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USACE / NAVFAC / AFCEC / NASA **UFGS-03 01 00 (February 2018)**

Preparing Activity: USACE **Superseding**
UFGS-03 01 30.71 (April 2006)
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 03 - CONCRETE

SECTION 03 01 00

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02/18

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SECTION 03 01 00

REHABILITATION OF CONCRETE
02/18

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NOTE: This guide specification covers the requirements for repair of portland cement concrete using epoxy resin grouts, mortars and concretes.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

1.1 SCOPE

This specification governs the rehabilitation of structural concrete.

1.2 DEFINITIONS

1.2.1 Bracing

Temporary supplemental members used to avoid local or global instability during construction, evaluation, or repair that are intended to be removed after completion of construction.

1.2.2 Delamination

A planar separation in a material that is roughly parallel to the surface of the material.

1.2.3 Rehabilitation

Repairing or modifying an existing structure to a desired useful condition.

1.2.4 Repair

The reconstruction or renewal of concrete parts of an existing structure for its maintenance or to correct deterioration, damage, or faulty construction of members or systems of a structure.

1.2.5 Shoring

Props or posts of timber or other material in compression used for the temporary support of excavations, formwork, or unsafe structures; the process of erecting shores.

1.2.6 Termination Joint

The interface where a placement of repair material meets existing concrete, the edge of an expansion joint, or other existing surfaces.

1.2.7 Unsound Concrete

Concrete that is fractured, delaminated, spalled, deteriorated, defective, contaminated or otherwise damaged.

1.3 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

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

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

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 288	(2021) Standard Specification for Geosynthetic Specification for Highway Applications

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 440.5	(2008) Specification for Construction with Fiber-Reinforced Polymer Reinforcing Bars
ACI 440.6	(2008) Specification for Carbon and Glass Fiber-Reinforced Polymer Bar Materials for Concrete Reinforcement
ACI 440.8	(2013) Specification for Carbon and Glass Fiber-Reinforced Polymer (FRP) Materials Made by Wet Layup for External Strengthening of Concrete and Masonry Structures
ACI 503.2-503.4	(2010, R 2003) Three Epoxy Specifications
ACI 503.3	(2010) Specification for Producing a Skid-Resistant Surface on Concrete by the Use of Epoxy and Aggregate
ACI 503.7	(2007) Specification for Crack Repair by Epoxy Injection
ACI 548.4	(2011) Standard Specification for Latex-Modified Concrete (LMC) Overlays
ACI 548.8	(2007) Specification for Type EM (Epoxy Multi-Layer) Polymer Overlay for Bridge and Parking Garage Decks
ACI 548.9	(2008) Specification for Type ES (Epoxy Slurry) Polymer Overlay for Bridge and Parking Garage Decks
ACI 548.10	(2010) Specification for Type MMS (Methyl Methacrylate Slurry) Polymer Overlays for Bridge and Parking Garage Decks
ACI 548.12	(2012) Specification for Bonding Hardened Concrete and Steel to Hardened Concrete with an Epoxy Adhesive

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE/SEI 37	(2015) Design Loads on Structures During Construction

ASTM INTERNATIONAL (ASTM)

ASTM A775/A775M	(2022) Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A934/A934M	(2022) Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C42/C42M	(2020) Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C387/C387M	(2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
ASTM C496/C496M	(2017) Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C881/C881M	(2020a) Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C882/C882M	(2020) Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear
ASTM C928/C928M	(2020a) Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
ASTM C1059/C1059M	(2021) Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C1077	(2017) Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1438	(2013; R 2017) Standard Specification for Latex and Powder Polymer Modifiers for use in Hydraulic Cement Concrete and Mortar
ASTM C1583/C1583M	(2013) 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)
ASTM C1600/C1600M	(2017) Standard Specification for Rapid

	Hardening Hydraulic Cement
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D93	(2019) Standard Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester
ASTM D226/D226M	(2017) Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
ASTM D323	(2015a) Vapor Pressure of Petroleum Products (Reid Method)
ASTM D450/D450M	(2007; R 2018) Standard Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing
ASTM D542	(2014) Index of Refraction of Transparent Organic Plastics
ASTM D1078	(2011) Standard Test Method for Distillation Range of Volatile Organic Liquids
ASTM D2103	(2015) Standard Specification for Polyethylene Film and Sheeting
ASTM D2822/D2822M	(2005; R 2011; E 2011) Standard Specification for Asphalt Roof Cement, Asbestos-Containing
ASTM D3418	(2015) Transition Temperatures of Polymers by Differential Scanning Calorimetry
ASTM D4016	(2014) Viscosity of Chemical Grouts by Brook field Viscometer (Laboratory Method)
ASTM D4580/D4580M	(2012) Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding
ASTM D4869/D4869M	(2016a) Standard Specification for Asphalt-Saturated Organic Felt Underlayment Used in Steep Slope Roofing
ASTM E329	(2021) Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 310.2R	(2013) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G[, [_____]]

Work Plan; G[, [_____]]

Quality Control Plan; G[, [_____]]

SD-03 Product Data

Conventional Concrete

Polymers

Miscellaneous Materials And Equipment

SD-04 Samples

Reinforcement And Reinforcement Supports

[Polymers]

[Miscellaneous Materials And Equipment]

SD-05 Design Data

Formwork And Shoring; G[, [_____]]

Repair Procedures; G[, [_____]]

Mixture Proportioning; G[, [_____]]

SD-06 Test Reports

Mixture Proportioning

Quality Control

[Tolerence Report]

[Reinforcement And Reinforcement Supports]

[Conventional Concrete]

[Polymers]

[Miscellaneous Materials And Equipment]

SD-07 Certificates

Qualifications

Reinforcement And Reinforcement Supports

[Conventional Concrete]

[Polymers]

SD-08 Manufacturer's Instructions

[Equipment For Concrete Preparation]

[Conventional Concrete]

[Polymers]

[Miscellaneous Materials And Equipment]

1.5 QUALITY ASSURANCE

1.5.1 General Requirements

a. Follow the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE for Work involving portland cement concrete.

b. To protect personnel from overexposure to toxic materials, conform to the applicable manufacturer's Safety data sheets or local regulations. Submit manufacturer's Safety Data Sheets for all polymers as well as other potentially hazardous materials.

c. Submit the repair procedures for executing the work as well as the test data and documentation on materials used for repair. Submittal must include component materials, mixture proportions, and supplier's quality control program.

d. Inspection and testing of surface preparation as well as placement of reinforcing steel must be in accordance with provisions included herein and the Contract Document.

e. Sampling and testing of materials, as well as inspection and testing of work, must be in accordance with established procedures, manufacturer's instructions, specific instructions from the Contracting Officer if given, or recommended practices as referenced herein and the Contract Documents.

f. Trial batches and testing requirements for various repair materials specified are the responsibility of the Contractor.

g. The testing agency must inspect, sample, and test repair materials and concrete production as required. When it appears that material furnished or work performed by Contractor fails to conform to Contract Documents the testing agency will immediately report such deficiency.

1.5.2 Quality Control Plan

Submit a quality control plan as specified in Sections 01 45 00 QUALITY CONTROL [and] [03 30 00 CAST-IN-PLACE CONCRETE].

1.5.3 Qualifications

The submittals must where applicable, identify agencies and individuals who will be working on this contract and their relevant experience. Do not make changes in approved agencies or personnel without prior approval of the Contracting Officer.

1.5.3.1 Testing Agencies

In addition to the requirements of Section 01 45 00 QUALITY CONTROL, agencies that test concrete materials must meet the requirements of ASTM C1077. Testing agencies that test or inspect placement of reinforcing steel must meet the requirement of ASTM E329. Submit data on qualifications of Contractor's proposed testing agency for acceptance.

1.5.3.2 Quality Control Personnel

Field tests of repair materials required must be made by an ICRI Concrete Surface Repair Technician Tier 2. Submit resumes, pertinent information,

past experience, training and education of all operators of specialized demolition equipment if needed for this and the three paragraphs above.

1.5.3.3 Contractor Qualifications

The contractor performing the repair work must have been involved in a minimum of [three][_____] concrete repair projects similar in size and scope to this project for at least [five][_____] years. Submit information, including name, dollar value, date, and point-of-contact for similar projects which demonstrates the required experience and/or training.

1.5.3.4 Worker Qualifications

a. Each worker engaged in the use of specialized removal or application equipment, including [saw operators] [milling machine operators,] [hydromilling equipment operators,] [epoxy injection] [_____], must have satisfactorily completed an instruction program and three years of experience in the operation of the equipment. [The worker must have active experience with the equipment within five years of the project.]

b. Workers installing adhesive anchors must be ACI Adhesive Anchor Installer certified or equivalent.

****

NOTE: Add worker qualification requirements for the usage of specialized equipment if needed. The instruction program for workers engaged in the use of grout injection equipment must have included theory on the nature and causes of cracking in concrete, the technical aspects of correct material selection and use, and the operation, maintenance, and troubleshooting of equipment used in the repair work.

****

1.5.3.5 Regulatory Requirements

Perform all work in accordance with applicable Federal, State, and local safety, health, and environmental requirements. The Contractor is responsible for obtaining all permits required by Federal, State, and local agencies for the performance of the work.

