aggregate for preplaced-aggregate concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Embedded items shall be free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of grout into voids. Welding, including tack welding, will not be permitted on embedded metals within 600 mm 2 feet of the surface of the preplaced-aggregate concrete.

3.2.2 Concrete on Earth Foundations

**NOTE: The Designer should insert the appropriate
Section number and title below.**

Earth surfaces upon which preplaced-aggregate concrete is to be placed shall be clean, damp, and free from debris, frost, ice, and standing or running water. Prior to placement of coarse aggregate, the earth foundation shall have been satisfactorily compacted in accordance with the provisions of [Section [____]] [____].

3.2.3 Concrete on Rock Foundations

Rock surfaces upon which coarse aggregate for preplaced-aggregate concrete is to be placed shall be clean, free from oil, standing or running water, ice, mud, drummy rock, coating, debris, and loose, semidetached, or unsound fragments. Joints in rock shall be cleaned to a satisfactory depth, as determined by the Contracting Officer, and to firm rock on the sides. Immediately before the coarse aggregate is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jets or sandblasting as defined in paragraph CONSTRUCTION JOINT TREATMENT.

3.2.4 Underwater Placement

Coarse aggregate for underwater preplaced-aggregate concrete shall be placed on rock surfaces which are clean, free from drummy rock, coatings, debris, and loose semidetached or unsound fragments.

3.2.5 Concrete Surfaces

Concrete surfaces on which coarse aggregate is to be placed or preplaced-aggregate concrete surfaces between stages shall be clean and free from foreign material. Excessive accumulation of fine material on the surface shall be removed with high-pressure water jets or other approved methods.

3.2.6 Construction Joint Treatment

3.2.6.1 Joint Preparation

- a. If grout in a preplaced-aggregate placement is not brought to the surface in order to form a construction joint, the intrusion grout rise

shall stop 300 mm 12 inches below the aggregate surface. Dirt and debris shall not be allowed to collect on the aggregate surface or allowed to filter down to the grout surface. The insert pipes shall be pulled just above the grout surface before the grout stiffens and rodded clear. When pumping is ready to resume, the insert pipes shall be worked back to near contact with the hardened grout surface and then pumping slowly resumed for a few minutes.

b. Preplaced-aggregate concrete in which the grout has been brought to the surface and any other concrete surfaces to which preplaced-aggregate concrete is to be bonded shall be prepared for receiving the next lift or adjacent preplaced-aggregate concrete by cleaning with air-water cutting, sandblasting, high-pressure water jet, or other approved method. Air-water cutting will not be permitted on formed surfaces or surfaces congested with reinforcing steel. Regardless of the method used, the resulting surfaces shall be free from all laitance and inferior concrete so that clean, well-bonded coarse aggregate is exposed uniformly throughout the lift surface. The edges of the coarse aggregate shall not be undercut. The surface shall be washed clean again as the last operation prior to placing the next lift.

3.2.6.2 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time and only on horizontal construction joints. The air pressure used in the jet shall be 690 kPa 100 psi plus or minus 70 kPa 10 psi, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved by the Contracting Officer, a retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in applications. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. Where necessary to remove accumulated laitance, coatings, stains, debris, and other foreign material, high-pressure water jet or sandblasting will be required as the last operation before placing the next lift.

3.2.6.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 20.7 MPa 3,000 psi may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed, and there is no undercutting of coarse-aggregate particles. If the water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.2.6.4 Wet Sandblasting

This method may be used when the concrete has reached sufficient strength to prevent undercutting of the coarse-aggregate particles. The surface of the concrete shall then be washed thoroughly to remove all loose materials.

3.2.6.5 Waste Disposal

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does

not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall be subject to approval.

3.3 COARSE-AGGREGATE AND GROUT PLACEMENT

3.3.1 Coarse-Aggregate Washing and Screening

Coarse aggregate shall be washed, screened, and saturated immediately before placement. Washing of the aggregate in the forms will not be permitted. If more than one size of coarse aggregate is used, the aggregate shall be weighed, batched, and mixed in the proper proportions onto the wash screen. The wash screen may be a vibrating deck or revolving.

