SECTION 03 01 32

CONCRETE REHABILITATION
12/11

PART 1 GENERAL

Work under this section covers concrete repairs to the substructure, superstructure, deck components, mooring and berthing systems, and appurtenances as shown on the drawings and specified herein.

Section 01 22 00.00 10 for measurement and payment for repair work.

1.1 REFERENCES

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

ACI INTERNATIONAL (ACI)

	(2010)ACI Concrete Terminology http://terminology.concrete.org
ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 211.1	(1991; R 2009) Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
ACI 301	(2010; Errata 2011) Specifications for Structural Concrete
ACI 304.2R	(1996; R 2008) Placing Concrete by Pumping Methods
ACI 305R	(2010) Specification for Hot Weather Concreting
ACI 306.1	(1990; R 2002) Standard Specification for Cold Weather Concreting
ACI 308R	(2001; R 2008) Guide to Curing Concrete
ACI 311.4R	(2005) Guide for Concrete Inspection
ACI 318	(2011; Errata 1 2011; Errata 2 2012; Errata 3-4 2013) Building Code Requirements for Structural Concrete and Commentary
ACI 347	(2004; Errata 2008; Errata 2012) Guide to Formwork for Concrete
ACI 364.3R	(2009) Guide for Cementitious Repair

Material Data Sheet

ACI 546R	(2004) Concrete Repair Guide
ACI 546.3R	(2006) Guide for the Selection of Materials for the Repair of Concrete
ACI E 706	(2004) Surface Repair Using form-and-pump Techniques

ASTM INTERNATIONAL (ASTM)

ASTM A 706/A 706M	(2009b) Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM C 1077	(2010d) Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 109/C 109M	(2008) Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or (50-mm) Cube Specimens)
ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143/C 143M	(2010) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C 157/C 157M	(2008) Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
ASTM C 172	(2010) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 231/C 231M	(2010) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 31/C 31M	(2010) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 39/C 39M	(2010) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 496/C 496M	(2004e1) Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C 1581/C 1581M	(2009a) Standard Test Method for

	Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage
ASTM D 75/D 75M	(2009) Standard Practice for Sampling Aggregates
ASTM C 1583/C 1583M	(2004e1) Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

	(2010) Concrete Repair Terminology
ICRI 310.1R-2008	(2008)Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion (formerly No. 03730)
ICRI 320.2R-2009	(2009) Guide for Selecting and Specifying Materials for Repair of Concrete Surfaces (formerly No. 03733)
ICRI 210.3-2004	(2004) Guide to Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials (formerly No. 03739)

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
EM 385-1-1	(2008; Errata 1-2010; Changes 1-3 2010; Changes 4-6 2011; Change 7 2012) Safety and Health Requirements Manual

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2012; Errata 2011) Structural Welding Code - Steel
AWS D1.4/D1.4M	(2011) Structural Welding Code - Reinforcing Steel

1.2 DEFINITIONS

The concrete and concrete repair terminology and definitions used are provided by "ACI Concrete Terminology" and ICRI "Concrete Repair Terminology" unless otherwise defined in the specifications.

1.2.1 Concrete

A composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregate, usually a combination of fine aggregate and coarse aggregate; in Portland cement

concrete, the binder is a mixture of Portland cement and water, with or without admixtures.

1.2.2 Pre-Packed Material

A composite material that consists of a mixture of cement paste, and fine aggregate, with or without admixtures.

1.2.3 Cement-Based Material

A material consisting of portland cement and/or other cementitious materials as a binder and aggregate. As used in this specification, cement-based materials include materials with polymer modifiers.

1.2.4 Embedded Galvanic Anode

A zinc material used to cathodically protect adjacent reinforcing steel from corrosion, typically embedded in low resistivity cementious matrix.

1.3 GENERAL REPAIR REQUIREMENTS

The following requirements shall be met:

a. The achievement of the specified requirements, characteristics, and properties of repair materials and systems and the composite repair system regarding the fulfillment of their purpose to prolong the useful service life of the structure.

b. The achievement of the compatibility of the existing concrete and reinforcement with the repair and protection materials and systems and compatibility between different repair and protection products, including avoiding the risk of creating conditions which may cause acceleration of corrosion.

c. The achievement of the required condition of the substrate regarding cleanliness, roughness, cracking, tensile and compressive strength, chlorides and other aggressive agents, depth of carbonation, moisture content, and temperature.

d. The achievement of the required repair application conditions regarding ambient temperature, humidity, wind force, and precipitation and any temporary protection when needed.

1.4 REPAIR STRUCTURAL FUNCTION

Repairs to reinforced concrete structures are required to perform different functions. In some cases replacement of deteriorated or damaged concrete to provide an acceptable appearance may be all that is required. This type of repair is considered a cosmetic repair. Another more common type of repair is a protective repair, with the main objective being to protect reinforcement from corrosion inorder to slow down the deterioration processes. In both of the above repair types stress-carrying function is not a primary consideration, and the repairs can be described as non-structural.

By contrast, repairs to some structural elements, such as beam and columns, may require removal of stress carrying concrete and replacement with material capable of carrying the same load, in this case the type of repair

is considered a structural repair and the remaining load must be defined. If all load is left on the structure during the repair operation, then the repair material will not become stressed. This "no-load-relief" case, occurs when compressive stress in the repair of a column, for instance, only results when creep or other deformation of the existing concrete takes place. In the event that the original member was overdesigned, and in tension zones of beams, some relief of the requirements for structural repairs may be available. Special considerations shall be given in project specific specifications regarding the structural function reqirements of the repair.

1.5 REPAIR MATERIAL PROPERTY REQUIREMENTS

All repair materials shall be in accordance with applicable provisions of ACI 546.3R, ICRI Guideline No. ICRI 320.2R-2009 and conform to the following requirements.

The most important characteristics governing the selection of repair materials for this project is the repair materials permeability, compatibility with the existing substrate, and sensitivity to cracking caused by restrained volume changes. The critical material properties that affect its resistance to cracking include splitting tensile strength, and drying shrinkage.

The project is intended to be for repairs of concrete spalls and cracks, with an intended service life of 15 years.

1.5.1 Concrete

Concrete shall satisfy the performance criteria in accordance with Section 03 30 00 CONCRETE and the following property criteria.

1.5.1.1 Form and Pour Material

Form and Pour Material shall be in accordance with Section 03 30 00 CONCRETE and the following property criteria.

Property	Test Method	Criteria
Splitting Tensile Strength	ASTM C 496/C 496M	367 psi (minimum) @ 28 Days
Drying Shrinkage	ASTM C 157/C 157M modified by ACI 364.3R	0.05%(maximum)@ 28 Days
Restrained shrinkage cracking	ASTM C 1581/C 1581M	No cracks within 14 days
Compressive Strength	ASTM C 39/C 39M	3,000 psi +/- 15% @ 28 Days

1.5.1.2 Form and Pump Material

Form and Pump Material shall be in accordance with Section 03 30 00 CONCRETE or paragraph 1.5.2 Pre-Packaged Material and meet the following property criteria.