[1.5.4 Pre-Construction Conference

****

NOTE: Appropriate technical representatives for specialized repair materials should be required to meet with the Government and Contractor representatives to ensure that all parties involved are knowledgeable of the material properties and application requirements.

****

[Conduct a pre-construction conference to discuss repair materials performance requirements, control provisions, and roles and responsibilities for the Work to ensure that the Contractor's personnel understand all aspects of the repair material, its properties and application procedures. The conference must include the Contracting

Officer or authorized representative, the Contractor's field superintendent and foreman, and a competent Technical Representative of the material manufacturer, and other involved trades or supplier representatives. The Technical Representative must be fully qualified to perform the work.]

]1.5.5 Work Plan

Prepare a work plan describing the methods of concrete removal and repair, including methods, equipment and materials to be used for each feature. Submit the work plan for approval at least 30 days prior to the start of the work. The plan must include, but not be limited to, repair materials to be used 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. Include a description of field demonstrations in the work plan. Do not commence work until the work plan and field demonstration representative of the type of work are approved.

1.6 ACCEPTANCE OF REHABILITATION WORK

1.6.1 General Requirements

a. Completed concrete rehabilitation work must conform to applicable requirements of Contract Document and this specification. The Contractor is responsible to bring Work into compliance with requirements of Contract Documents if the Concrete repair work fails to meet one or more requirements of Contract Documents.

b. Correct rejected repair work by removing and replacing or by strengthening with additional construction acceptable to the Contracting Officer. Use repair methods that meet applicable requirements for function, durability, dimensional tolerances, and appearance.

c. Submit proposed work plan, repair methods, materials, and modifications to the Work needed to correct rejected repair work to meet the requirements of Contract Documents.

1.6.2 Tolerances

a. Construction tolerances for repairs must conform to [ACI 117][_____]. Where existing conditions do not allow tolerances to conform to [ACI 117][_____], use the details and materials for such conditions as indicated in the Contract Documents. For conditions not shown or that are different than indicated in the Contract Documents, notify the Contracting Officer before proceeding with the work at those locations.[Provide a tolerence report as required by Section 03 30 00 CAST-IN-PLACE CONCRETE.]

b. Inaccurately formed concrete surfaces resulting in concrete members with dimensions that exceed [ACI 117][_____] tolerances are subject to rejection.

1.6.3 Appearance

Concrete surfaces not meeting the requirements of the Contract Documents must be brought into compliance.

1.7 PROTECTION OF COMPLETED REHABILITATION WORK

a. Do not allow construction loads to exceed the loads that a structural member or structure is safely capable of supporting without damage. Provide supplemental support if construction loads are expected to exceed safe load capacity.

b. Protect repaired and adjacent areas from damage by construction traffic, equipment, and materials. During the curing period, protect repair materials from damage by mechanical disturbances, including load-induced stresses, shock, and vibration.

c. Protect repair materials from environmental damage by weather events during the length of the curing period.

PART 2 PRODUCTS

****

NOTE: Unconventional products and materials could sometimes be the best solutions for repairs. Since the repair industry is evolving, products and materials not listed in this document that have had a record of success in the field could be allowed on a project. The Contracting Officer must permit the usage of those materials prior to application. Additional submittals for those materials should also be requested as needed.

****

Products or materials used must conform to the requirements included herein as well as the Contract Documents. The usage of other products or materials not covered by this requirement or specified in the Contract Documents are permitted upon approval by the Contracting Officer. Additional information and submittals for products and materials not included in this document including product data, samples, design data, test reports, certificates, manufacturer's instructions, and field reports must be submitted as requested by the Contracting Officer.

2.1 MATERIALS FOR SHORING AND BRACING

2.1.1 Shoring and Bracing Systems

Use commercially manufactured and engineered shoring and bracing systems and components, except where custom built assemblies of lumber or other suitable materials are permitted by the Contracting Officer.

2.1.2 Design Requirements

The design of the bracing and shoring must be based on ASCE/SEI 37.

a. Non-manufactured shoring and bracing systems must have calculations signed and sealed by a Licensed Design Professional.

b. Members of non-manufactured shoring systems, must be designed in accordance with the provisions of the governing building code for the specific material of the member.

c. Members of manufactured shoring systems, consisting of pre-engineered components designed and produced specifically for structural shoring,

must be used in accordance with the manufacturer's recommendations.

2.2 EQUIPMENT FOR CONCRETE PREPARATION

****
NOTE: Refer to ACI 546R and ICRI 310.2R for more detail guidance on methods discussed in this paragraph.
****

Means and methods used for concrete removal and surface preparation must be selected and used such as to minimize damage to the structure and to the concrete substrate that remains.

2.2.1 Equipment for Concrete Removal

Removal equipment and techniques must be suitable to produce concrete surface profiles and level of cleanliness in designated areas as required by this specification and the contract Documents.

[2.2.1.1 Cutting Equipment

****
NOTE: Cutting equipment and methods are used to cut and remove concrete sections. Include this paragraph if cutting equipment and methods are required or permitted for concrete removal.
****

a. The following cutting equipment are permitted: [High-pressure water jet without abrasives][Saw cutting][Diamond wire cutting][Mechanical shearing][Stitch drilling][_____].

****
NOTE: Refer to ACI 546R for details on selecting the different equipment and methods for cutting concrete.
****

b. Cutting, lifting, and transporting equipment must be adequate to cut, support, and transport concrete sections without incurring any damage to the existing structure.

]2.2.1.2 Concrete Breakers

****
NOTE: concrete breakers are also known as impact methods. These are the most commonly used methods for concrete removal.
****

a. Provide sharp tips on breaker equipment to minimize microcracking damage in partial depth removal.

****
NOTE: Sharp-pointed tools tend to reduce the potential for microcracking of the surface concrete left in place.
****

b. The use of the following impact equipment and methods is permitted: [Hand-held breakers][Boom-mounted breakers][Scabblers][Needle scalers][Scarifiers][Milling methods][_____].

c. [The maximum breaker size is [_____]][_____].

****

NOTE: Use the information provided in this note and ACI 546R to select the suitable type and size of impact breakers allowed on the project (bullet point b and c). Note that you can include different types and sizes of breakers for a job and specify where each should be used. Using large breakers increases the potential for microcracking, and that is why a suitable size (or limits) should be specified.

Hand-held breakers (chipping hammers): size ranges from 8 to 90 lbs (3.5 to 41 kg). Smaller hand-held breakers are commonly used in partial depth removal of sound and unsound concrete and concrete removal around reinforcing steel because they minimize damage to the existing concrete and reinforcing steel. Larger breakers are used for removal of large volumes of concrete. For example, a 14 kg (30 lbs) breaker can be specified for removal of concrete above reinforcing steel while a smaller 7 kg (15 lbs) hammer can be specified to remove concrete around reinforcing steel.

Boom-mounted breakers: is like the hand-held breaker except that it is mechanically operated and considerably larger than a handheld breaker. Boom-mounted breakers differ from hand-held breakers as they function on the principle of high energy and low frequency rather than low energy and high frequency, and are driven by compressed air or hydraulic pressure. The reach of the hydraulic arm enables the breaker to be used on vertical or overhead surfaces at a considerable distance above and below the machine level.
The boom-mounted breaker is a highly productive means of removing concrete; however, the high-cycle impact energy delivered to a structure by the breaker generates forces that may damage the existing concrete and reinforcing steel and adversely affect the integrity of the structure. For boom-mounted breakers, limits specified are based on energy not weight (example 205 N-m or 150 ft-lbs).

Milling methods can remove a specified amount of concrete from large areas of horizontal or vertical surfaces. The removal depth typically ranges from 1/4 to 4 in. (6 to 100 mm). Removal depth is determined by the number and size of teeth. Milling operations typically leave a sound surface with fewer microfractures than impact methods.
Rotary head milling equipment is used for uniform

depth removal on horizontal or vertical surfaces. Boom-mounted milling head are used typically for vertical surfaces.

For information on Scabblers, Needle scalers, and Scarifiers refer to ACI 546R.

****

[2.2.1.3 Hydromilling Equipment

****

NOTE: Delete this paragraph if water blasting equipment is not allowed on the job. For more information on hydrodemolition refer to ACI 546R and ICRI 310.3R.

****

a. Hydromilling equipment must include a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water re-supply equipment. The water tank and auxiliary re-supply equipment must be of sufficient capacity to permit continuous operations.

b. Hydrodemolition for concrete removal is permitted in the following locations: [_____]

****

NOTE: Specify where (the locations) hydrodemolition is permitted to be used for concrete removal.

****

c. Use protective covers and barriers to protect adjacent surfaces not intended to be repaired from water blasting and over-spray.

d. Use equipment capable of delivering pressures of 35 MPa 5000 psi to 275 MPa 40,000 psi at 7.5 liters/min 2 gal/min to 190 liters/min 50 gal/min for concrete removal and surface preparation.

e. [Noise resulting from hydrodemolition operations must be at a noise level of less than [90 decibels][_____] at a distance of [15 m 50 ft.][_____].]