3.3.2 Transporting and Placing Coarse Aggregate

Coarse aggregate shall be transported to the forms and placed in substantially horizontal layers by means which will prevent objectionable segregation and breakage. Foreign material and excessive accumulation of fine material on the lift surface shall be removed before placing the next lift. Placing of coarse aggregate under water shall be continuous in each stage or lift until placement in that stage or lift is completed. When the coarse aggregate is to be placed in the dry, there shall be no vertical drop greater than 1.5 m 5 feet except where suitable equipment is provided to prevent breakage and segregation and where specifically authorized. Vehicle traffic on top of preplaced-coarse aggregate shall not be permitted.

3.3.3 Cold-Weather Placing of Preplaced-Aggregate Concrete

When the cold-weather placing of preplaced-aggregate concrete is likely to be subjected to freezing temperatures before the expiration of the curing period, it shall be placed in accordance with the approved procedure previously submitted in accordance with paragraph SUBMITTALS. The ambient temperature of the space adjacent to the preplaced-aggregate concrete placement and surfaces to receive preplaced-aggregate concrete shall be above 0 degrees C 32 degrees F. The placing temperature of the preplaced aggregate concrete having a minimum dimension less than 300 mm 12 inches shall be between 13 and 24 degrees C 55 and 75 degrees F when measured in accordance with ASTM C 1064/C 1064M. The placing temperature of the preplaced-aggregate concrete having a minimum dimension greater than 300 mm 12 inches shall be between 10 and 21 degrees C 50 and 70 degrees F. Heating of the mixing water or aggregates will be required to regulate the concrete-placing temperatures. Materials entering the grout mixer shall be free from ice, snow, or frozen lumps. Salt, chemicals, or other materials shall not be mixed with the grout to prevent freezing. The forms shall be free of frost, and the aggregate, when deposited in the form, shall be free of ice, snow, and frozen lumps.

3.3.4 Hot-Weather Placing of Preplaced-Aggregate Concrete

NOTE: See the appropriate DM for the proper placing temperature.

Hot-weather placing of preplaced-aggregate concrete shall be properly placed and finished with the approved procedures previously submitted in accordance with paragraph SUBMITTALS. The preplaced-aggregate concrete temperature shall not exceed [_____] degrees C F when measured in

accordance with ASTM C 1064/C 1064M. Cooling of the mixing water may be required to obtain an adequate placing temperature. A retarder meeting the requirements of paragraph WATER-REDUCING OR RETARDING ADMIXTURES may be used to facilitate placing and finishing. Steel forms and reinforcement shall be cooled prior to concrete placement when steel temperatures are greater than 49 degrees C 120 degrees F.

3.3.5 Grout Mixing and Pumping

3.3.5.1 Charging Sequence

The order of placing material in the mixer shall be as follows:

- a. Water, or premixed water and fluidifier, if the fluidifier is in a liquid form.
- b. Cement, or preblended cement and fluidifier, if the fluidifier is in a powder form.
- c. Remaining ingredients.

3.3.5.2 Mixing Time

The mixing time for each batch, after all solids are in the mixer, shall be not less than 2 minutes. The mixer shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. Mixer shall not be charged in excess of the capacity recommended by the manufacturer nor shall they be operated at a speed in excess of the manufacturer's recommendation.