Property	Test Method	Criteria
Splitting Tensile Strength	ASTM C 496/C 496M	367 psi (minimum) @ 28 Days
Drying Shrinkage	ASTM C 157/C 157M modified by ACI 364.3R	0.05%(maximum)@ 28 Days
Restrained shrinkage cracking	ASTM C 1581/C 1581M	No cracks within 14 days
Compressive Strength	ASTM C 39/C 39M	3,000 psi +/- 15% @ 28 Days

1.5.2 Pre-Packaged Material

Pre-packaged material shall satisfy the following property criteria:

1.5.2.1 Form and Pump Material

Property	Test Method	Criteria
Splitting Tensile Strength	ASTM C 496/C 496M	367 psi (minimum) @ 28 Days
Drying Shrinkage	ASTM C 157/C 157M modified by ACI 364.3R	0.05%(maximum)@ 28 Days
Restrained shrinkage cracking	ASTM C 1581/C 1581M	No cracks within 14 days
Compressive Strength	ASTM C 39/C 39M	3,000 psi +/- 15% @ 28 Days

1.5.2.2 Hand Troweling Material

Property	Test Method	Criteria
Splitting Tensile Strength	ASTM C 496/C 496M	367 psi (minimum) @ 28 Days
Drying Shrinkage	ASTM C 157/C 157M modified by ACI 364.3R	0.05%(maximum)@ 28 Days
Restrained shrinkage cracking	ASTM C 1581/C 1581M	No cracks within 14 days

Property	Test Method	Criteria
Compressive Strength	ASTM C 109/C 109M	3,000 psi +/- 15% @ 28 Days

1.6 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are 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 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Repair Plan; G
Contractor Qualifications; G
Worker Qualifications; G
Testing Technicians; G
Testing Agencies; G
Licensed Professional Engineer (PE) Qualifications; G
CP Specialist Qualifications; G

Submit statements that the concrete testing technicians and agencies meet the specified requirements.

Field Survey Results; G
Letter of Acceptance of Government's Defect Quantities; G
Procedures to Repair Defective Work; G
Permanent Fiberglass Formwork - erection plan; G
Permanent Fiberglass Formwork - work plan; G

SD-02 Shop Drawings

Formwork; G

SD-03 Product Data

Concrete; G
Reinforcing Steel; G
Pre-Packaged Material; G
Fiberglass Formwork

SD-05 Design Data

Repair Material Mixing Proportioning; G
Trial Batch; G
Mix Design; G
Fiberglass Formwork; G

SD-06 Test Reports

Concrete; G
Pre-Packaged Material; G
Continuity Test Report; G

Aggregates; G
Admixtures; G
Cement; G
Water; G

SD-07 Certificates

Batch Tickets; G
Form Removal Schedule; G
Placement and Compaction; G
QC Inspection Checklist; G

Manufacturer's certifications should be submitted with test results for proposed materials. Certificates should certify compliance with the appropriate specification referenced herein. Do not place materials without prior approval from the Contracting Officer.

SD-08 Manufacturer's Instructions

Pre-Packaged Material; G
Admixtures; G

Submit manufacturer's written surface preparation, mixing, application and curing instructions for each type of material.

Manufacturer's Material Safety Data Sheets

Submit manufacturer's Material Safety Data Sheets for potentially hazardous materials.

Testing Equipment; G

1.7 QUALITY ASSURANCE

1.7.1 Qualifications

Submit Contractor qualifications and worker qualifications for approval in accordance with paragraph SUBMITTALS. The submittals shall, where applicable, identify individuals who will be working on this contract and their relevant experience. Do not make changes in approved personnel without prior approval of the Contracting Officer.

1.7.1.1 Contractor Qualifications

The Contractor performing the repair work shall have been involved in a minimum of 3 concrete repair projects similar in size and scope to this project within the last 5 years.

Contractor should be capable of demonstrating successful experience in all types of repairs specified in this project.

1.7.1.2 Worker Qualifications

Each worker engaged in the use of specialized removal or application equipment, including saw operators, and form-and-pump process, shall have satisfactorily completed an instruction program in the operation of the equipment. Each worker engaged in the operation of specialized equipment for the contract work shall have a minimum of 3 years of experience in the

operation of the equipment.

1.7.1.3 Field Testing Technicians and Agency

The individuals who sample and test concrete and other repair materials 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 1.

Testing agencies that perform testing service on repair materials shall meet the requirements of ASTM C 1077 and/or ACI 311.4R.

The QC inspector, inspecting repair work, shall be a licensed Professional Engineer (PE) qualified in the areas of work being performed.

1.7.2 Regulatory Requirements

Perform all work in accordance with 01 57 19.00 25 TEMPORARY ENVIRONMENTAL CONTROLS and applicable Federal, State and local safety, health, environmental requirements, and EM 385-1-1. The Contractor shall be responsible for obtaining all permits required by Federal, State and local agencies for the performance of the work.

1.7.3 Pre-Construction Conference

Before starting the repair project, the Contracting Officer or authorized representative shall meet the Contractor's project manager and superintendents at the pre-construction conference. At this meeting, the Contractor should present a work schedule to determine its acceptability to the owner and determine if there are going to be any conflicts with daily operations that should be resolved.

All aspects of field demonstrations, application procedures, repair materials, and corrosion protection employed should be discussed to ensure that the Contractors' personnel understand all aspects of the repair project. The conference shall also include competent technical representatives of repair materials and corrosion protection systems manufactures.

1.7.4 Drawings

1.7.4.1 Formwork

ACI 347. Include design calculations indicating arrangement of forms, sizes and grades of supports (lumber), panels, and related components stamped by a licensed professional engineer. Indicate placement schedule, construction, and location and method of forming control joints. Include locations of inserts, pipework, conduit, sleeves, and other embedded items. Furnish drawings and descriptions of shoring and reshoring methods as required for horizontal concrete members.

1.7.4.2 Form Removal Schedule

Submit schedule for form removal indicating element and minimum length of time for form removal. Submit technical literature of forming material or liner, form release agent, form ties, and gasketing to prevent leakage at form and construction joints. Provide a full description of materials and methods to be used to patch form-tie holes.

1.7.5 Repair Material Mixing Proportioning

Submit, at least 45 days before work commences, a repair material mixture proportioning for each use. Test reports shall accompany the mixture proportions. Identify the proposed source of the materials and state the proportions of each constituent. When determining the mixture design, use samples of materials to be used on the job.

a. Trial batch: Trial batches and testing requirements for various repair materials specified shall be the responsibility of the material manufacturer and Contractor. The pre-packaged material manufacturers representative shall be on-site for all trial batch operations. The laboratory performing the tests shall be on-site and shall conform to ASTM C 1077. Samples of aggregates shall be obtained in accordance with the requirements of ASTM D 75/D 75M. Samples of materials including the aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, which will produce a range of strength encompassing those required for the work.

b. Supporting criteria: Include in the submittal the following data for each trial batch:

(1) Proportions by weight

(2) Unit weights and specific gravities of constituents

(3) Batch weights

(4) Compressive strengths in accordance with the following:

Material	Specimen Size	Test
Concrete	6 by 12 inch cylinders	ASTM C 39/C 39M
Mortar	2 inches cubes	ASTM C 109/C 109M

(5) Curing time

(6) Working time

(7) Slump

(8) Air content

1.7.6 Test Reports

1.7.6.1 Concrete

See Section 03 30 00 CONCRETE.

1.7.6.2 Pre-Packaged Material

Include the following:

a. Compressive Strength

b. Splitting Tensile Strength

c. Drying Shrinkage

d. Restrained Shrinkage Cracking

e. Chloride Ion Penetration

f. Bond Strength

g. Aggregates

h. Admixtures

i. Cement

1.7.6.3 Water

Submit test results.

1.7.7 Placement and Compaction

a. Submit technical literature for equipment and methods proposed for use in placing repair material. Include pumping or conveying equipment including type, size and material for pipe, valve characteristics, pressure gauge, and the maximum length and height concrete will be pumped. No adjustments shall be made to the mixture design to facilitate pumping.

b. Submit technical literature for equipment and methods proposed for vibrating and compacting repair material. Submittal shall include technical literature describing the equipment including vibrator diameter, length, frequency, amplitude, centrifugal force, and manufacturer's description of the radius of influence under load. Where flat work is to be cast, provide similar information relative to the proposed compacting screed or other method to ensure dense placement.