****

NOTE: Hydrodemolition does not produce significant sound that is transmitted through a structure; however, the noise from the hydrodemolition unit in the work area is sufficiently loud and may be objectionable to the public. If noise resulting from hydrodemolition operations need to be controlled, then add the above requirement and make changes to it as needed

****

]2.2.2 Surface preparation and cleaning equipment

[2.2.2.1 Abrasive Blasting

a. Use [dry][wet][dry or wet] oil-free abrasive blasting capable of removing loose micro-fractured (bruised) or otherwise damaged or

pulverized concrete surfaces, and rust from exposed steel reinforcement, and providing a surface profile in compliance with the Contract Documents.

****
NOTE: Choose if dry or wet abrasive blasting can be used. Refer to ACI 546R for more information on the topic.
****

b. [Use the following abrasive blasting methods: [Sandblasting] [Shotblasting] [_____]]

****
NOTE: Add this requirement if methods of abrasive blasting need to be specified. This requirement can be expanded to include locations where certain methods of abrasive methods should be used. If this is needed, then specify the method along with the location that it should be used.
****

][2.2.2.2 Low Pressure Water Cleaning

Use equipment capable of delivering 7 MPa 1000 psi to 35 MPa to 5000 psi at 7.5 liters/min 2 gal/min to 38 liters/min 10 gal/min for cleaning loose material from repair areas.

]2.2.2.3 Other Cleaning Equipment

Use equipment that delivers oil free air capable of cleaning loose material and debris from repair areas. If necessary to dry the concrete surface, [gas-fired torches or] clean, dry, compressed air may be used. Also, use vacuums capable of removing loose material and debris.

2.3 MATERIALS FOR FORMWORK AND EMBEDDED ITEMS

a. Formwork and embedded items must meet the requirements specified in Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

****
NOTE: Formwork requirements for repairs are similar to requirements for new construction. Formwork should be designed to support repair material pressures as well as pressure resulting from placement and consolidation vibrations. Formwork should also be designed to maintain specified dimensional tolerances.
****

b. Install and remove formwork without damaging or staining the existing structure or repair material.

c. Forms used for polymer concrete/mortars must be tight enough to hold the material that is used without leaking. All surfaces where bond is not desired, but which are exposed to the monomer or resin, must be treated with a form release agent.

****

NOTE: Some polymers/resins/monomers have low viscosity and might require tighter forms than what is usually used for portland cement concrete.

****

2.4 REINFORCEMENT AND REINFORCEMENT SUPPORTS

2.4.1 Steel Bars, Wires, and Fiber-reinforced Concrete

a. Reinforcement and reinforcement support must meet the requirements specified in Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

****

NOTE: Conventional reinforcement used for repairs is no different than reinforcement used for new construction.

****

b. Repair coating damage incurred during shipment, storage, handling, and placing of reinforcing bars in accordance with [the appropriate ASTM standard practices for repair of damaged reinforcement][ASTM A780/A780M][ASTM A775/A775M][ASTM A934/A934M][_____]. Damaged areas must not exceed 2 percent of surface area in each linear foot of each bar.

****

NOTE: Coated reinforcing bars often incur damage during transportation and handling. Coated reinforcing bars are used to mitigate corrosion and that is why it is important to ensure that they are not damaged and the cause of future localized corrosion failures.

ASTM has several documents that discuss practices for repair of damaged bars. ASTM A780/A780M discusses the repair Zinc-coated reinforcing bars, while ASTM A775/A775M and ASTM A934/A934M discuss practices for repair of epoxy-coated bars (See ASTM standards for other types of bar repairs). Specify a standard for repair of bars as needed in your project. If the statement "...in accordance with the appropriate ASTM standard practices for repair of damaged reinforcement" is selected, then it will be up to the Contractor to choose the ASTM standard for repair when multiple standards exist.

****

c. Mechanical splices for coated reinforcement must have compatible coatings, in accordance with manufacturer's instructions. Splices for galvanized reinforcement must be galvanized or coated with dielectric material. Splices used with epoxy-coated or dual-coated reinforcement must be coated with dielectric material.

d. Submit mill certificates and shop drawings as requirement by Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

2.4.2 Fiber-Reinforced Polymers

****

NOTE: Fiber-Reinforced Polymers (FRP) include FRP bars and FRP laminates. FRP bars are used inside (and sometimes outside) the concrete to replace conventional steel reinforcement. FRP laminates are attached outside concrete members mainly for strengthening purposes. For more information on FRP bars and laminates, refer to ACI 440 documents.

****

a. Fiber-Reinforced Polymers (FRP) bars used as internal reinforcement in concrete and their supports must meet the product requirements of ACI 440.5 and conform to [ACI 440.6][_____].

****

NOTE: ACI 440.5 and ACI 440.6 are two ACI specifications related to the use of FRP bars in concrete. ACI 440.5 is a construction standard, while ACI 440.6 is a material standard. ACI 440.6 was written by an ACI committee as the basis of a future ASTM standard. If ACI 440.6 is withdrawn and adopted by ASTM, refer to the ASTM material standard instead of ACI 440.6.

****

b. Submit test reports and certificates for FRP bars as required by ACI 440.5 and the Contract Documents.

c. Fiber-Reinforced Polymer (FRP) laminate materials externally bonded to concrete made by wet layup must meet the requirements of ACI 440.8 and the Contract Documents. Submit product data sheets for materials used for FRP layup systems as described in ACI 440.8.

d. The use of externally bonded FRP systems other than wet layup systems are permitted upon approval by the Contracting Officer. Submit product and materials data, design data, test reports, certificates, manufacturer's instructions, and field reports for those systems as requested by the Contracting Officer and required by Contract Documents.

****

NOTE: To learn more about commercially available externally bonded FRP systems refer to ACI 440.2R.

****

2.5 CONVENTIONAL CONCRETE

****

NOTE: Conventional concrete used for repairs has the same base requirements as concrete used for new construction.
Additional requirements to consider in material selection include:
- Good tensile bond, to have a strong bond between the repair and substrate.
- Modulus of elasticity similar to substrate.
- Low drying shrinkage so that the material does not

lose volume over time.
- Matching coefficient of thermal expansion with the substrate by using similar coarse aggregate type. Materials with different coefficients of thermal expansion will shrink/expand at different rates and cause cracking or spalling.
- Low creep so that the repair does not relax over time due to loads.
Note that these material requirements and properties should have been considered in the design phase. Refer to ACI 546R, ACI 546.3R, and ICRI 320.2R. for more information the selection of materials for repair.
****

a. Portland cement concrete materials must meet the requirements specified in Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

b. Materials for shotcrete must meet the requirements of Section 03 37 13 SHOTCRETE.

c. [For cement based bonding systems use neat portland cement or a blend of portland cement and an ASTM C33/C33M fine aggregate filler proportioned one to one by mass. The water-to-cement ratio of the bonding mixture must be [equal to the water-to-cement ratio of concrete used as a repair or overlay material][_____]. Water used must meet ASTM C1602/C1602M requirements.]

****
NOTE: If the use of cement based bonding agent is not permitted, delete this requirement. If it is permitted, then specify the water-to-cement ratio for that mixture.
****

d. [Use cementitious materials indicated in the Contract Documents.][Use cementitious materials of the same brand and type from the same manufacturing plant as the cementitious materials used in the concrete represented by the submitted field test records or used in trial mixtures.][_____]

****
NOTE: If information on cementitious materials is provided in the Contract Documents, then the first part of the requirement should be sufficient. If the information on cementitious materials is not provided, the second part of the requirement will require the use of materials that match the existing concrete (substrate).
Using similar cementitious materials is prescribed to have compatibility between the repair material and the existing substrate. The use of incompatible materials can cause deterioration at the interface between the existing and new concrete due to differential volume changes.
Note that this requirement is only applicable if the materials originally used for the substrate were adequate and not the cause of deterioration.

Material selection should have been considered in the design phase of the repair.

****

e. Aggregates used in concrete must be obtained from the same sources [,be of the same type][and have the same size range] as aggregates used in the concrete represented by submitted historical data or used in trial mixtures.

****

NOTE: Like cementitious materials requirements, aggregates used for concrete need to be compatible with the existing concrete.

Only require the same size range of aggregate if it is appropriate for the repair. Remember that the maximum coarse aggregate size should not exceed three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs, overlays, or partial depth repairs.

****

f. Refer to Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][03 37 13 SHOTCRETE][_____] for details on submittals involving conventional concrete.

2.6 POLYMERS

****

NOTE: For more information on polymers and their use in repair, refer to ACI 503, 546, 548, RAP (Repair Application Procedures) documents and ICRI 320.2R.

When selecting polymers for repairs, select the material based on the desired properties. Some polymers like epoxies are well defined and standardized which makes specifying them much easier. Other materials like urethanes are not well standardized for usage in construction. These should only be specified after reviewing information obtained from the material manufacturer and comparing that to the desired properties needed for the repair.

Some of the properties to consider when specifying these materials are: working time of the material, curing times and requirements, viscosity and the ability to penetrate cracks, resistance to temperature changes, sensitivity to light (UV rays) and other exposures, thickness of material required, strength, flexibility and rigidity, and compatibility with other materials.