3.2.5.3 Pumping Procedure

Before starting to mix and pump grout, disconnect the grout hoses from inserts or from inlet points and flush the lines with water. Excess water shall be cleared from the pumps and lines. At the start of grouting, with the grout delivery lines disconnected at the inserts, grout shall be pumped and wasted until grout exiting the line is the same uniform consistency as that being discharged from the mixer. The coarse aggregate within the forms shall be in a moist condition at the time of intrusion. The intrusion shall be started at the lowest point in the aggregate. All pumping shall be done uniformly and at the rate that will permit the grout to fill all voids and avoid displacing the aggregate. After being discharged into the agitator tank, each batch of grout shall be continuously agitated until that batch is fully discharged into the pump. Grout insert pipes shall be properly arranged and spaced to ensure a relatively level uniform grout surface. Initially the outlet end of the intrusion lines shall penetrate the aggregate mass to within 50 mm 2 inches of the base of the aggregate, unless otherwise directed. The outlets shall be raised as the grout rises, and after grouting has progressed sufficiently to so permit, the outlets shall extend into the grout not less than 300 mm 12 inches. Satisfactory means shall be provided for venting the underside of embedded projections with procedures previously submitted in accordance with paragraph SUBMITTALS. Grouting shall be continued until grout of the specified quality is returned from the vent pipes, thereby indicating completeness of grout injection. During the intrusion procedure, the forms shall be externally vibrated in the vicinity of the grout surface. Sounding wells or other approved means of accurately locating the grout surface without interrupting the intrusion procedure shall be provided for observation and regulation of the level of the grout.

Agitation of grout shall be continuous during any shutdown of the intrusion procedure. When there is a lapse in the operation of intrusion in excess of 15 minutes, the grout shall be recirculated through the pump, or agitator and pump. The grout delivery lines shall be flushed with clean water if they become blocked. They shall be disconnected from grout insert pipe before the flushing operation is performed and shall not be reconnected to grout insert pipe after flushing until pumping is resumed and grout appears. In no case shall grout be used after appreciable stiffening of the grout mixture has occurred. [When placed underwater, intrusion shall begin while aggregates are being placed and shall follow closely behind aggregate placement unless otherwise approved. At no time shall the grout surface be brought closer than 300 mm 1 foot of the lowest point of the aggregate lift prior to topping out.]

3.3.5.4 Blocked Pipes

Care shall be exercised to avoid blocking grout insert pipes by avoiding interruptions in pumping; however, when a pipe becomes blocked, it shall be withdrawn immediately until the end is at least 600 mm 2 feet above the level of the grout before an attempt is made to unblock it by washing out the line. In no case shall washing be attempted with the end of the grout line inserted in the grout.

3.3.5.5 Placing Temperature

Intrusion grout shall not be placed when the ambient temperature is below 2 degrees C 35 degrees F, unless specifically approved by the Contracting Officer. The preplaced-aggregate concrete, without special protection, shall not be subjected to freezing temperatures before grout reaches a unconfined compressive strength of 3500 kPa 500 psi. Grout which is intruded during cold weather shall have a temperature of not less than 5 degrees C 40 degrees F nor more than 15 degrees C 60 degrees F. Heating of the mixing water or fine aggregate will not be permitted until the temperature of the grout has decreased to 7 degrees C 45 degrees F. All methods and equipment for heating shall be subjected to approval.

3.4 FINISHING

NOTE: Consult the appropriate DM for those surfaces to receive a trowel finish, abrasive aggregate finish, or broom finish. Be sure those special finishes are shown.

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 10 degrees C 50 degrees F. In hot weather when the rate of evaporation of surface moisture, as determined by use of Figure 2.1.5 of ACI 305R, may reasonably be expected to exceed 1 kg/square meter 0.2 psf per hour, provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material shall be made in advance of placement. Such protective measures shall be taken as quickly as finishing operations will allow. All unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish. Additional finishing shall be as specified below and shall be true to the elevation shown in the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown in the drawings and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or as directed.

3.4.1 [Formed Top Surface]

A venting form constructed of muslin shall be used to produce the finished surface. The venting form shall be placed on top of the aggregate and backed up by fly screen, diamond metal lath, and sheeting boards spaced from 13 to 25 mm 1/2 to 1 inch apart. The form shall be tied down against uplift pressure.]