1.7.8 Repair Plan

Submit the proposed methods for constructing or repairing each type of concrete repair. The plan shall include, but shall not be limited to, procedures for removal of deteriorated material, surface preparation, testing of repair materials, placing of material, curing, and test patches. The plan shall also include repair materials to be used along with specific information on products and/or constituents, and requirements for handling, storage, etc., equipment to be used, surface preparation, and requirements for placement, finishing, curing and protection specific to the materials used. Repair plan shall contain a proposed schedule for repairs. Submit the repair plan for approval 30 days after notice to proceed, in accordance with Paragraph 1.6, SUBMITTALS.

1.7.9 Field Demonstration

Field demonstrations shall be completed on each repair method to verify the surface preparation, formwork placement, repair material, and placement technique prior to production repair work. Materials utilized in field demonstrations shall be tested in accordance with Paragraph 3.8, FIELD QUALITY CONTROL.

Successful completion of the field demonstration will be determined by the results of the test reports, bond pull off tests, and the inspection of the repair at 28 days to ensure that the requirements of the specifications have been met.

1.7.9.1 Spall Repairs

Trial spall repairs should be undertaken by the Contractor for each type of repair long enough in advance of the repair project being scheduled to start to allow curing of repair materials and completion of the evaluation tests. Evaluation test results should be in compliance with the requirements of this specification.

Trial spall repairs should include a spall repair of 4 square feet or greater in a beam or pile cap utilizing form and pump material, a spall under 4 square feet in a beam or pile cap utilizing hand troweling material, a spall of 4 square feet or greater in the underside of deck utilizing form and pump, and a spall over 4 square feet in the top of deck utilizing form and pour material.

Trial spall repairs should be carried out using the same concrete removal and surface preparation methods, and the same materials and application methods as those to be used in the work. New trial repairs should be carried out if any changes in materials and equipment occur during the course of the work.

The formwork should be removed after a minimum of 7 days and the repairs should be checked to ensure that the requirements of this specification have been met. Hammer sounding for debonding should be conducted along with pull-off bond tests after 28 days. The tests should be performed on completed sample repairs.

The direct pull-off bond test should be conducted for the acceptance of each trial spall repair. Three individual pull-off tests should be performed in each trial spall repair in accordance with the ICRI 210.3-2004. Bond strength should not be less than 150 psi, unless failure is at least 1 inch into the existing concrete substrate. Areas damaged by pull-off bond tests should be repaired with hand trowel mix.

If the trial sample repair is not accepted by the Contracting Officer, the Contractor should remove the repair, reapply and test the repair until the satisfactory results are obtained at no additional cost to the Government.

The quality and appearance of the sample repairs should be subject to the approval of the Contracting Officer, and if not judged satisfactory, additional sample repairs should be performed and tested until approval is attained.

The surface preparation procedures, repair materials, and application techniques used in conducting the approved sample repairs should be employed in production the repair project.

1.8 DELIVERY, STORAGE, AND HANDLING

1.8.1 Packing, Shipping, Handling, and Unloading

Inspect materials delivered to site for damage, unload and store with minimumal handling. Deliver resin components and aggregate materials in

original sealed containers where applicable.

1.8.2 Polymer Materials

Storage areas shall be in windowless and weatherproof, but ventilated, insulated noncombustible buildings. Store polymer materials at temperatures between 40 degrees F to 85 degrees F, unless approved by the polymer manufacture. Do not allow polymer materials to freeze.

1.8.3 Chemical Admixtures

Protect chemical admixtures and store and maintain between 40 degrees F to 90 degrees F, unless approved by the chemical admixture manufacture. Do not use any admixture that has been subjected to temperatures outside this range or in storage for longer than recommended by the manufacturer. Remove such materials from the site.

1.9 PROJECT/SITE CONDITIONS

1.9.1 Environmental Requirements

Do not place repair materials when weather conditions detrimentally affect the quality of the finished product. Do not place cement-based repair materials when the air temperature is below 40 degrees F in the shade. When air temperature is likely to exceed 90 degrees F, the cement-based repair material shall have a temperature not exceeding 85 degrees F when deposited, the difference in temperature between repair material and substrate should be not more than 10 degree F apart and the surface of such placed cement-based repair material shall be kept damp with a water fog until the approved curing medium is applied. Do not place polymer-modified repair materials when the air temperature is below 45 degrees F or above 85 degrees F unless approved by the polymer manufacturer. Placement restrictions for other materials shall be in accordance with the manufacturer's published literature. Halt work when weather conditions are potentially detrimental to the quality of repairing or bonding concrete. Follow manufacturer's instructions for weather conditions and temperature ranges.

1.9.2 Existing Conditions

1.9.2.1 Embedded Materials

The contract drawings and reference drawings do not constitute a complete description of all metal parts and other materials that may be encountered, but represent the best information available to the Government. Other items, or different locations for items shown, may exist. Exercise care to avoid drilling through functional embedded items intended to remain in service. The Contractor's selection of equipment and methods shall consider the presence of such materials, and the Government will not be responsible in any way for the effect of such items on the Contractor's equipment or progress. Where indicated, remove existing metal items to the limits noted on drawings.

1.10 SEQUENCING AND SCHEDULING

Unless otherwise specified, perform the work in such sequence that work does not damage previously completed work. Do not perform concrete removal and other operations which cause vibrations within 30 feet of repair materials that have cured less than 24 hours. Provide protective measures

as required to protect completed work.

1.11 CONSTRUCTION TOLERANCES

1.11.1 Concrete Depth Removal

Remove concrete to the lines of removal indicated on the contract drawings. A tolerance of plus or minus 1 inch will be allowed about the lines indicated (except for the 1 inch clearance behind all existing reinforcing steel, which is an absolute minimum). Concrete removals that vary by more than the indicated tolerance will not be acceptable, unless approved in advance by the Contracting Officer. Unauthorized concrete removals shall be repaired by the Contractor to the satisfaction of the Contracting Officer and at no additional cost to the Government.

1.11.2 Concrete Area Removal

Area removal tolerance shall be within 25 percent of the areas indicated in the contract drawings. Concrete removals that vary by more than the indicated tolerance will not be acceptable, unless approved by the Contracting Officer or indicated in the approved Letter of Acceptance of Government's Defect Quantities. Unauthorized concrete removals shall be repaired by the Contractor to the satisfaction of the Contracting Officer at no additional cost to the Government.

1.11.3 Repair Materials and Products

Place repair materials to the lines indicated on the drawings. Construction tolerances for concrete and mortar repair materials shall meet the requirements of ACI 117.

1.12 Field Measurements

Prior to beginning any repair work, the contractor shall perform a survey of the structure to verify all repair quantities and locations indicated on the drawings. The contractor shall notify the government in writing of any discrepancies effecting the quantities, price, or schedule of the work prior to beginning construction.

Contractor shall submit the field survey results and Letter of Acceptance of Government's Defect Quantities within 30 days of award.

1.13 SAFETY

Perform all work in accordance with EM 385-1-1. To protect personnel from overexposure to toxic materials, conform to the applicable Manufacturer's Material Safety Data Sheets (MSDS) or local regulation.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Concrete

2.1.1.1 Form and Pour Concrete

Concrete test data shall meet the requirements specified in Section 03 30 00, CONCRETE. Submit mix design.

2.1.1.2 Form-and-Pump Concrete

Concrete test data shall meet the requirements specified in Section 03 30 00, CONCRETE. Submit mix design

2.1.2 Pre-Packaged Material

2.1.2.1 Form-and-Pump Material

The pre-packaged form and pump materials should be extended with coarse aggregate in accordance with the manufacturers written instructions. The test data should meet the performance requirements specified in Part 1.5.2.1

2.1.2.2 Hand Troweling Material

The pre-packaged hand troweling materials should be in accordance with the manufactures written instructions. The test data should meet the performance requirements specified in Part 1.5.2.2

2.1.3 Water

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

2.1.4 Reinforcing Steel

Steel bars shall comply with the requirements of ASTM A 706/A 706M, deformed, of the grades and sizes shown.