****

a. The requirements for the properties of polymers and aggregates used in

polymers must meet the requirements specified in this paragraph as well as the properties specified in the referenced specifications and the Contract Documents.

b. Polymers used must be compatible with other polymers and materials used on the project. Unless repair materials are specified in the contract documents, the Contractor is responsible for verifying material compatibilities.

****

NOTE: Material compatibility is vital in repairs. Make sure that you specify materials that will work well together and work well with concrete.

****

c. Submit product data, manufacturer's Safety Data Sheets,samples, design data, test reports, certificates, manufacturer's instructions, and field reports for materials as required by this document as well as the referenced specifications and the Contract Documents.

2.6.1 Epoxies

****

NOTE: Epoxy mortars and concrete do not have thermal characteristics compatible with portland cement concrete. This thermal incompatibility should be carefully considered before specifying epoxy mortar or concrete for exterior concrete surface repairs.
For example, when used to repair cracks, limit their use to cracks ranging from 0.002 to 0.25 in. (0.05 to 6 mm) wide; a thicker cross section of the epoxy in a crack exposed to large temperature variations can cause internal stresses in the repaired concrete. Moreover, epoxy should not be used to repair active cracks (still moving) because cracks parallel to the original cracks are likely to occur.

For more information on epoxies and crack repair refer to ACO 546R, ACI 546.3R, and ACI 548.1R.

****

a. Epoxy mortars and epoxy compounds must conform to ASTM C881/C881M [.][,Type [_____]; Class [_____]; Grade [_____]; [_____].]

b. Epoxy mortars used for repairing defects in hardened portland cement concrete must meet the requirements of ACI 503.2-503.4.

c. Epoxy used for crack repair must meet the requirements of ACI 503.7.

****

NOTE: Epoxy is one of the main polymer materials used for crack repairs. Crack repair are usually either for structural purposes (strength related) or for sealing cracks (stop water and other materials from passing through). Because of their bond strength, epoxies are the main materials used for structural crack repairs. They should however not be

used with active cracks. Refer to ACI 546R and 546.3R for more details.

Also, note that ASTM C881/C881M, Type IV, Grade 1 is good for repairing crack sizes from 0.005 to 0.010 in. (0.13 to 0.25 mm). Smaller cracks may not need repair. For larger cracks, a more viscous epoxy may be appropriate (ACI RAP 1 and ACI 503.7).

****

d. Epoxy used to produce a skid-resistant surface on hardened concrete must meet the requirements of ACI 503.3.

e. Epoxy used for overlays must meet the requirements of [ACI 548.8][ACI 548.9].

****

NOTE: ACI 548.8 covers Epoxy multi-layer overlays while ACI 548.9 covers epoxy slurry overlays (for Bridge and Parking Garage Decks). Refer to those documents for more details.

****

f. Epoxy used for bonding freshly mixed concrete and hardened concrete must meet the requirements of ASTM C881/C881M, Type [II][V], Grade [2][3], Class [A][B][C].

****

NOTE: Type II adhesives are used in non-load-bearing applications, whereas Type V are for load-bearing uses. Grade 1 materials are low viscosity (not to be used for this application). Grade 2 materials are medium viscosity. Grade 3 materials have a non-sagging consistency. Class A materials are used when temperatures are below 40°F (4°C), Class B materials are used when temperatures are typically between 40 and 60°F (4 and 16°C), and Class C materials are used when temperatures are above 60°F (16°C) with upper limits set by the manufacturer.

Refer to ASTM C881/C881M for more information about types, grades, and classes of epoxies.

Refer to ACI 548.11R for more information about epoxy used as bonding agent.

****

g. Epoxy used for bonding hardened concrete and steel to hardened concrete must meet the requirements of ACI 548.12.

2.6.2 Latexes

a. Latex used in polymer modified portland cement concrete/mortar must meet the requirements of ASTM C1438.

b. Latex used in polymer modified portland cement concrete overlays must meet the requirements of ACI 548.4.

c. Latex used for bonding freshly mixed concrete and hardened concrete must meet the requirements of ASTM C1059/C1059M, Type II.

****
NOTE: Refer to ASTM C1059 for more information about latex used as bonding agent. Also, refer to ACI 548.12 for information about use and application of this material.
****

2.6.3 Methacrylates

****
NOTE: Per ACI 546R, methacrylates have high adhesive strength and can bond cracks as a structural repair. Methacrylates can therefore be used to restore strength (like epoxies) to a structural as well as for sealing cracks.
****

a. Methyl methacrylate slurry (MMS) used for overlays must meet the requirements of ACI 548.10.

b. High molecular weight methacrylate (HMWM) must be a 2-component, rapid curing, and solvent-free system.

c. HMWM monomers must be a high molecular weight or substituted methacrylate that conforms the following properties:

Physical Properties of HMWM Monomer		
Property	Test Method	Criteria
Vapor Pressure Flash Point Density	ASTM D323 ASTM D93	Less than 133 Pa at 25 degrees C Greater than 93 degrees C Greater than 1.0 g per cubic cm at 25 degrees C Less than 0.02 psi at 77 degrees F Greater than 200 degrees F Greater than 8.4 lbs. per gal. at 77 degrees F
Viscosity Index of Refraction Boiling point @ 133 Pa 0.02 psi Shrinkage on cure	ASTM D4016 ASTM D542 ASTM D1078	0.012 ± 0.004 Pas at 23 degrees C; 1.470 ± 0.002 70 degrees C Less than 11 percent 12 ± 4 cps at 73 degrees F 1.470 ± 0.002 158 degrees F Less than 11 percent
Glass Transition Temperature (DSC)	ASTM D3418	57.2 degrees C 158 degrees F

Physical Properties of HMWM Monomer		
Curing Time (100 g mass)	ASTM D3418	Greater than 40 minutes at 25 degrees C, with 4 percent cuemene hydroperoxide Greater than 40 minutes at 73 degrees F, with 4 percent cuemene hydroperoxide
Bond Strength	ASTM C882/C882M	Greater than 10.3 mPa Greater than 1,500 psi

d. The initiator/promoter system for HMWM must be capable of providing a surface cure time of not less than 40 minutes nor more than 3 hours at the surface temperature of the concrete during application. The initiator/promoter system must be such that the gel time may be adjusted to compensate for changes in temperature that may occur throughout the treatment application.

d. The initiator/promoter system for HMWM must meet the following criteria:

Initiator Cuemene Hydroperoxide	78 percent
Promoter Cobalt Napthenate	6 percent

[2.6.4 Other Polymers

****

NOTE: There are many types of polymers that could be used for concrete repair. Some of them however can vary a lot in properties and are not well defined or standardized in the construction industry. These materials should only be used after understanding their properties. Refer to ACI 546R and 546.3R for more information.

Note that not all polymers have similar properties and thus are usage specific. For example, while a polyurethane grout could be used to seal cracks, it will not restore structural strength like epoxies or methacrylates do. The polyurethane however could be a better choice than an epoxy if a crack is active and the only reason for using the polyurethane is to seal cracks and stop water from going through.

****

The use of [urethanes][silicones][acrylics][_____] is permitted.

****

NOTE: Choose the types of polymers (other than epoxies, latexes, and methacrylates) that can be used on your project. You could also add to this the locations where those materials could be used and

where they should not.
****

Submit [product data], [samples], [design data], [test reports], [certificates], [manufacturer's instructions] for acceptance by the Contracting Officer.

****
NOTE: Based on the materials being specified, specify the submittals required by the Contractor.
****

]2.6.5 Aggregate

a. Unless otherwise specified or recommended by the polymer material manufacturer, aggregate used with polymers must meet ASTM C33/C33M requirements.

b. Aggregate properties and proportions used with polymers must meet the requirements of the polymer material manufacturer, the requirements of the referenced polymer standard, and the Contract Documents.

c. Aggregate used with polymers must be dry and free of dirt, asphalt, and other organic materials. Aggregate moisture content must be less than [0.2][1][_____] percent by weight.

****
NOTE: If a specific moisture content for aggregate is required, add this requirement in c. ACI 548.1R recommends a moisture content of less than 1 percent for use with polymers. Note that some referenced standards do have limits specified.
****

d. For patch repairs, the maximum-sized aggregate must not be greater than one third the depth of the patch area.

2.7 MISCELLANEOUS MATERIALS AND EQUIPMENT

2.7.1 Packaged and proprietary materials

****
NOTE: Material properties and durability requirements for this material should be included in the Contract Documents. Specify submittals required for those materials.
****

The required properties for the materials listed in this paragraph must meet the properties specified in the Contract Documents. Submit [Product data], [samples,] [design data,] [test reports,] [certificates,] [manufacturer's instructions], [and field reports] as required by the Contracting Officer and the Contract Documents.

a. Packaged, rapid hardening concrete repair materials must conform to ASTM C928/C928M.

b. Packaged, mortar and concrete must conform ASTM C387/C387M.

c. Rapid hardening cement must conform to ASTM C1600/C1600M.

Water used with packaged and proprietary materials must meet ASTM C1602/C1602M requirements. Aggregates must meet the repair material manufacturer's requirements if available and ASTM C33/C33M if such requirements are not specified.