3.4.2 [Screeded or Trowelled Surface]

The grout shall be brought up to flood the aggregate surface and any diluted surface grout shall be removed by brooming. Following this, a thin layer of pea gravel or 9.5 to 12.5 mm 3/8 to 1/2 inch crushed aggregate shall be worked down into the surface by tamping and raking. When the surface is sufficiently hardened to permit working, the surface shall be screeded, floated, or trowelled to the specified finish.]

3.5 CURING AND PROTECTION

Curing and protection shall conform to the following requirements.

3.5.1 Duration

The length of the curing period shall be determined by the type of cementitious material, as specified below. Concrete shall be cured by an approved method.

[Type I portland cement 7 days]

[Type II portland cement 14 days]

[Portland cement blended with 25 percent or less fly-ash 14 days]

[Portland cement blended with more than 25 percent Fly-ash 21 days]

Immediately after placement, preplaced-aggregate concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, and mechanical damage. All materials and equipment needed for adequate curing and protection shall be available and at the placement site to the start of grouting. Preplaced-aggregate concrete shall be protected from the damaging effects of rain for 12 hours and from flowing water for 14 days. No fire or excessive heat, including welding, shall be permitted near or in direct contact with concrete or concrete embedments at any time.

3.5.2 Moist Curing

Preplaced-aggregate concrete that is moist-cured shall be maintained continuously, not periodically, wet for the entire curing period. If water or curing materials stain or discolor concrete surfaces that are to be permanently exposed, they shall be cleaned as required in paragraph APPEARANCE. Where wooden form sheathing is left in place during curing, the sheathing shall be kept wet at all times. Where steel forms are left in place during curing, the forms shall be carefully broken loose from the hardened concrete and curing water continuously applied into the void to continuously saturate the entire concrete surface. Horizontal surfaces may be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm 2 inches of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Burlap and cotton mats shall

be rinsed to remove soluble substances before using. Water for curing shall comply with the requirements of paragraph WATER.

3.5.3 Curing with Membrane-Forming Curing Compound

Concrete may be cured with an approved membrane-forming curing compound in lieu of moist curing, except that membrane curing will not be permitted on any surface to which a grout-cleaned finish is to be applied or other concrete is to be bonded, on any surface containing protruding steel reinforcement, on an abrasive aggregate finish, or any surface maintained at curing temperature by use of free steam. A styrene acrylate or chlorinated rubber compound may be used for surfaces that are to be painted. The curing compound selected shall be compatible with any subsequent paint specified.

3.5.3.1 Pigmented Curing Compound

A pigmented curing compound meeting the requirements of paragraph MEMBRANE-FORMING CURING COMPOUND may be used on surfaces that will not be exposed to view when the project is completed.

3.5.3.2 Nonpigmented Curing Compound

A nonpigmented curing compound containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. Concrete cured with nonpigmented curing compound must be shaded from the sun for the first 3 days when the ambient temperature is 32 degrees C 90 degrees F or higher.

3.5.3.3 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. The surfaces shall be thoroughly moistened with water, and the curing compound shall be applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared. The curing compound shall be applied in a two-coat continuous operation by approved motorized power-spraying equipment operating at a minimum pressure of 520 kPa 75 psi, at a uniform coverage of not more than 10 square meters/L 400 square feet per gallon for each coat, and the second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other cause that will disrupt the continuity of the curing membrane.

3.5.4 Impervious-Sheet Curing

Horizontal surfaces may be cured using impervious sheets. The sheets shall comply with the requirements of ASTM C 171, except that polyethylene film shall not be used. All surfaces shall be thoroughly wetted and be completely covered with waterproof paper, or with polyethylene-coated burlap having the burlap thoroughly water-saturated before placing. Covering shall be lapped not less than 300 mm 12 inches and securely weighted down or shall be lapped not less than 100 mm 4 inches and taped to form a continuous cover with completely closed joints. The sheet shall be

weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Covering shall be folded down over exposed edges of the slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.5.5 Cold-Weather Curing and Protection

When the daily outdoor low temperature is less than 0 degrees C 32 degrees F, the temperature of the concrete shall be maintained above 5 degrees C 40 degrees F for the first 7 days after placing. In addition, during the period of protection removal, the air temperature adjacent to the concrete surfaces shall be controlled so that concrete near the surface will not be subjected to a temperature differential of more than 15 degrees C 25 degrees F. This shall be determined by observation of ambient and concrete temperatures indicated by suitable temperatures measuring devices furnished by the Government as required and installed adjacent to the concrete surface and 50 mm 2 inches inside the surface of the concrete. The installation of the thermometers shall be made by the Contractor at such locations as may be directed.