2.1.5 Bonding Compound

Bonding compounds shall not be permitted. Provide a roughened clean surface for bonding in accordance with ICRI Division 310 concrete surface profile chips.

2.2 MIXTURE PROPORTIONING

2.2.1 Concrete

Concrete shall meet the requirements specified in Paragraph 1.5.1. Batch tickets shall be furnished for each load of concrete.

2.2.2 Pre-Packaged Material

Proportion materials in accordance with manufacturer's recommendations. Materials shall comply with the requirements of Paragraph 1.5.2.

PART 3 EXECUTION

3.1 EQUIPMENT

Assemble at the site of the work sufficient equipment that is dependable, appropriate, and adequate to accomplish the work specified and as recommended by product manufacturers. Deliver the equipment with sufficient time before the start of repairs to permit thorough inspection, calibration of weighing and measuring devices, adjustment of parts, and the making of any repairs that may be required. Machines, tools, and equipment used in the performance of the work shall be approved before the work is

started and shall be maintained in satisfactory condition at all times. Maintain the equipment in good working condition.

3.1.1 Surface Preparation and Mixing Equipment

Surface preparation shall be in accordance with applicable requirements of ICRI Guideline No. ICRI 310.1R-2008 and ACI 546R unless specified otherwise. Mixing equipment shall be in accordance with the specifications and manufacturers recommendations.

3.1.2 Drilling Equipment

Use percussion or rotary drilling equipment of a type suitable for the depth, diameter and material to be drilled. Use only rotary drilling equipment where vibration from percussion drilling could damage the concrete to remain or adjacent structures. Use equipment capable of maintaining the required alignment.

3.1.3 Diamond-Blade Cutting

Use diamond-blade cutting for cutting through relatively thin sections and defining limits of removal to be performed by other methods. Perform diamond blade cutting using equipment of the correct type and power and with appropriate blade composition for the material being cut. Roughen the cut surface in accordance with ICRI concrete surface profile scale CSP3 to CSP4.

3.1.4 Demolition Equipment

3.1.4.1 Hydrodemolition Equipment

Hydromilling equipment shall consist of filtering and pumping units. The equipment shall produce a highly roughened, bondable surface in accordance with ICRI concrete surface profile scale CSP5 to CSP7.

3.1.4.2 Mechanical Demolition Equipment

Use 15 pound maximum breaker for removal of concrete above and around reinforcing steel.

3.1.5 Pumping Equipment

The specified form-and-pump free-flowing repairs require pumping through a pump line to the formed cavity. Use hydraulic/swing valve pump for the best results. All pumping equipment must have adequate controls to regulate flow rates and pressure. Pressure shall be monitored with a pressure gauge.

3.2 PROTECTION

3.2.1 Protection of Existing Features

Before beginning any concrete removal work, carefully survey the structure and examine the drawings and specifications to determine the extent of the work. Take all necessary precautions to insure against damage to existing concrete or other structures to remain in place, and repair or replace any damage to such items as approved by the Contracting Officer at no additional cost to the Government. Carefully coordinate the work of this section with all other work, and construct and maintain shoring, bracing

and supports, as required. Ensure that structural elements are not overloaded, and increase structural supports or add new supports as may be required as a result of any removal work performed under any part of this contract.

3.2.2 Protection of Personnel

Ensure that adequate measures are in place to protect workers, facility operation personnel and the public from injury due to the operations being performed. Provide protective measures in accordance with EM 385-1-1.

3.3 REMOVAL OF EXISTING CONCRETE

The following is intended to supplement Section 02 41 00 DEMOLITION.

3.3.1 General

Remove the existing concrete in the area to be repaired to the minimum depth indicated on the drawings. Remove concrete with care to avoid damage to adjacent structures and concrete that is not to be repaired under this contract and embedded metal that is not to be removed. Repair any such damage at no additional cost to the Government. Mark on the surface the limits of concrete removal for approval by the Contracting Officer prior to any removal.

Care must be exercised to ensure that further damage to reinforcement is not caused by the concrete removal process. Chipping operation can damage reinforcing steel and/or its bond to existing concrete if used. Constant vigilance must be exercised to assure maintenance of the necessary standards of workmanship. For this reason, a reinforcing bar locator should be used to determine the depth, size, quantity, and approximate location of the reinforcement in the concrete.

Care should be taken not to vibrate the reinforcement or otherwise cause damage to its bond to concrete adjacent to the repair area.

Do not remove metal and other embedded items exposed during the concrete removal operations without authorization of the Contracting Officer. Unless otherwise indicated, continue removal using appropriate equipment to remove sound and unsound concrete and to eliminate any offsets in the area to be repaired which would cause an abrupt change in thickness of the repair and to remove protrusions between holes. Variations in the final prepared surface shall not exceed the nominal maximum size aggregate of the repair material, except for relatively thin repairs in which case the variation shall not exceed 25 percent of the repair thickness. Any removal beyond the limits shown on the drawings shall be approved by the Contracting Officer prior to performing the additional removal. All equipment and removal methods shall comply with applicable sections of EM 385-1-1 and ACI 546R.

Concrete removal addresses deteriorated and damaged material. Some sound concrete, however, may be removed to permit structural modifications and to ensure that all unsound material is removed. The effectiveness of various removal techniques can differ for deteriorated and sound concrete. Some techniques may be more effective in sound concrete, while others may work better for deteriorated concrete.

Concrete removal techniques selected should be effective, safe, economical, environmentally friendly, and minimize damage to the concrete left in

place. The removal technique chosen may have a significant effect on the length of time that a structure will be out of service. Some techniques permit a significant portion of the work to be accomplished without removing the structure from service. The same removal technique, however, may not be suitable for all portions of a given structure.

3.3.1.1 Determination of Removal Limits

Approximate locations and areas of repairs are indicated on the drawings. Determine actual locations and limits of deteriorated concrete by visual inspection and by tapping with a hammer or steel rod and listening for dull or hollow sounds. On horizontal surfaces, a chain drag may be used in lieu of the hammer or rod. Perform sounding in the presence of the Contracting Officer or authorized representative. Mark areas where sounding does not produce a solid tone with highly visible paint. After the investigation process is completed, the Contracting Officer will inspect the areas marked by the Contractor to confirm the limits of removal. Do not remove concrete from these areas until the Contracting Officer approves the areas. Upon completion of removal, sound the surface and remove any additional concrete until testing produces a solid tone.

Areas requiring repair should be modified to provide for simple layouts. The layouts shall provide for reduced boundary edge length and eliminate acute angles.

Removal of concrete around reinforcing bars shall extend to point where bar is well bonded to concrete and free of corrosion products.

In cases where apparently corroded or heavily oxidized reinforcing bars extend beyond marked repair areas into apparently sound concrete, the Contracting Officer shall direct contractor how far to extend limits of repair area.

The extent and depth of concrete removal in each repair area shall be measured and recorded on drawings by the Contractor.

3.3.1.2 Perimeter Saw Cut

For repair areas make a perpendicular saw cut at 3/4 inch deep, but no deeper than the reinforcing steel, 2 inches outside of the area to be repaired to delineate the perimeter of the repair area and avoid feather edges. Vertical and overhead repair saw cuts shall be beveled 3 to 5 degrees to create a keyed in repair. Exercise care not to cut through existing steel reinforcement or embedded metal that is not to be removed.

The disc cut surfaces should be roughened prior to application of a repair material. It is best achieved at the same time as final surface preparation of exposed reinforcement and concrete in repair cavity is conducted. Care should be exercised when roughening the disc cut surfaces to prevent damage to the cavity edges.