2.7.2 Bond Breakers

****

NOTE: Bond breakers are used as separator layers between existing concrete and overlays in unbonded overlay construction. The performance of unbonded resurfacing of concrete pavements depends largely upon obtaining effective separation between the two pavements. Because unbonded resurfacing is generally for concrete pavements in a more advanced state of deterioration, distresses in the underlying pavement can reflect through the resurfacing and compromise its performance if not addressed. To minimize the effect of the distresses in the underlying pavement on the performance of the unbonded resurfacing, a separator layer is placed so that the two pavements act independently of each other. It may be less expensive and enhance longevity to simply fill low spots with concrete in the resurfacing process. A wide variety of materials have been used as separator layers, including polyethylene sheeting, wax-based curing compounds, liquid asphalts, and hot-mix asphalt materials. The most common successful used separator layer is 1 in. (2.5 cm) of asphalt. Less than 1 in. (2.5 cm) thick asphaltic separator layers, such as slurry seals, have worked well in some cases, but are generally not recommended because they do not eliminate mechanical interlock, they erode near the joints, and they do not effectively separate the two layers. Polyethylene sheeting and curing compounds are also not recommended. They do not prevent working cracks from reflecting through the resurfacing and they trap moisture in the concrete, which may accelerate freeze-thaw damage. Typically, a fine-graded asphalt surface mixture has been used for the separator layer. On most pavements, a nominal 1 in. (2.5 cm) thick layer provides adequate coverage over irregularities in the existing pavement. The thickness could be slightly increased when irregularities are large enough to impact placement operations. The separator layer does not provide significant structural enhancement; therefore, the placement of an excessively thick layer should be avoided.

For more information on overlays, refer to ACI 325.13.

****

a. Bond breaker materials must meet the requirements of [ASTM D2822/D2822M

], [ASTM D4869/D4869M], [ASTM D226/D226M, Type I], ASTM D2103, and must have a minimum thickness of [0.25 mm 0.010 in.][_____], [AASHTO M 288, Erosion Control, Class B], [ASTM D450/D450M, Type II].

****

NOTE: ASTM D2822/D2822M is an asphalt roofing cement, ASTM D226/D226M and ASTM D4869/D4869M are asphalt saturated organic felt. ASTM D2103 is polyethylene sheet. AASHTO M 288 is geotextile. ASTM D450/D450M is a bituminous coating.

Note that the choice of material and thickness should have been accounted for in the design of the overlay.

****

b. Bond breaker materials used must not have detrimental effects on portland cement concrete and reinforcement.

2.7.3 Structural steel

Structural steel used for repairs must meet the requirements of 05 12 00 STRUCTURAL STEEL.

2.7.4 Concrete Accessories

****

NOTE: Any accessories specified in other sections (used for new construction) and not listed in this section should be referenced in this paragraph.

****

All concrete accessories not included in this document must meet the requirements specified in Section 03 30 00 CAST-IN-PLACE CONCRETE [and 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE].

2.7.5 Miscellaneous Equipment

a. Equipment designed specifically for the application of repair materials must be used as required by the repair material manufacturer and the referenced specification.

b. Equipment not listed in this specification but referenced or used for repairs must be clean and in good operating condition.

c. All supplies and equipment must be available in sufficient quantities to allow continuity in the installation project and quality assurance.

2.8 MIXTURE PROPORTIONING

a. Portland cement-based concrete mixtures must be in accordance with the requirements of Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][03 37 13 SHOTCRETE].

b. Polymer concrete/mortar/resin/monomer proportioning, handling, and mixing procedures as well as equipment used for mixing these materials must conform to the requirements of the referenced material specifications and the repair material manufacturer's directions.

****

NOTE: Polymers have different requirements for proportioning and mixing. This information is usually provided by the material manufacturer or in the referenced specification.

For example, for epoxies used for crack repairs, the ACI standard requires the following: "Use equipment for the two components of the injection adhesive that can establish and maintain a ratio of the components within the tolerance specified by the manufacturer of the injection adhesive over the full range of operating pressures and temperatures. If the manufacturer of the adhesive does not specify a tolerance for the mixture ratio, maintain a mixture ratio within ±3 percent of the nominal mixture ratio specified by the manufacturer of the adhesive."

****

c. Polymer-modified portland cement concrete proportioning, handling, and mixing procedures as well as equipment used for mixing these materials must conform to the requirements provided by the repair material manufacturer as well as ACI 548.4 when such materials are used for overlays.

d. Proportioning and mixing materials not specified above must follow the requirements provided by the repair material manufacturer.

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

3.1.1 Examination

Locate area of unsound concrete or delamination using hammer sounding or chain drag sound methods in accordance to ASTM D4580/D4580M. Denote and mark perimeter boundaries and notify the Contracting Officer to approve the unsound concrete layout boundaries.

3.1.2 Protection

Protect pedestrians, motorized traffic, mechanical, electrical, and plumbing equipment, surrounding construction, project site, landscaping, and surrounding buildings from damage or injury resulting from concrete rehabilitation work.

a. Construct dust and debris barriers surrounding repair work perimeter to control dust and to protect and control construction traffic.

b. Dispose of runoff from wet demolition or surface preparation operations in accordance with all local ordinances. Disposal methods must avoid soil erosion, avoid undermining pavements and foundations, damage to landscaping and vegetation, and minimize water penetration through other parts of buildings.

c. Collect and neutralize alkaline wastes and acid wastes and dispose in accordance with local, state, and federal regulations.

d. Comply with local noise ordinances during demolition operations.

e. Perform demolition work and surface preparation work in a manner that minimizes disturbances of operations. Coordinate work with the Contracting Officer.

f. Submit a proposed protection plan for approval by owner representative and Licensed Design Professional.

3.1.3 Formwork and Shoring

Execution of formwork and shoring must meet the requirements specified in Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

3.1.3.1 Formwork

a. Construct forms to sizes, shapes, lines, and dimensions to match existing adjacent surfaces and textures. Provide forms that match openings, offsets, chamfers, anchorages, inserts and other features as described on Contract Documents. Construct forms to accommodate installation of products by other trades. Provide forms for easy removal to minimize damage to concrete surfaces and adjacent surfaces. Apply form release coating over formwork surfaces prior to each concrete placement. Form release agents must not be applied to or come in contact with the repair area concrete substrate or reinforcement.

b. Do not damage repair material during removal of formwork for columns, walls, sides of beams, and other parts not supporting weight of concrete or repair material. Perform needed repair and treatment required on vertical surfaces at once and follow immediately with specified curing. Remove all formwork anchors embedded in existing concrete. Fill anchor holes and repair all damage to existing concrete at anchor holes.

3.1.3.2 Shoring

a. Provide shoring in accordance with the shoring drawings prior to performing work to brace the substrate structure temporarily while repair work is proceeding. Shoring must be designed, documented, and stamped by a Licensed Design Professional. Shoring designs must be submitted to and approved by the Contracting Officer prior to work commencing.

b. Leave formwork and shoring in place to support existing loads, construction loads and weight of repair material in beams, slabs, and other structural members until in-place strength of repair material determined in accordance with the Contract Documents. For post-tensioned construction, leave formwork and shoring in place until stressing is complete. When shores and other supports are arranged to allow removal of form-facing material without allowing structural slab or member to deflect, form-facing material and its horizontal supporting members may be removed at an earlier age.

****

NOTE: Formwork and shoring requirements for repairs are like requirements for new construction. Requirements unique to repair are provided here. The need for shoring is determined during the design phase. Construction loads and sequence of

construction must be communicated in the Contract Documents.
****

3.1.4 Concrete preparation

a. Remove concrete as needed per the removal requirements of this section. Limits on removal equipment are specified in the paragraph titled EQUIPMENT FOR CONCRETE PREPARATION.

b. Remove foreign material, such as dirt, oil, grease, or other chemicals, from the cracks before injection using compressed air, low-pressure water, or vacuuming. Allow wet surfaces to dry at least 24 hours.

c. Immediately before placing the repair material or installing formwork, make the repair area available for inspection by the Contracting Officer. Obtain acceptance by the Contracting Officer of surface preparation before proceeding with Work. If the Work is rejected, perform additional operations to the satisfaction of Contracting Officer.

d. [Perform tensile pull-off tests in accordance with ASTM C1583/C1583M and guidance at [location]. Pull-off strength must meet or exceed [250 psi 1.7 MPa][_____]. [Test a minimum of 3 specimens at locations no greater than 420 square meters 500 square yards of prepared surface.]]

****
NOTE: If the adequacy of the prepared substrate is required, add the tensile pull-off test. Additional guidance is provided in ICRI 210.3R. The surface profile is determined by the designer for the repair. This may vary for the different repair methods and for the same repair method within same project. ICRI 310.2R and ACI 546R provide guidance on selecting surface profiles for various repairs. The profile is often stated in the Contract Documents along with the repair method, repair material, extent of repair, and sequence of Work.
****

e. [The prepared surface must have a concrete surface profile equivalent to CSP [_____] as defined by ICRI 310.2R].