3.5.6 Appearance

Permanently exposed surfaces shall be cleaned, if stained or otherwise discolored, by a method that does not harm the concrete and that is approved.

3.6 TESTING AND QUALITY VERIFICATION FOR CONTRACTOR QUALITY CONTROL

With the testing and quality verification for contractor quality control the Contractor shall conform to the following requirements.

3.6.1 General

The Contractor shall perform the inspection and tests described below, and based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the preplaced-aggregate concreting operations are out of control, aggregate and intrusion grouting shall cease. The laboratory performing the tests shall be onsite and shall conform with ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I. The individuals who perform the inspection of concrete construction shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of Concrete Construction Inspector, Level II. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per year thereafter for conformance with ASTM C 1077.

3.6.2 Testing and Inspection Requirements

3.6.2.1 Fine Aggregate

- a. Grading - At least once during each shift when the grout plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the

fine aggregate. The grading shall conform to requirements in paragraph FINE-AGGREGATE GRADING. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits.

b. Corrective Action for Fine-Aggregate Grading - When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately be reported to the Contracting Officer.

c. Moisture Content Testing - There shall be at least four tests for moisture content in accordance with ASTM C 566 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the grout flow is out of control or excessive variation in consistency is reported by the placing foreman. The results of tests for moisture content shall be used to adjust the added water in the control of the grout mixing.

d. Moisture Content Corrective Action - Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device), if necessary to maintain the specified flow.

3.6.2.2 Coarse Aggregate

a. Grading - At least once during each shift in which the coarse aggregate is being placed in the forms, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The coarse aggregates shall conform to the requirements found in paragraph COARSE-AGGREGATE GRADING. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the forms within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control which are coarser than the specification limits for samples taken at locations other than as delivered to the forms to allow for degradation during handling.

b. Corrective Action for Grading - When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of five tests are outside specification limits, the operation shall be considered out of control and shall be reported to the Contracting Officer. Aggregate placement shall be stopped and immediate steps shall be taken to correct the grading.

3.6.2.3 Quality of Aggregates

The quality of aggregates shall meet the following requirements.

NOTES: Tests should be those listed in paragraph

QUALITY.

The petrographic examination shall be used to identify deleterious substances in aggregates. Deleterious substances shall be listed individually with respective limits.

Depending upon the quality of aggregates available, some tests may not be required. Refer to EM 1110-2-2000 for the purpose of each test.

a. Frequency of Quality Tests - Thirty days prior to the start of preplaced-aggregate concrete placement the Contractor shall perform all tests for aggregate quality listed on the following page. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality in accordance with the frequency schedule. Samples of fine aggregate tested after the start of concrete placement shall be taken immediately prior to entering the grout mixer. Samples of coarse aggregate tested after the start of concrete placement shall be taken immediately prior to entering the forms.

FREQUENCY

PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TEST
Specific Gravity	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
Absorption	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
[Durability Factor using, Procedure A	Every 12 months	Every 12 months	COE CRD-C 114 ASTM C 666]
[Clay Lumps and Friable Particles	Every 3 months	Every 3 months	ASTM C 142]
[Material Finer than the 75 µm (No. 200) Sieve	Every 3 months	Every 3 months	ASTM C 117]
[Organic Impurities	Every 3 months	Not applicable	ASTM C 40 ASTM C 87)]
[L.A. Abrasion	Not applicable	Every 6 months	ASTM C 131 ASTM C 535]
[Soft and Friable (Scratch Hardness)	Not applicable	Every 6 months	COE CRD-C 130]
[Petrographic Examination	Every 6 months	Every 6 months	ASTM C 295]
[Chert, less than 2.40 specific gravity]	Every 6 months	Every 6 months	ASTM C 123