3.3.1.3 Reinforcing Steel

Exposing and undercutting reinforcing steel in the repair area should be accomplished by initial concrete removal operations. The reinforcing bars exposed in the repair areas should be undercut a minimum of 1 inch. Removal of concrete around reinforcing bars should extend to the point where bars are well bonded to concrete and free of corrosion.

Following the concrete removal operation, carefully inspect the condition of all exposed reinforcing bars in accordance with ICRI 310.1R-2008.

The purpose of the inspection is to determine whether the reinforcing steel is capable of performing as intended by the design. If the cross-section of the repair has been reduced by corrosion by more than 20 percent, cut out the damaged portion and weld splice in replacement bar. Welding should be performed in accordance with Section 05 05 23 WELDING, ACI 318, and AWS D1.1/D1.1M. Cutting and welding should be performed by a welder AWS Certified to the requirements of AWS D1.4/D1.4M. Care should be exercised during the welding procedures not to overheat the existing concrete because this can induce thermal stresses on cooling and could damage the bond between existing reinforcement and concrete substrate.

Concrete reinforcement shall conform to the requirements of ASTM A 706/A 706M. Where the bond between the concrete and any reinforcing steel has been destroyed, or where the concrete deterioration is caused by corrosion of the reinforcing steel, remove the adjacent concrete to a depth that will permit cleaning of the steel and bonding of the concrete.

When uncoated reinforcing steel is exposed in the repair area application of a protective coating should not be done, because it may cause corrosion in areas immediately adjacent to a repair.

Proper cleaning of the rebar helps to assure the anode tie wires are able to make a good electrical connection. Since the anodes function on electrochemical principles, maintaining low resistance connections ensures peak performance.

3.3.2 Impacting

Take adequate precautions to prevent impact equipment from vibrating on reinforcing steel. All demolition equipment shall be subject to approval of the Contracting Officer.

3.4 MIXING MATERIALS

Make batches small enough to ensure placement before binder sets. Mix materials in accordance with manufacturer's recommendations.

3.5 SUBSTRATE SURFACE PREPARATION

3.5.1 General

Regardless of the nature of repair material and methods of its application, the repair is only as good as the surface preparation of the substrate to form a composite system with the repair material.

The surface of existing concrete and reinforcement should be prepared in accordance with applicable requirements of ICRI 310.1R-2008 and ACI 546R unless specified otherwise.

After removal of concrete to the specified limits, clean the surface to which the repair material is to be applied to remove dust, debris and laitance. Perform final cleaning immediately prior to placement of the repair material.

3.5.2 Cleaning

Mechanical demolition equipment leaves the resulting surface with varying degrees of microcracks and fractures, commonly referred to as "bruising." Bruising creates a zone of weakness that will affect the bond of the repair material to the substrate. Removal subjects the concrete substrate to a wide range of dynamic loads and the resulting bruising will depend on the method used and the quality of the concrete. The depth of the bruised layer varies, but is typically on the order of 1/8 inch. Use hydrodemolition equipment capable of eroding the substrate concrete surface. The equipment shall produce a highly roughened, bondable surface.

Perform all cleaning operations to the satisfaction of the Contracting Officer. Protect adjacent structures and embedded items. Use potable water for cleaning operations. Perform a preliminary cleaning as soon as the chipping is completed to remove loose materials and dust particles. Clean surfaces to which new concrete is to be bonded in accordance with ACI 546R, Concrete Repair Guide, Chapter 2, "Concrete Removal, Preparation, and Repair Techniques". Final cleaning shall remove all laitance, scum, dirt, oil, grease, and loose or disintegrated concrete. Perform additional surface chipping to remove coarse aggregate that is undercut by cleaning process. Perform such additional chipping as determined necessary by the Contracting Officer at no additional cost to the Government. Wire brush or hydroblast metal surfaces against which the concrete is to be placed to remove rust and other contaminants which would prevent proper bond with the concrete. Perform final cleaning immediately prior to concrete placement. Protect all work from contamination during all phases of cleanup and preparation prior to repair.

3.5.3 Rust Cleaning

Freshly cleaned reinforcing steel may rust between the time it is cleaned and the time repair material is placed. If the rust that forms is tightly bonded to the rebar that it cannot be removed by wire brushing, no action should be taken. If the rust is loosely bonded so as to inhibit bond between the steel rebar and the repair material, the reinforcement should be cleaned again before repair material is placed.

3.5.4 Waste Water Disposal

Dispose of waste water employed in demolition, curing, washing, and rinsing or concrete surfaces in a manner such that the waste water does not stain, discolor, or effect exposed surfaces of the structure, or damage the environment of the project area.

3.6 SURFACE REPAIRS

The proper repair methods, material selection, and installation are critical for a successful repair project that is capable to provide the desired serviceability and durability. Each repair application places different demands on the repair materials, and the materials should have suitable properties to meet these demands throughout the designed life of the repair.

Availability of repair materials and methods, cost effectiveness, and the technical feasibility of using them should be considered. Manufacturers or suppliers can provide assistance in the selection of repair materials and application techniques. When selecting the appropriate repair material, one should keep in mind that the technical data presented in manufacturer's

literature may not be sufficient because the tests performed may not be representative of the use of the material in a particular application.

All repair materials have limitations and the specifier shall specify the materials characteristics, properties and test methods in strict accordance with ACI 364.3R, "Guide for Cementitious Repair Material Data Sheet." The range of acceptable performance criteria has to be selected using Guidance of the ACI 546.3R, "Guide for Selection of Materials for the Repair of Concrete," unless otherwise specified herein. ACI 546 R, Guide for Concrete Repair and ICRI Guideline 320.1R-1996 provide guidance for selecting application methods for repair.

The location of potential in-situ bond pull-off core locations should be identified for each discrete repair area so reinforcing steel is not encountered during final acceptance testing.

3.6.1 General

Four repair methods are specified for this project:

a. Form and Pump material applications should be employed for all substructure vertical and overhead repair locations with repair areas of 2 square feet or greater. This includes all concrete encasement repairs of pile caps.

b. Hand Troweling material applications should be employed for all deck soffit and substructure vertical and overhead repair locations with repair areas of less than 2 square feet.

c. Form and pour material applications should be employed for all topical horizontal repairs.

d. Dry Pack material applications should be employed for repairing all in-situ bond pull-off core holes.

3.6.2 Formwork

Formwork for repairs involving form-and-pump method should be constructed in accordance with ACI 347, except for the calculation of form pressure. Form pressure should be designed for a minimum of 14 psi in accordance with ACI E 706, Surface Repair Using Form-and-Pump Techniques. Maximum pressure exerted on formwork occurs after the formed cavity is full and pressurized. Forms should be constructed to fit tightly against existing concrete surfaces. See drawing for specifications of fiberglass forms to remain in-place permanently. Preformed foam gaskets or cast in place foam should be used to address difficult to match surfaces. Temporary forms shall be removed after 7 days.

3.6.3 Form-and-Pump Repairs

3.6.3.1 General

Form and pump repair is a method of replacing deteriorated or damaged concrete by filling the formed cavity with a repair material under pump pressure. The method is generally recommended for vertical and overhead repairs a minimum of 4 inches thick, and more than 2 square feet area, incorporating closely spaced reinforcement, when use of other repair methods may result in poor consolidation of repair material around the reinforcing steel and inadequate bond to the concrete substrate.

Formwork should be constructed with strength sufficient to handle the pressure induced by hydrostatic pressure and the additional pump pressure required to consolidate the repair material. The cavity and formwork design should provide for venting the air. Venting can be accomplished by the removal profile of the prepared concrete. Pumping the cavity is stared at the lowest point in vertical repairs or at an extremity in overhead repairs. Pumping continues until the material flows from an adjacent port in the formwork. Pumping continues until the cavity is completely full. During the final pressurization, the repair material is consolidated around the reinforcing steel and driven into the crevices of the prepared substrate to improve bond.

