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SECTION TABLE OF CONTENTS

DIVISION 03 - CONCRETE

SECTION 03 11 14.00 10

FORMWORK FOR CONCRETE

04/06

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 DESIGN REQUIREMENTS
- 1.3 SUBMITTALS
- 1.4 SHOP DRAWINGS
- 1.5 SAMPLE PANELS

PART 2 PRODUCTS

- 2.1 MATERIALS
 - 2.1.1 Forms and Form Liners
 - 2.1.1.1 Class "A" Finish
 - 2.1.1.2 Class "B" Finish
 - 2.1.1.3 Class "C" Finish
 - 2.1.1.4 Class "D" Finish
 - 2.1.2 Form Coating
- 2.2 ACCESSORIES

PART 3 EXECUTION

- 3.1 INSTALLATION
 - 3.1.1 Form Construction
 - 3.1.2 Chamfering
 - 3.1.3 Coating
- 3.2 FORM REMOVAL
 - 3.2.1 Formwork Not Supporting Weight of Concrete
 - 3.2.2 Formwork Supporting Weight of Concrete
 - 3.2.3 Tunnel Forms
- 3.3 INSPECTION

-- End of Section Table of Contents --

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

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

ACI INTERNATIONAL (ACI)

ACI 347 (2004) Guide to Formwork for Concrete

APA - THE ENGINEERED WOOD ASSOCIATION (APA)

APA PS 1 (1995) Voluntary Product Standard for Construction and Industrial Plywood

ASTM INTERNATIONAL (ASTM)

ASTM C 1074 (2004) Standard Practice for Estimating Concrete Strength by the Maturity Method

ASTM C 1077 (2007) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

ASTM C 31/C 31M (2006) Standard Practice for Making and Curing Concrete Test Specimens in the Field

ASTM C 39/C 39M (2005e1) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

1.2 DESIGN REQUIREMENTS

The design, engineering, and construction of the formwork shall be the responsibility of the Contractor. The formwork shall be designed for anticipated live and dead loads and shall comply with the tolerances specified in Section [03 31 01.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE] [03 70 00 MASS CONCRETE] [03 30 04 CONCRETE FOR MINOR STRUCTURES], paragraph CONSTRUCTION TOLERANCES. However, for surfaces with an ACI Class A surface designation, the allowable deflection for facing material between studs, for studs between walers and walers between bracing shall be limited to 0.0025 times the span. The formwork shall be designed as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. The adequacy of formwork design and construction shall be monitored prior to and during concrete placement as part of the Contractor's approved Quality Control Plan.

1.3 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. Submittals should be kept to the minimum required for adequate quality control.

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, 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.

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.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings

Drawings and design computations for all formwork required shall be submitted at least [_____] days either before fabrication on site or before delivery of prefabricated forms. If reshoring is permitted, the method, including location, order, and time of erection and removal shall also be submitted for review.

SD-03 Product Data

Materials

Manufacturer's literature shall be submitted for plywood, concrete form hard board, form accessories, prefabricated forms, [and] form coating[, and form-lining materials].

SD-04 Samples

Sample Panels[; G][; G, [_____]]

After shop drawings have been reviewed, sample panels for Class A finish with applied architectural treatment shall be built on the project site where directed.

SD-06 Test Reports

NOTE: If form removal is not allowed before 24 hours, the submittal, "Formwork Not Supporting Weight of Concrete; G", and the corresponding bracketed sentences in paragraph FORMWORK NOT SUPPORTING WEIGHT OF CONCRETE should be deleted.

Inspection

The Contractor shall submit field inspection reports for concrete forms and embedded items.

Formwork Not Supporting Weight of Concrete[; G][; G, [____]].

If forms are to be removed in less than 24 hours on formwork not supporting the weight of concrete, the evaluation and results of the control cylinder tests[or maturity instrumentation] shall be submitted to and approved before the forms are removed.

1.4 SHOP DRAWINGS

The shop drawings and data submitted shall include the type, size, quantity, and strength of all materials of which the forms are made, the plan for jointing of facing panels, details affecting the appearance, and the assumed design values and loading conditions.

1.5 SAMPLE PANELS

Panels shall be of sufficient size to contain joints and shall be not less than 2 meters long and 1.5 meters wide 6 feet long and 4 feet wide. The panels shall be of typical wall thickness and constructed containing the full allocation of reinforcing steel that will be used in the structure, with the forming system that duplicates in every detail the one that will be used in construction of the structure. The same concrete mixture proportion and materials, the same placement techniques and equipment, and the same finishing techniques and timing shall be used that are planned for the structure. Construction of Class A finish will not be permitted until sample panels have been approved. Sample panels shall be protected from construction operations in a manner to protect approved finish, and are not to be removed until all Class A finish concrete has been accepted.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Forms and Form Liners

NOTE: See the appropriate Concrete Materials Design Memorandum and EM 1110-2-2000 for description of class finishes. See paragraph 5.4.e in EM

1110-2-2000 for guidance in selecting appropriate finishes.

Forms and form liners shall be fabricated with facing materials that will produce a finish meeting the specified irregularities in formed surface requirements as defined in **ACI 347**. Forms and form liners shall be fabricated with facing materials as specified below.

2.1.1.1 Class "A" Finish

This class of finish shall apply to [____]. The form facing material shall be composed of new, well-matched tongue-and-groove lumber or new plywood panels conforming to **APA PS 1**, Grade B-B concrete form, Class I. [High density overlay shall be used in [____] locations.][Structural I shall be used in [____] locations.]