FREQUENCY

PROPERTY	FINE AGGREGATE	COARSE AGGREGATE	TEST
[Coal and Lignite, less than 2.00 specific gravity]	Every 6 months	Every 6 months	ASTM C 123

b. Corrective Action for Aggregate Quality - If the result of a quality test fails to meet the requirements for quality immediately prior to start of preplaced-aggregate concreting operations, production procedures or materials shall be changed and additional tests shall be performed until the material meets the quality requirements prior to proceeding with either mixture proportioning studies or starting preplaced-aggregate concreting operations. After preplaced-aggregate concreting operations commences, whenever the result of a test for quality fails the requirements, the test shall be rerun immediately. If the second test fails the quality requirement, the fact shall be reported to the Contracting Officer and immediate steps taken to rectify the situation.

3.6.2.4 Scales

a. Accuracy in Determination of Mass - The accuracy of the scales shall be checked by reference masses prior to start of grouting operations and at least once every 3 months for conformance with the applicable requirements of paragraph BATCHING EQUIPMENT. Such tests shall also be made as directed whenever there are variations in properties of the fresh grout that could result from batching errors.

b. Scales Corrective Action - When the accuracy of determination of mass does not comply with specification requirements, grouting shall not be performed until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately to the Contracting Officer.

3.6.2.5 Grout Plant Control

The measurement of all constituent materials including cementitious materials, aggregate, water, and admixtures shall be continuously controlled. The fine aggregate mass and amount of added water shall be adjusted as necessary to compensate for free moisture in the fine aggregate. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan used, amount and source of admixtures used, aggregate source, the required aggregate and water in mass per cubic meter, amount of water as free moisture in the fine aggregate, and the batch aggregate and mass of water per cubic meter for each mixture batched during grouting operations.

3.6.2.6 Grout Mixture

a. Air-Content Testing - Air-content tests shall be made when test specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate grout mixture produced during each 8-hour period of grout production. Additional tests shall be made when excessive variation in consistency is reported by the placing foreman or Government quality assurance representative. Tests shall be made in accordance with ASTM C 231.

Test results shall be plotted on control charts which shall at all times be readily available to the Government. Copies of the current control charts shall be kept in the field by the Contractor's quality control representatives and results plotted as tests are made. When a single test result reaches the upper or lower action limit, a second test shall immediately be made. The results of the two tests shall be averaged. This average shall be used as the air content of the batch to plot on the control chart for air content and on the control chart for range and to determine the need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate chart for each mixture on which an average line is set at the midpoint of the specified air-content range from paragraph AIR CONTENT. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line. An upper action limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a control chart for range where an upper warning limit is set at 2.0 percentage points and up upper action limit is set at 3.0 percentage points. Samples for air content may be taken at the mixer; however, the Contractor is responsible for delivering the grout to the placement site at the stipulated flow. If the Contractor's materials or transportation methods cause flow loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer and the air content at the mixer controlled as directed.

b. Air-Content Corrective Action - Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as is practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the control chart range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air-content tests shall be made when grout mixing is restarted. All this shall be at no extra cost to the Government.

3.6.2.7 Grout Flow

a. Tests - At least two tests shall be made on randomly selected batches of grout mixture during each shift's production in accordance with ASTM C 939. Additional tests shall be made when excessive variation in flow of grout mixture is reported by the grout foreman or Government inspector. Test results shall be plotted on control charts which shall at all times be readily available to the Government. Copies of the current control charts shall be kept in the field by the Contractor's quality control representatives and results plotted as tests are made. When a single-flow test reaches or goes beyond the upper or lower action limit, a second test shall immediately be made on the same batch of concrete. The results of the two tests shall be averaged. This average shall be used as the flow of the batch to plot on the control chart for flow and the chart for range and to determine the need for any remedial action. An upper warning limit shall be set at 1 second below the maximum allowable flow on separate control charts for flow used for each type of mixture as specified in paragraph GROUT