The form-and-pump repairs should be performed in accordance with ACI E 706, Surface Repair Using Form-and-Pump Techniques.

The form-and-pump is an advanced multi-step repair method of preparing and constructing formwork, and pumping the repair material into the cavity confined by formwork and existing concrete substrate. Prior to construction of the formwork, any substrate surfaces that may cause air to become trapped during the pumping operations must be trimmed, or vent tubes installed.

3.6.3.2 Pumping Procedure

Pumping of the repair material mixtures should be in conformance with ACI 304.2R, ACI E 706 and specified requirements. Attachment of the pump line hose to the formwork can be achieved by use of plumbing fittings with flanges and ball valves.

The sequence of material placement and amount of ports into the formed cavity depends on location and geometry of the repair involved. Vertical surfaces should start at the lowest point, filling in the manner that prevents air entrapment. Arrangement of ports for pump line attachments is usually horizontal with spacing of 3 - 4 feet in grid form. Pumping continues even after material flow occurs from adjacent ports to expel air. When the flow is without intrusion of air, the pump is temporarily shut off, the port closed off, and the pump line connected to the adjacent port that has seen flow. The sequence is continued until the cavity is filled. In some conditions, the cavity can be pumped from one port. In this situation, each adjacent port is capped off as flow occurs. It is necessary to monitor pump-line pressure with a pressure gauge to confirm cavity pressurization and prevent excessive backpressure when pumping long distances. Once the cavity is filled, the full-line pressure is available to pressurize the formed cavity. The formed cavity should target to be pressurized to a 3 to 5 psi increase in line pressure near the cavity port.

Before starting the pumping operation, there should be a direct, continuous communication established between the pump operator and crew at the formwork. The crew at the formwork should direct the pump.

Care must be exercised in the final pressurization because the excessive pump-line pressure (hydraulic pumps can exert in excess of 800 psi} may cause the form to fail. Pressure gauges should be attached to the pump line near the exit to monitor cavity pressure. If the formwork fails due to over-pressurization, the failure will generally occur as a slight movement in a form panel seam or perimeter seal.

Overhead placements are accomplished by starting at an extremity of the surface and proceeding in a fashion similar to vertical placements.

Material will flow radically from the injection port to the adjacent ports.

Exterior vibrators shall be used for repair consolidation as conditions determined by the trial sample repairs require. All vibration operations should be completed prior to pressurizing the form. Vibration after pressurization may cause unwanted movement and overstressing of the form.

3.6.3.3 Curing

The form-and-pump material repairs should be cured in forms for no less than 7 days.

3.6.4 Form and Pour Repairs

3.6.4.1 General

Top surface partial depth repairs may assist in reinstating load carrying capacity in some instances but their usual function is to reinstate protection to the reinforcement locally rather then to act structurally. Conventional concretes and pre-packaged repair materials extended with aggregate are usually employed for this application.

The placement process and equipment should be arranged to deliver the material to its final position without segregation. The equipment should be adequately and properly arranged so that placing can proceed without undue delays and manpower should be sufficient to ensure the proper and timely placing, consolidating, finishing and curing of the repair.

Temperature of the repair material mixture should be between 50° and 85°F, and it should not vary more than approximately 10°F from the temperature of the substrate against which it is placed.

The material placement procedure should begin by slightly overfilling the repair cavity to allow for the reduction in volume. The repair material must fully encapsulate exposed reinforcing steel and achieve satisfactory bond with the substrate. Vibration of the repair material should be performed by interior vibrators or vibrating screeds or both in combination.

Surface finishing (beyond floating) should not be initiated before initial set nor before bleeding water has disappeared from the repair surface.

Repair material should be carefully finished to the cross-section of existing structure. The recommended finishing procedure is to screed from the center of the repair out to the repair boundaries. This will provide the smoothest interface with the existing concrete and will develop an adequate bond at the perimeter of the repair.

Following repair consolidation the finishing operations shall be conducted in a manner in which the repair material is worked and manipulated as little as possible to produce the desired result.

All topical horizontal repairs should employ the form-and-pour repair method, formwork may not be required. Advanced planning should ensure an adequate and consistent supply of repair material during the placement operations.

The placement process and equipment should be arranged to deliver the material to its final position without segregation. The equipment should be adequately and properly arranged so that placing can proceed without

undue delays and manpower should be sufficient to ensure the proper and timely placing, consolidating, finishing and curing of the repair.

3.6.4.2 Cold Weather

Comply with the requirements of ACI 306.1. Do not allow concrete temperature to decrease below 50 degrees F. Obtain approval prior to placing concrete when ambient temperature is below 40 degrees F or when concrete is likely to be subjected to freezing temperatures within 24 hours. Cover concrete and provide sufficient heat to maintain 50 degrees F minimum adjacent to both the formwork and the structure while curing. Limit the rate of cooling to 5 degrees F in any one hour and 50 degrees F per 24 hours after heat application.

3.6.4.3 Hot Weather Repair Operations

Hot weather is any combination of the following conditions that tends to impair the quality of freshly mixed or hardened cement-based concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results:

a. High ambient temperature

b. High concrete temperature

c. Low relative humidity

d. Wind speed

e. Solar Radiation

Maintain required concrete temperature using Figure 2.1.5, "Effect of Concrete Temperatures, Relative Humidity, and Wind Velocity on the Rate of Evaporation of Surface Moisture From Concrete" in ACI 305R to prevent the evaporation rate from exceeding 0.2 pound of water per square foot of exposed concrete per hour. Cool ingredients before mixing or use other suitable means to control concrete temperature and prevent rapid drying of newly placed concrete. Shade the fresh concrete as soon as possible after placing. Start curing when the surface of the fresh concrete is sufficiently hard to permit curing without damage. If the evaporation rate exceeds 0.1 pound of water per square foot per hour, fog spray the exposed concrete surfaces until active moist curing is applied.Provide water hoses, pipes, spraying equipment, and water hauling equipment, where job site is remote to water source, to maintain a moist concrete surface throughout the curing period. Provide burlap cover or other suitable, permeable material with fog spray or continuous wetting of the concrete when weather conditions prevent the use of either liquid membrane curing compound or impervious sheets. For vertical surfaces, protect forms from direct sunlight and add water to top of structure once concrete is set. Concrete temperatures shall be limited to 90 degrees F at the time of placement. Internal concrete temperatures at any time during the construction shall not exceed 150 degrees F.

The following list of measures to reduce or avoid the potential problems of hot weather repair operations must be considered:

a. Cool the material mixture;

b. Minimize the time to transport, place, consolidate, and finish

the repair;

c. Plan the job to avoid adverse exposure to the environment; schedule placing operations during times of the day or night when the weather conditions are favorable;

d. Protect the repair from moisture loss during placing and curing periods;

e. Schedule a pre-placement meeting to discuss the requirements of hot weather repair operations.

Preparations should be made to transport, place, consolidate, and finish the repair material at the fastest possible time.

Delivery to the repair location should be performed so the material mixture will be placed promptly. If necessary, the repair material mixture should be cooled by using ice for part of the mixture water available for substitution.

3.6.4.4 Consolidation

The repair material must fully encapsulate exposed reinforcing steel and achieve adequate bond with the concrete substrate. The repair material should be consolidated by systematic vibration during placement.

Failure to do so, and to do it properly, may result in poor durability and rapid deterioration. Voids between the repair and substrate can cause total debonding. Voids between embedded reinforcing steel and repair material can cause early corrosion.

The vibration of the repair should be performed by interior vibrators or vibrating screeds or both in combination.