****
NOTE: If a specified Concrete Surface Profiles (CSP) is desired, specify surface profiles based on ICRI 310-2R. CSP 1:acid-etched ; CSP 2:grinding ; CSP 3:light shotblast ; CSP 4:light scarification ; CSP 5:medium shotblast ; CSP 6:medium scarification ; CSP 7:heavy abrasive blast ; CSP 8:scabbled ; CSP 9:heavy scarification—rotomilled ; CSP 10:handheld concrete breaker followed by abrasive blasting. Refer to ICRI 310-2R for more details on surface profiles.
****

3.1.5 Quality Control

3.1.5.1 Quality control of surface preparation

Evaluation of prepared substrate must be continuously monitored to assure that the prepared substrate surface meets project requirements.

3.1.5.2 Quality control of repair overlays

All components of overlay PPCC materials must be certified by the material manufacturer or aggregate supplier to meet all project testing requirements. During the PPCC overlay, take mixed samples and check that the materials are mixed properly. Confirm that the right PC overlay thickness was applied by recording the volume of PC overlay materials and the substrate surface area covered by the overlay.

3.1.6 Curing

a. For portland cement concrete Work, follow the requirements indicated in [03 30 00 CAST-IN-PLACE CONCRETE][_____].

b. For polymer concrete/mortar Work, follow [manufacturer's requirements for curing][_____]

****

NOTE: Polymers have curing requirements different than portland cement concrete. Follow manufacturer's requirement in addition to ACI specifications for that specific polymer if available. Refer to ACI 548 documents for additional information or referenced specification

****

c. For polymer modified portland cement concrete Work follow [manufacturer's requirements for curing][_____].

****

NOTE: ACI 548.4 covers latex-modified concrete overlays. Refer to ACI 548.4 and the manufacturer's requirements if using latex modified concrete for overlays.

****

3.1.7 Clean up

a. Clean and remove all spills and leaks of injection adhesive and stains caused by the injection adhesives.

b. Dispose wastewater used for cutting and cleaning without staining or damaging the existing surfaces of the structure or the environment of the project area. The method of disposal must meet all the requirements of Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS.

3.1.8 Safety

a. Provide Material Safety Data Sheets (MSDS) for products on site reviewing them before work begins.

b. Provide safety guards, maintenance, and warnings for all machinery and equipment.

c. Have personal protection equipment practice in place - eye protection and face guards.

d. Have all workers in contact with wet cementitious material wear protective gloves and clothing.

e. Provide eyewash facilities on-site with location signage.

f. Provide dust masks for workers operating mixers.

g. Have confined space procedures in place including adequate ventilation in closed spaces before operating equipment or using products that emit potentially dangerous or toxic exhaust, fumes, or dust.

h. Provide secured storage available for all hazardous or flammable materials.

i. Conduct safety meetings prior to beginning repair operations.

3.2 CRACK REPAIR

3.2.1 Preparation

3.2.1.1 General Requirements

a. Clean all cracks in accordance with the paragraph titled Concrete Preparation.

b. Do not repair cracks when the temperature of the concrete is below freezing and moisture conditions indicate the possibility of ice on the internal surfaces of the crack.

c. Do not apply adhesive if the temperature of the concrete is not within the range of application temperatures recommended by the manufacturer of the adhesive.

3.2.1.2 Crack routing

Inspect surfaces adjacent to crack to receive repair material. If deteriorated, route a V-groove section at the crack face until sound concrete is reached.

3.2.1.3 Sealing

a. For epoxy injection, apply a surface seal over all exterior faces of the crack that can be reached to contain the injection adhesive in the crack.

b. For gravity fill repairs, apply a surface seal along the bottom surface of the element that can be reached to contain the repair material in the crack.

3.2.2 Application

3.2.2.1 Epoxy Injection

a. Install the injection entry and venting ports using flush mounted or drilled fittings per proprietary manufacturer's instructions.

b. Space the ports at [a distance equal to the thickness of the member] [200 mm 8 in.].

c. Inject the epoxy using material manufacturer's recommended equipment.

d. Apply recommended manufacturer's injection pressure.

e. For vertical or inclined cracks, apply injection by pumping epoxy into entry ports at the lowest elevation, cap, and move upward.

f. For horizontal cracks, apply injection by proceeding from one end of the crack to the other until the crack is fully sealed.

g. [After 10 min., repeat injection procedure until all ports refuse injection.]

h. [Remove ports and remove the surface seal by [heat,] chipping, or grinding or other acceptable means after the injected epoxy has cured.]

****

NOTE: Epoxy injection is a structural repair of the concrete. Epoxy resin is a thermosetting polymer that cures when mixed with a catalyzing agent or hardener. Once cured, epoxies have exceptional physical properties. Epoxies are recognized for their superior bond strength to concrete, which typically exceeds the tensile strength of normal concrete. Epoxies are used to repair cracks that typically range from 0.002 to 0.25 in. (0.05 to 6 mm) wide. Epoxy resin should only be used in nonmoving or dormant cracks. Reference ACI RAP-1, ICRI 210.1R, and ACI 503.7.

****

3.2.2.2 Gravity fill

a. Mix resin or monomer per material manufacturer's instructions.

b. Pre-fill cracks at least 3 mm 0.125 in. wide with aggregate.

c. Pour resin or monomer onto the surface, over the cracks and spread with brooms, rollers, or squeegees.

d. Work material back and forth over the cracks to maximize fill in crack.

e. Allow at least [20 minutes][_____] for material to penetrate cracks.

f. Remove excess material once cracks have been filled to refusal.

g. [Broadcast [0.5 to 1.0 kg per square meter 1 to 2 lbs per square yard][_____] of sand.]

h. Allow material to cure per material manufacturer's recommendations.

i. [Remove sealant and grind smooth.]

****

NOTE: The primary objective of this repair is to

fill the crack and structurally bond the concrete on both sides of the crack. This repair is to seal cracks that are not moving. By penetrating and filling the cracks, the resin can form a polymer plug that seals the crack, keeping out water, chlorides, carbon dioxide, sulfates, and other aggressive liquids and gases. This repair can only be applied to horizontal concrete elements such as slabs. The two most common polymer materials used for gravity feed crack repairs are epoxies and high molecular weight methacrylates (HMWM); more information on material selection is given in PRODUCTS. Use sand if a skid-resistant surface is desired or grind for a smooth surface. Reference ACI RAP-2, ACI RAP-13, and ACI 546R.

****

3.2.3 Quality Control

a. [Conduct quality [and control] tests for metering accuracy and mixing effectiveness of the continuous mixing pump in accordance with ACI 503.7.]

b. Qualify the test injection procedures in accordance with ACI 503.7.

3.2.4 Acceptance Criteria

3.2.4.1 Core Sampling

a. Obtain core samples in accordance with ASTM C42/C42M.

b. Allow 24 hours after injection before coring.

c. Obtain cores in a manner that includes as much of the bond line of the repaired concrete as possible. Replace cores that do not intersect the crack for at least 75 percent of the length of the core.

d. Obtain three diameter core from first 30 m 100 ft. and one core for each 30 m 100 ft. thereafter.

e. If cores would sever reinforcing steel or other embedded items, do not core, and notify the Contracting Officer so that an alternative location can be chosen.

f. Obtain cores at least 50 mm 2 in. in diameter for visual inspections and at least 100 mm 4 in. in diameter for the splitting tensile test. Perform a splitting tensile test on one core from the first 30 m 100 ft. and one core for each 75 m 250 ft. thereafter.

g. Fill core holes with [non-shrink grout][_____].

****

NOTE: In some cases, a 50 mm (2 in.) diameter cores may not be wide enough to intersect cracks that may not be perpendicular to the surface where the core is drilled.

****

3.2.4.2 Core Testing

a. Test a portion of the core samples for the splitting tensile strength in accordance with ASTM C496/C496M.

b. Allow 72 hours after injection before beginning splitting tensile tests

c. Prepare core sample per ASTM C42/C42M.

d. Align the core so that the crack is in a plane as close to vertical as possible.

****
NOTE: Testing for the splitting tensile strength is only necessary for structural repairs, where returning the concrete to its original strength is required by the project.
****

3.2.4.3 Acceptance

Work is acceptable if at least 90 percent of the depth of the crack in each core is filled with adhesive [and a or b is met][_____].

a. [The splitting tensile strength of the core is at least 90 percent of the splitting tensile strength of a core taken from an uncracked area within 300 mm 12 in. of the repaired crack.]

b. [A splitting tensile test of the core indicates that no more than 10 percent of the bonded area of the crack in each core exhibits combined areas of separation of the adhesive from the concrete or cohesive failure within the adhesive.]

3.3 CORROSION AND SURFACE REPAIR

3.3.1 Preparation

3.3.1.1 Identification of Extent of Concrete Removal

a. Configure geometry of removal area to maximize the use of right-angle geometry, avoiding reentrant corners, and to obtain uniformity of depth. Determine the depth, location, and size of reinforcing bars prior to removal of concrete.

b. [Perform visual inspection and hammer tapping, chain drag sounding, or other methods acceptable by the Contracting Officer to identify cracked, delaminated, spalled, disintegrated, and otherwise unsound concrete for removal. Mark boundaries of repair area before concrete removal.] [_____]

****
NOTE: The methods listed above are the basic methods commonly used to detect delamination. For more specialized methods refer to ACI 228.2R and add the desired methods above.
****

c. Inspect the marked boundaries with the Contracting Officer prior to commencing with the concrete removal. Revise the repair area

boundaries as instructed by the Contracting Officer.