2.1.1.2 Class "B" Finish

This class of finish shall apply to all surfaces except those specified to receive[Class A][,][Class C][,][Class D]. The form facing material shall be composed of tongue-and-groove or shiplap lumber, plywood conforming to **APA PS 1**, Grade B-B concrete form, tempered concrete form hard board or steel. Steel lining on wood sheathing will not be permitted.

2.1.1.3 Class "C" Finish

This class of finish shall apply to [____]. The form facing may be either tongue-and-groove lumber, plywood, concrete form hard board or steel. Wood form facing for curved or warped surfaces shall be composed of splines of lumber which can be bent to the required shape without splitting or cracking.

2.1.1.4 Class "D" Finish

This class of finish shall apply to [____]. The form facing may be of wood or steel.

2.1.2 Form Coating

Form coating shall be commercial formulation that will not bond with, stain, cause deterioration, or any other damage to concrete surfaces. The coating shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, the Contractor shall follow the recommendation of the form coating manufacturer.

2.2 ACCESSORIES

NOTE: Removable tie rods are not allowed for structures intended to be a water barrier. Specify the locations where removable tie rods are not to be used.

Ties and other similar form accessories to be partially or wholly embedded in the concrete shall be of a commercially manufactured type. After the

ends or end fasteners have been removed, the embedded portion of metal ties shall terminate not less than 50 mm 2 inches from any concrete surface either exposed to view or exposed to water. [Removable tie rods shall not be allowed in [] locations.] Plastic snap ties may be used in locations where the surface will not be exposed to view. Form ties shall be constructed so that the ends or end fasteners can be removed without spalling the concrete.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Form Construction

Forms shall be constructed true to the structural design and required alignment. The form surface and joints shall be mortar tight and supported to achieve safe performance during construction, concrete placement, and form removal. The Contractor shall continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface class [or classes] specified in paragraph FORMS AND FORM LINERS and tolerances specified in paragraph DESIGN REQUIREMENTS. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse.

3.1.2 Chamfering

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 300 mm twelve inches outside the limit of the earth or rockfill so that the end of the chamfers will be clearly visible.

3.1.3 Coating

Forms for exposed or painted surfaces shall be coated with form oil or a form-release agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's instructions. Forms for unexposed surfaces may be wet with water in lieu of coating immediately before placing concrete, except that, in cold weather when freezing temperatures are anticipated, coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.2 FORM REMOVAL

NOTES: For unsupported concrete, form removal is based upon a minimum time requirement of 24 hours. As an option, form removal may be allowed between 18

hours and 24 hours after placement. In this case, form removal is based upon a minimum time (18 hours), minimum ambient temperature (10 degrees C (50 degrees F)), and minimum compressive strength requirement. For supported concrete, form removal is based solely upon a minimum compressive strength requirement.

An experienced concrete materials engineer or [_____] should be consulted before allowing the use of the maturity concept instead of compressive strength test on field cured cylinders.

Forms shall not be removed without approval. The minimal time required for concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the [minimum time][,][or][minimum compressive strength][,][or][minimum time, minimum ambient temperature, and minimum compressive strength] requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed as specified in Section [_____] [____], paragraph [_____]. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C 31/C 31M and ASTM C 39/C 39M at the expense of the Contractor by an independent laboratory that complies with ASTM C 1077 and shall be tested within 4 hours after removal from the site.[After obtaining approval, the Contractor may use maturity instrumentation instead of control cylinders to determine the compressive strength of the concrete. ASTM C 1074 procedures shall be used for estimating concrete strength by means of the maturity method. All expenses associated with instrumenting the concrete and evaluating the strength using maturity relationships shall be the responsibility of the Contractor.]

3.2.1 Formwork Not Supporting Weight of Concrete

NOTES: If form removal is to be allowed before 24 hours, the concrete must have sufficient strength to resist damage from the removal operation. A minimum of 3.5 MPa (500 psi) is recommended.

If the bracketed sentences below are deleted from

the project specification, the corresponding submittal requirements for the evaluation and results of control cylinder tests [or maturity instrumentation] should also be deleted from paragraph SUBMITTALS.

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed. [Form removal before 24 hours will be allowed for simple floor slab, sidewalks, and driveways provided the ambient temperature during this period has not fallen below 10 degrees C 50 degrees F at any time since placement and evidence from compressive tests on field-cured concrete control cylinders [or maturity instrumentation]indicate[s] that the concrete has attained a compressive strength of at least [_____] MPa psi. Control cylinders shall be prepared for each set of forms to be removed before 24 hours. The stability of the concrete shall be evaluated by a structural engineer prior to removal of the forms.]

3.2.2 Formwork Supporting Weight of Concrete

NOTE: ACI 347 suggests that at least 70 percent of the design strength should be achieved before removal of formwork support from horizontal members, unless otherwise approved by the Contracting Officer. (ACI 347, paragraph 3.7.2.1) When specifications are being prepared, a structural engineer should determine the actual minimum percentage of design strength that should be achieved for the specific conditions on each structure.

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders [or maturity instrumentation] indicate evidence the concrete has attained at least [_____] percent of the compressive strength required for the structure in accordance with the quality and location requirements of Section [[_____] [_____] , paragraph [_____]].

3.2.3 Tunnel Forms

Tunnel lining bulkhead forms shall not be removed in less than 12 hours and tunnel lining forms in not less than 16 hours.

3.3 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

-- End of Section --