Vibrators should not be used to move repair material laterally. They should be inserted and withdrawn at 15 to 30 degrees from the vertical, so that they quickly penetrate the layer and are withdrawn slowly to remove entrapped air. Vibrate at close intervals using a systematic pattern to ensure that all repair material is adequately consolidated. The mixture is adequately consolidated when it stops settling, air bubbles no longer emerge, and a smooth layer of mortar appears at the surface.

The operating speed of interior vibrators should be at least 4,000 vibrations per minute.

Vibration periods of 5 to 15 seconds for each penetration are usually sufficient. The amount of vibration in one spot may be gauged by surface movement and texture of the repair material, by the appearance of cement paste on surface, by the approach of the sound of the vibrator to a constant tone, and by the feel of the vibrator in the operator's hand. Systematic spacing of the points of vibration should be established to ensure that no portions of the repair material are missing.

3.6.4.5 Finishing

The repair should match the existing concrete surface in texture (smooth, broom, form, ect.) and color; it should be carefully finished to the cross-section of existing deck.

Surface finishing should not be initiated before initial set or before bleed water has disappeared from the repair material surface.

The recommended finishing procedure is to screed from the center of the repair out to the repair boundaries. This will provide the smoothest interfaces with existing concrete and will develop an adequate bond at the perimeter of the repair.

To obtain a durable surface of the repair, proper procedures should be carefully followed. Following consolidation, the operations of screeding, floating, and troweling should be performed in such a manner that the repair material will be worked and manipulated as little as possible to produce the desired result.

Over-manipulation of the concrete brings excessive fines and water to the surface, which lessens the quality of the surface, causing checking, crazing, and dusting.

The repair surface shall be hand-troweled to remove any remaining minor irregularities. The edge of a repair located next to a joint should be tooled to provide a good reservoir for joint sealing. Extra mortar from troweling can be used to fill any saw overcuts at the repair corners.

3.6.5 Hand-Trowel Applied Repairs

3.6.5.1 General

In trowel-applied repairs, the repair material is applied directly to the repair location with a trowel (or sometimes by hand). Trowel-applied materials are pressed against the substrate to develop intimate contact without voids. These repairs depend primarily on the adhesive bond between the fresh repair material and the substrate concrete for satisfactory placement. These repairs do not have the benefit of formwork to support the material until it sets, or pneumatic pressure to increase the application pressure and adhesive bond of the applied material. Coarse aggregate is normally not included in the repair material because the coarse aggregate decrease the cohesiveness to the point where the material is weaker than the pull of gravity and falls out of the repair area before the material can set.

This repair technique is critically dependent on the skill of the mason. Masons must have proven experience in hand-troweling repairs, and close quality control should be conducted.

3.6.5.2 Concrete Surface Treatment

The final concrete surface treatment, prior to application of the repair material, should be performed in accordance with the manufacturers' instructions.

3.6.5.3 Application

Proper troweling techniques should be used to prevent the entrapment of air at the bonding surface, which will negatively affect the bond strength.

Special care must be exercised in achieving full intimate contact and consolidation of hand-troweled repair material around the exposed reinforcement.

3.6.5.4 Dry Pack Repairs

Dry packing techniques can be used in all locations, including overhead and vertical. Best applications are generally small cavities, small areas of surface honeycomb, or rib bottoms. Dry pack should not be used for relatively shallow cavities were lateral restraint cannot be obtained.

Dry packing is a repair method of placing zero-slump, or near zero-slump, concrete or mortar, by ramming into surface cavities. Sufficient water should be used to produce a mix that will stick together while being molded into a ball with the hands and will not exuded water but will leave the hands damp. Any less water will not make a sound, solid pack; any more will result in excessive shrinkage and failure.

A bonding agent consisting of neat cement, cement-sand, or latex-cement-sand shall be used because dry pack lacks the extra moisture necessary to promote good bond.

Compaction densifies the repair material and provides the necessary intimate contact with the existing concrete for achieving adequate bond. Dry pack should be solidly compacted over the entire surface by a hardwood stick and a hammer. Much of the tamping should be directed at a slight angle and toward the sides of the cavity to assure maximum compaction in these areas. Each dry pack repair is usually placed in layers.

Because of the relatively small volume of most repairs and the tendency of old concrete to absorb moisture from new material, water curing is a necessary procedure at least during the first 72 hours. The best results are accomplished with a continuous 7-day moisturizing.

3.7 CURING AND PROTECTION

a. ACI 301 and ACI 308R unless otherwise specified. Prevent concrete from drying by misting surface of concrete. Begin curing immediately following final set. Avoid damage to concrete from vibration created by blasting, pile driving, movement of equipment in the vicinity, disturbance of formwork or protruding reinforcement, by rain or running water, adverse weather conditions, and any other activity resulting in ground vibrations. Protect concrete from injurious action by sun, rain, flowing water, frost, mechanical injury, tire marks, and oil stains. Do not allow concrete to dry out from time of placement until the expiration of the specified moist curing period.

b. Wet cure concrete using potable water for a minimum of 7 days. Do not allow construction loads to exceed the superimposed load which the structural member, with necessary supplemental support, is capable of carrying safely and without damage. After completion of moist cure a curing compound shall be used for the remainder of the 28 day curing period.

3.7.1 Moist Curing

3.7.1.1 Fog Spraying or Sprinkling

Apply water uniformly and continuously throughout the curing period. For temperatures between 40 and 50 degrees F, increase the curing period by 50 percent.

3.7.1.2 Pervious Sheeting

Completely cover surface and edges of the concrete with two thicknesses of wet sheeting. Overlap sheeting 6 inches over adjacent sheeting. Sheeting shall be at least as long as the width of the surface to be cured. During application, do not drag the sheeting over the finished concrete nor over sheeting already placed. Wet sheeting thoroughly and keep continuously wet throughout the curing period.

3.7.1.3 Impervious Sheeting

Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 12 inches minimum. Provide sheeting not less than 18 inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Overlap and continuously tape sheeting joints; and introduce sufficient water to soak the entire surface prior to completely enclosing.

3.7.2 Liquid Membrane-Forming Curing Compound

Apply in accordance with the recommendations of the manufacturer immediately after any water sheen which may develop after finishing from 7 day moist cure has disappeared from the concrete surface. Provide and maintain compound on the concrete surface throughout the remainder of the 28 day curing duration curing period. Do not use this method of curing where the use of Figure 2.1.5, "effect of Concrete Temperatures, Relative Humidity, and Wind Velocity on the Rate of Evaporation of Surface Moisture From Concrete" in ACI 305R indicates that hot weather conditions will cause an evaporation rate exceeding 0.2 pound of water per square foot per hour.

3.7.2.1 Application

Mechanically agitate curing compound thoroughly during use. Use approved power-spraying equipment to uniformly apply two coats of compound in a continuous operation. The total coverage for the two coats shall be 200 square feet maximum per gallon of undiluted compound unless otherwise recommended by the manufacturer's written instructions. The compound shall form a uniform, continuous, coherent film that will not check, crack, or peel. Immediately apply an additional coat of compound to areas where the film is defective. Respray concrete surfaces subjected to rainfall within 3 hours after the curing compound application.

3.7.2.2 Protection of Treated Surfaces

Prohibit pedestrian and vehicular traffic and other sources of abrasion at least 72 hours after compound application. Maintain continuity of the coating for the entire curing period and immediately repair any damage.

3.7.3 Curing Periods

Moist cure concrete using potable water for a minimum of 7 days. Continue additional curing for a total period of 28 days. Begin curing immediately after placement. Protect concrete from premature drying, excessively hot temperatures, and mechanical injury; and maintain minimal moisture loss at a relatively constant temperature for the period necessary for hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval by the Contracting Officer.

3.8 FIELD QUALITY CONTROL

3.8.1 General

An independent material inspection and testing contractor shall perform the required field inspection and test procedures outlined in this section, on a daily basis when concrete is being delivered or when pre-packaged material is being batched on-site.