3.3.1.2 Shoring and Formwork

a. Provide shoring and formwork per the paragraph titled Formwork and Shoring.

b. For post-tensioned concrete, detension strands and wires as required by Contract Documents prior to repair.

3.3.1.3 Concrete Removal

a. Remove concrete from repair areas to indicated depth and profile. Notify Contracting Officer if additional delaminated, fractured, or unsound concrete is present.

b. Do not damage embedded reinforcing and adjacent concrete. The removal methods must produce minimal microcracking (bruising) of the prepared substrate surfaces. Avoid directly striking reinforcing steel with impact tools used for concrete removal.

c. Provide perpendicular edges at perimeter of repair area. The perimeter of the repair areas must be saw cut to a depth of 0.50 to 0.75 in. 15 to 20 mm. [For vertical or overhead surfaces, provide 45-degree slope at repair boundaries to facilitate air and rebound escape.] Do not cut or damage embedded reinforcement or other embedded items. If embedded reinforcing steel or other embedded items are too close to the surface to provide the perpendicular edge cut, notify the Contracting Officer for direction before proceeding.

d. Extend concrete removal along the corroded reinforcing steel to a point where there is no further delamination, concrete cracking, or reinforcing steel corrosion, and where the reinforcement is bonded to the surrounding concrete.

e. Remove concrete around the exposed layer of reinforcement to a uniform depth beyond within the repair areas to provide a minimum clearance between exposed reinforcing steel and surrounding concrete of [0.75 in. 20 mm][_____], or at least 0.25 in. 5 mm larger than the maximum nominal size of the coarse aggregate in the repair material.

f. [Do not remove concrete behind vertical reinforcing bars in columns.]

****

NOTE: Indicate conditions where it is allowable to remove concrete behind vertical reinforcing in columns such as for lightly loaded or non-structural columns or if other methods such as phased repairs or supplemental restraint of bars to prevent buckling are incorporated to facilitate such removal.

****

3.3.1.4 Preparation of Concrete Substrate Surface

a. Confirm perpendicular edges at repair area perimeter, and reinstate if damaged by concrete removal process. Remove loosely bonded concrete, bruised or fractured concrete, and bond-inhibiting materials such as dirt, concrete slurry, or any other detrimental materials from the concrete substrate using approved methods. Where concrete has been

removed by impact methods, abrasive blasting must be used to prepare the surface and remove bruised concrete.

b. Provide substrate surface profiles as specified in the Contract Documents.

c. Visually inspect and sound substrate surface to confirm that no further delaminations or otherwise unsound concrete remains. If encountered, notify the Contracting Officer.

d. Clean the substrate per the paragraph titled Concrete preparation.

3.3.2 Application

[3.3.2.1 Existing Reinforcement Preparation

a. Clean existing reinforcement that will remain. Remove corrosion and/or other laitance and notify the Contracting Officer if section loss is greater than [20%][_____].

b. [Replace coating on reinforcement per [ASTM A780/A780M][ASTM A775/A775M][ASTM A934/A934M][_____]. Exposed areas must not exceed 2 percent of surface area in each linear foot of each bar.]

c. [Permit evaluation of existing reinforcement and placement of new reinforcement by the Contracting Officer.]

][3.3.2.2 Placement of New Reinforcement

Placement of new reinforcement

a. Placement of new reinforcement to replace or strengthen existing reinforcement is like new construction. Placement, splicing, and handling of new reinforcement must meet the requirements specified in Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

b. Reinforcement must be free of materials deleterious to bond. New reinforcement with rust, mill scale, or a combination of both will be considered satisfactory, provided minimum nominal dimensions, nominal weight, and minimum average height of deformations of a hand-wire-brushed test specimen are not less than applicable ASTM specification requirements.

]3.3.2.3 Placement of Concrete

a. [If portland cement concrete is used as the repair material, follow the requirements indicated in [03 30 00 CAST-IN-PLACE CONCRETE][_____] as well the Contract Document for proportioning, mixing, and placing concrete. For all other materials, follow material manufacturer's recommendations.][_____]

****

NOTE: The same requirements that apply to concrete in new construction also apply to concrete being used as repair material. For other materials, such as polymer-modified concrete or polymer concrete, follow manufacturer recommendations.

****

b. [For vertical and overhead applications of portland cement concrete, use shotcrete. Follow the requirements indicated in [03 37 13 SHOTCRETE][_____]].

****
NOTE: In some cases, such as vertical and overhead applications using shotcrete might be the best way of placing concrete. Include this provision (as presented here or modified) if shotcrete is required to be used on the project.
****

c. [A bonding agent [must be used][must not be used][_____].]

****
NOTE: Choose whether or not a bonding agent should be used to bond existing concrete to the repair material. See PRODUCTS for discussion on use of bonding agents.
****

d. [Apply [corrosion inhibitors][sacrificial anodes][_____] as designated by the Contract Documents.]

****
NOTE: Specify if any corrosion inhibitors, sacrificial anodes, or other material should be installed prior to placement of concrete or repair material.
****

e. [Bristle broom a thin coat of the repair material into the saturated surface dry substrate filling roughened surface pores before placing the repair material in the repair area. Do not allow thin coat to dry before placing repair material.][_____]

****
NOTE: This requirement only applies when bonding agents are not used
****

f. [Consolidate the repair material after placement with a vibrating screed or internal vibrator.][_____]

****
NOTE: Specify if any alternative method of consolidation should be used.
****

g. Finish the surface to match surface finish and texture requirements indicated in the Contract Document. [Screed, float and trowel the repair material or broom the surface for non-slip texture. Follow the requirements of 03 30 00 CAST-IN-PLACE CONCRETE][For shotcrete, apply finishing techniques and requirements indicated in 03 37 13 SHOTCRETE][_____].

****
NOTE: Add requirements related to finishing

concrete if needed.

****

3.3.2.4 Placement of Other Repair Materials

a. Equilibrate repair material(s) and substrate to the temperature, cleanliness of substrate and reinforcement, and moisture requirements of the repair material manufacturer's requirements.

b. Comply with the repair material manufacturer's requirements for batching, mixing, placing and curing repair materials.

c. Review consistency of the mixed repair material(s) relative to the parameters documented in the repair material manufacturer product data sheet. If non-conforming, adjust consistency in compliance with the repair material manufacturer's requirements.

d. Apply or install repair material(s) within the application time frame (pot life) requirements of the repair material manufacturer's requirements, and place and consolidate to provide well-compacted repair.

e. Finish and tool repair materials, finished in accordance with the repair material manufacturer's written instructions and as indicated in Contract Documents.

f. Protect installed repair material(s) from damage, exposure to environmental conditions that are detrimental to the uncured or cured properties of the material. Cure in accordance with the requirements of the repair material manufacturer's requirements.

3.3.3 Quality Control

a. Protect concrete surfaces, beyond limits of surfaces receiving bonding agent adhesive, against spillage. Immediately remove any bonding agent adhesive that has spilled beyond desired area. Perform cleanup with material designated by bonding agent adhesive manufacturer. Avoid contamination of work area.

b. [The bond strength between the existing concrete and the repair material must be a minimum of [1.7 MPa 250 psi][_____] per [ASTM C1583/C1583M][_____]. [Test a minimum of 3 specimens at locations no greater than 420 square meters 500 square yards of prepared surface.]]

****

NOTE: Bond tests are usually performed to evaluate bond strength between the existing concrete and the repair material. 250 psi (1.8 MPa) is a value obtained from ACI 548.10. Alternatively, the soundness of the repair can be evaluated by hammer-sounding or other non-destructive methods; hollow sounds may represent poor bond to substrate.

The testing frequency is acceptable for large repair areas, for smaller repair area specify a requirement for testing appropriate for the repair.

****

3.4 OVERLAYS

****

NOTE: Prior to specifying a certain type of overlay, the existing concrete slab must be evaluated. It is also important to understand what the different types of overlays are and when each should be used. If you would like to learn more about overlays (sometimes also referred to as "toppings"), refer to ACI 224R, ACI 302.1R, ACI 360R, ACI 325.13R, and ACI 546R. For information about polymer concrete overlays refer to ACI 548 documents.

****

3.4.1 Preparation

****

NOTE: Overlays must be properly designed and constructed for their application. Overlays are typically bonded or unbonded. If the surface is not properly designed or prepared, it can result in a partially bonded overlay. Partially bonded overlays can exhibit unanticipated random cracking and higher than expected curling/warping due to unplanned bonded and unbonded areas. For this reason, it is important for the Contracting Officer to verify that a surface was properly prepared before an overlay is placed.

****

[3.4.1.1 Bonded Overlays

****

NOTE: Bonded overlays are generally used to strengthen existing concrete surfaces or improve surface abrasion or impact resistance. The thickness of a bonded overlay as well as the type of material used should be accounted for in the design of the overlay. Materials used for bonded overlays include portland cement concrete, polymer modified concrete, and polymer concrete/mortars. In general, surface preparation requirements for bonded overlays are the same regardless of the type of material used for the overlay. Proper surface preparation is essential for the success of bonded overlays.