FLOW, and upper and lower action limit lines shall be set at the maximum and minimum allowable flows, respectively, as specified in the same paragraph. The range between each consecutive flow test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at 2 seconds. Samples for flow shall be taken at the agitator; however, the Contractor is responsible for delivering the grout to the placement site at the stipulated flow. If the Contractor's materials or transportation methods cause flow loss between mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer and the flow at the mixer controlled as directed.

b. Grout Flow Corrective Action - Whenever points on the control chart for flow reach the upper warning limit, an adjustment shall be immediately made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum W/C specified, based upon aggregates which are in a saturated surface-dry condition. When a single flow reaches the upper or lower action limit, no further grout shall be delivered to the placing site until proper adjustments have been made. Immediately after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive flow tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the grouting operation shall immediately be halted, and the Contractor shall take appropriate steps to bring the flow under control. Also, additional flow tests shall be made as directed. All this shall be at no additional cost to the Government.

c. Temperature - The temperature of the grout shall be measured when compressive strength specimens are fabricated. Measurement shall be in accordance with ASTM C 1064/C 1064M. The temperature shall be reported along with the compressive strength data.

d. Compressive-Strength Specimens - At least one set of test specimens shall be made each day on each different preplaced-aggregate concrete mixture placed during the day. Additional sets of test cylinders shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A random grout sampling plan shall be developed by the Contractor and approved prior to the start of construction. The plan shall assure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength, per paragraph DESIGN REQUIREMENTS, shall consist of six cylinders, three to be tested at 7 days and three at 28 days. A set of test specimens for concrete with a 90-day strength, per paragraph DESIGN REQUIREMENTS, shall consist of nine cylinders, three tested at 7 days, three at 28 days, and three at 90 days. Test specimens shall be molded and cured in accordance with ASTM C 943 and tested in accordance with ASTM C 39/C 39M. All compressive-strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength tests, moving average for strength, and moving average for range for each mixture. The charts shall be similar to those found in ACI 214R.

3.6.2.8 Inspection Before Pumping Grout

Foundation or construction joints, forms, and embedded items shall be

inspected for quality by the Contractor in sufficient time prior to each grout placement to certify to the Contracting Officer that they are ready to receive grout. The results of each inspection shall be reported in writing.

3.6.2.9 Grout Pumping

a. Placing Inspection - The placing foreman shall supervise all placing operations, shall determine that the correct quality of grout is placed in each location as directed by the Contracting Officer, and shall be responsible for measuring and recording grout temperatures and ambient temperature hourly during placing operations, weather conditions, time of grout placement, amount of grout placed, and method of placement.

b. Pumping Corrective Action - The placing foreman shall not permit grouting operations to begin until he has verified that an adequate number of vibrators in working order and with competent operators are available. If any batch of grout fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.6.2.10 Curing

a. Moist-Curing Inspections - At least once each shift and once per day on nonwork days, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist-Curing Corrective Action - When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for such areas shall be extended by 1 day.

c. Membrane-Curing Inspection - No curing compound shall be applied until the Contractor's authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, he shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square meters/L square feet per gallon. It shall be noted whether or not coverage is uniform.

d. Membrane-Curing Corrective Action - When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet-Curing Inspection - At least once each shift and once per day on nonwork days, an inspection shall be made of all areas being cured using material sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet-Curing Corrective Action - When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by 1 day.

3.6.2.11 Cold-Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonwork days, an inspection shall be made of all areas subject to cold-weather protection. The protection system shall be inspected for holes, tears, unsealed joints, or other deficiencies that could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported.

3.6.2.12 Cold-Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other deficiencies, the deficiency shall be corrected immediately and the period of protection extended 1 day.

3.6.3 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

-- End of Section --