3.8.2 Preparations for Placing

A qualified licensed Professional Engineer (PE) must inspect prepared surfaces, forms, and embedded items in sufficient time prior to each placement of repair material to certify that the surfaces are ready to receive the repair material. The professional engineer shall fill out, sign, and submit the QC Inspection Checklist prior to contractor placing repair material. Blank QC Inspection Checklist included.

3.8.3 Concrete and Pre-Packaged Material Testing

3.8.3.1 Time and Mix Pot Life

Verify repair material has not exceed allowable time or pot life.

3.8.3.2 Sampling

Collect representative sample of fresh concrete or pre-packaged mortar repair material to perform test specified in conformance with ASTM C 172 and ASTM C 31/C 31M.

3.8.3.3 Temperature

Test the concrete delivered and the concrete in the forms. Perform tests in hot or cold weather conditions below 50 degrees F and above 80 degrees F for each batch (minimum) or every 10 cubic yards (maximum) of concrete, until the specified temperature is obtained, and whenever test cylinders and slump tests are made.

3.8.3.4 Air Content

Test air content twice during each shift that repair material is placed. Obtain samples in accordance with ASTM C 172 and test in accordance with ASTM C 231/C 231M.

3.8.3.5 Slump

Test slump twice during each shift that repair material is produced. Obtain samples in accordance with ASTM C 172 and test in accordance with ASTM C 143/C 143M.

3.8.3.6 Consolidation and Protection

Ensure that the repair material is properly consolidated, finished, protected, and cured.

3.8.3.7 Compression Tests

Prepare compression test specimens during each shift that the repair

material is produced in accordance with ASTM C 31/C 31M and cure at the site under the same conditions as the repair. Test in accordance with ASTM C 109/C 109M or ASTM C 39/C 39M.

3.8.3.8 Curing

a. Moist-Curing Inspections - At least once each shift, and once per day on nonwork days, inspect all areas subject to moist curing. Note and record the surface moisture condition.

b. Sheet-Curing Inspection - At least once each shift and once per day on nonwork days, inspect all areas being cured using material sheets.

Note and record the condition of the covering and the tightness of the laps and tapes.

3.8.3.9 Aggregates

Test gradation in accordance with ASTM C 136 and ASTM C 117. Determine the percent passing the No. 200 sieve by washing in accordance with ASTM C 117.

3.8.4 Action Required

3.8.4.1 Placing

The placing foreman shall not permit placing to begin until they have verified that appropriate placement, consolidation, and finishing equipment,are available. Equipment shall be in working order and have competent operators.

3.8.4.2 Time and Mix Pot Life

Dispose of material if it is beyond the designated time or pot life.

3.8.4.3 Air Content

Whenever a test result is outside the specification limits, do not deliver the concrete to the forms and adjust the dosage of the air-entrainment admixture.

3.8.4.4 Slump

Whenever a test result is outside the specification limits, do not deliver the concrete to the forms and an adjustment should be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the water-cementitious materials ratio does not exceed that specified in the submitted concrete mixture proportion.

3.8.4.5 Temperature

Whenever a test result is outside the specified limits, dispose of material and prepare a new batch.

3.8.4.6 Curing

a. Moist-Curing Corrective Action - When a daily inspection report lists an area of inadequate curing, take immediate corrective action, and extend the required curing period for such areas by

one (1) day.

b. Sheet-Curing Corrective Action - When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, promptly repair the tears and holes or replace the sheets, close the joints, and extend the required curing period for those areas by 1 day.

3.8.4.7 Laboratory Test Results

If compression test results fall outside of specified limits, remove defective material and install material meeting specified limits.

3.8.5 Final Inspection and Acceptance Testing

Following completion of the work, inspect surfaces for damage, staining, and other distresses. Inspect repairs for cracking, crazing, delamination, unsoundness, staining and other defects. Inspect the finish and surface tolerances of the repairs to verify that all requirements have been met. Repair all surfaces exhibiting defects as directed at no cost to the Government when defects are due to Contractor workmanship or procedures. Contractor to submit procedures to repair defective work prior to completing repairs.

Perform repair acceptance pull-off bond testing in accordance with the ICRI 210.3-2004, "Guide to Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials" and ASTM C 1583/C 1583M. Bond strength should not be less than 150 psi, unless failure is at least 1 inch into the existing concrete substrate. Areas damaged by pull-off bond tests should be repaired with dry pack repair material.

Perform completed repair acceptance pull-off bond testing at ages consistent with the trial repair pull off testing. Perform bond pull-off test quantities in accordance with ICRI 210.3-2004. Perform a minimum of three pull off tests on hand troweled repairs.

The location of each individual test in designated test areas should be selected by the Contracting Officer prior to repair application and marked on a drawing in order to avoid cutting the reinforcing steel during the test performance.

The following acceptance criteria should be satisfied:

a. Minimum Bond Strength
No individual test result is below 75% of the specified pull-off bond strength.

b. Average Bond Strength
Average pull-off bond strength of the specimens is not less than the specified strength.

3.8.6 Reports

Report the results of all tests and inspections conducted at the project site informally at the end of each shift and in writing weekly and deliver within 3 days after the end of each weekly reporting period.

Reports on lab tests shall be submitted with 35 days of pouring operations.

3.8.7 Manufacturer Field Service

Provide, at no additional cost to the Government, the services of the manufacturer's experienced technical representative during mixture proportioning, planning and production. The manufacturer's representative shall be available for consultation by both the Contractor and the Contracting Officer during mixture proportioning, planning, and production of the materials and shall be on-site immediately prior to and during at least the first placement of the material, and at other times if directed.

3.9 CLEAN UP

Clean all surfaces of concrete and adjacent facilities which are stained by dirt, oil, grease, fuel, or other byproducts that are created by the construction operations with detergent and pressure wash. Dispose of debris in accordance with applicable local, state, and federal laws.

3.10 PROTECTION PRIOR TO ACCEPTANCE

Do not permit vehicular or heavy equipment traffic on the repair surfaces until the repair material obtained the designed strength. Permit light local traffic on the concrete surfaces at the end of the curing period, if approved by the Contracting Officer. Where shelter or other protective measures are provided for repair during inclement weather, maintain such protective measures until the repair material has cured and discontinuance of the measures is authorized.

3.11 FINAL ACCEPTANCE

All defects shall be inspected and documented prior to any repair being completed. Contractor shall submit procedure to Government and A/E for approval prior to repairing any defects.

Contractor to repair all cracks in repairs prior to the end of the warranty period at the 11 month period.

QC INSPECTION CHECKLIST

PROJECT:		CONTRACTOR	NAME:
PROJECT LOCATION:			ADDRESS:
			PHONE:
DEFECT ID:		PROFESSIONAL ENGINEER	NAME:
DEFECT LOCATION:			LICENSE NUMBER:

INSPECTION TASKS

TASK:	DATE COMPLETED:	PROFESSIONAL ENGINEER SIGNATURE:
DETERMINATION OF REMOVAL LIMITS		
CONCRETE DEMOLITION		
CONCRETE DEPTH REMOVAL		
SUBSTRATE SURFACE PREPARATION		
RUST CLEANING		
ANODES INSTALLED		
CONTINUITY TEST		
PULL-OFF BOND TEST CORE LOCATION MARKED		
FORMWORK INSTALLED		
FORMWORK SEALED		
FORM REMOVAL		
FIELD QUALITY CONTROL		
FINAL INSPECTION		
PULL-OFF BOND TEST		
FINAL ACCEPTANCE		

REPAIR QUANTITIES

TASK:	QUANTITY:	DATE INSTALLED:
REINFORCING STEEL (LBS)		

INSPECTION TASKS		
ANODES (EA)		
CONCRETE (SF)		

-- End of Section --