****

a. Provide surface preparation as required in this Section.

****

NOTE: Choose one or more mechanical abrasion method to prepare the surface of the existing slab. The surface preparation technique used should not be so aggressive that it damages the underlying pavement. An aggressive preparation technique will create a weak layer in the existing slab immediately below the bond interface that might cause the

overlay to fail. For additional guidance on surface preparation, refer to ACI 546R.

If the slab being prepared for an overlay is supported, loads from equipment should have been considered as part of the design; shoring should be provided as needed.

****

b. [Repair cracks and patch deteriorated concrete prior to final surface preparation.]

c. Apply additional preparation requirements specified by the overlay material manufacturer

][3.4.1.2 Unbonded Overlays

****

NOTE: Unbonded overlays surface preparation mainly consists of installing a bond breaker (Separation Layer) over the existing concrete slab before the overlay is placed.
Per ACI 224R and ACI 302.1R, unbonded overlays are used where severe cracking is present in the base, where cracking can later develop, or when contamination of the existing slab prevents complete bond with the overlay. Unbonded overlays are not used to strengthen existing slabs and must be sufficiently thick to resist loads on their own. Per ACI 302.1R, unbonded overlays should have a minimum thickness of 3 in. (75 mm) for foot-traffic, and a minimum thickness of 4 in. (100 mm) if the surface is to be subjected to vehicular traffic. Because of the thickness requirements, unbonded overlays are usually portland cement concrete based and include a type of reinforcement.

****

a. Repair distresses that cause a major loss of structural integrity when present[.][, including [_____]]

****

NOTE: In the blank above add any observed distress that needs to be repaired prior to the installation of the overlay. Unbonded concrete overlays generally require minimal pre-overlay repairs; repairs are only done for severe distresses.
For example, shattered slabs are usually replaced and full depth repairs are performed for punchouts, high-severity transverse cracks with ruptured steel, and unstable slabs or pieces of slabs with large deflections or pumping.

****

b. Clean the existing slab and remove any loose materials.

****

NOTE: Either a mechanical sweeper or an air blower may be used to clean the slab.

****

c. Install the separator layer as required by the Contract Documents and recommended by the material manufacturer.

]3.4.2 Application

3.4.2.1 Portland Cement Concrete

a. [Apply the specified bonding agent. Follow the requirements of 3.4.2.4.]

****

NOTE: Delete the above requirement if bonding agents are not to be used on the project.

****

b. Follow the requirements of Section [03 30 00 CAST-IN-PLACE CONCRETE] [_____] and the Contract Documents for installing forms, placing reinforcement, placing and consolidating concrete, and finishing concrete.

****

NOTE: Application (Mixture, placement, consolidation, finishing, etc...) requirements for portland cement concrete overlays do not differ from conventional portland cement concrete. The same requirements that apply for conventional concrete slabs, apply to overlays.

For bonded concrete overlays, if you are using a bonding agent, see the paragraph on bonding agents.

For unbonded concrete overlays, reinforcement, such as deformed bars, welded wire fabric, bar mats, or fibers should be placed in the overlay in sufficient quantities to reduce the width of shrinkage cracks and to bridge existing cracks in the base slab. Reinforcement in unbonded topping slabs is essential due to increased curling stresses and potential bridging of existing cracks in the base slab.

****

3.4.2.2 Polymer-modified Portland Cement Concrete

****

NOTE: ACI 548.4 covers latex-modified concrete overlays. Refer to ACI 548.4 and the manufacturer's requirements if using latex modified concrete.

****

For polymer modified portland cement concrete overlays follow [ACI 548.4 requirements][manufacturer's requirements][_____] for placing and finishing the overlay.

3.4.2.3 Polymer Concrete/Mortar

****

NOTE: Placement requirements for polymers depend on

the type of polymer being used. Follow manufacturer's requirement in addition to ACI specifications for that specific polymer if available. ACI 548.10 is written above as an example, see other ACI 548 documents for specifications that match the type of overlay required.
****

For polymer concrete overlays, follow [manufacturer's requirements][ACI 548.8 requirements][ACI 548.9 requirements][ACI 548.10 requirements][_____] for placing and finishing the overlay.

[3.4.2.4 Bonding Agents

****
NOTE: A bonding agent is a material used to improve the bonding between the overlay and the underlying material (concrete). A bonding agent can be used, but success has been seen without its use.

Use bonding agents with caution. Bonding agents should not be allowed to dry too early and form a skin that can act like a bond breaker that reduces the bond strength rather than increase it.
****

a. Use a [cement slurry][epoxy bonding agent][latex bonding agent][_____] to improve the bonding between the overlay and the existing concrete.

****
NOTE: Choose the type of bonding agent to improve the bond between the overlay and the existing concrete.
A cement slurry is a neat portland cement or blend of portland cements and fine aggregate filler approximately proportioned one-to-one by mass.
The rest of the bonding agents are polymer-based materials, see ACI 548 documents for more details.
****

b. [Follow material manufacturer's instructions for mixing, preparing, and applying bonding agent. Do not exceed the manufacturer’s thickness recommendations][_____].

****
NOTE: Polymer based bonding agents have their own application instructions, follow manufacturers instruction for those materials.
If a cement slurry is used however, it is suggested to add the following sentence instead "Apply cement slurry just prior to overlay placement with a stiff-bristled broom"
****

c. [Condition materials and the existing concrete surface to a temperature consistent with manufacturer’s recommendations at the time of installation.]

d. [Do not allow bond agents to dry before placement of repair material.]
]

****
NOTE: The above requirement applies primarily to polymer-based bonding agents.
****

3.4.3 Quality Control

****
NOTE: Strength and durability requirements should be defined in the general concrete specifications. For polymer concrete overlays, refer to PRODUCTS requirements and the referenced standards.
****

a. [Concrete overlays must meet all the strength and durability requirements of 03 30 00 CAST-IN-PLACE CONCRETE][Material properties must meet the requirements defined in PRODUCTS.][_____].

b. [The bond strength between the existing concrete and the overlay must be a minimum of [1.8 MPa 250 psi][_____] per [ASTM C1583/C1583M][_____]. [Test a minimum of 3 specimens at locations no greater than 420 square meters 500 square yards of prepared surface.]]

****
NOTE: This requirement is for bonded overlays only. Bond tests are usually performed to evaluate bond strength between the existing concrete and the overlay. 250 psi (1.8 MPa) is a value obtained from ACI 548.10. Refer to ICRI 210.3R for more details.

Before bond tests are performed, proper bonding can be evaluated by non-destructive methods. Acoustic impact methods such as chain drag sounding, hammer sounding, electromechanical sounding, and rotary percussion methods are commonly used. Refer to ICRI 210.4 for more details.
****

3.4.4 Joints

****
NOTE: The performance of a bonded overlay depends on creating a monolithic structure, the joints in the overlay should match the joints in the underlying pavement. Matched joints help to ensure that the two layers of the pavement structure can move together, helping to maintain bond between them. Matched joints also help to prevent reflection cracking. Because of the importance of matched joints, not only should the location of the joint be matched, but also the joint width and type; that is, if there is an expansion joint in the underlying pavement, it should be recreated in the overlay.

For unbonded overlays, additional joints may be

recommended depending on the overlay thickness. This information should be included in drawings or contract document.
****

a. [Place joints as indicated in [03 30 00 CAST-IN-PLACE CONCRETE] [and as shown on the drawings] [_____].]

****
NOTE: The requirement above applies to unbonded concrete overlays but not for bonded overlays. Requirements for unbonded overlays should not be different from new concrete slab construction.

Some of the requirements below could apply to unbonded overlays, but they are mainly present in this paragraph for bonded overlays.
****

b. [Construct expansion and contraction joints in concrete overlay at the locations shown. Maintain alignment of control joints within 6 mm 1/4 in., to either side, of the required joint alignment.]

c. [Construct expansion and contraction joints at the locations shown and in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE.]

d. [Construct expansion joints in the overlay at existing joint locations in the base slab while maintaining joint width and type[.][, and extending the full depth of the overlay.]]

****
NOTE: Extending a joint to the full depth of the overlay applies to bonded overlays. For unbonded overlays, follow the same procedure used for new concrete construction.
****

e. [Construct control joints by tooling the plastic concrete, then sawcutting at the appropriate time. Saw control joints to a minimum [depth of [_____] mm in.] [of 25 percent of the thickness of the slab]. Maintain an ample supply of saw blades on the job before concrete placement is started, and have at least one standby sawing unit in good working order available at the jobsite at all times during the sawing operations. Begin sawcutting as soon as it is possible to saw the concrete without damaging adjacent concrete.]

f. [Inspect the faces of joints during sawcutting for undercutting or washing of the concrete due to early sawing. Complete sawcutting within 16 hours of concrete placement. Continue sawcutting regardless of weather conditions. Delay sawing if undercutting is sufficiently deep to cause structural weakness or excessive roughness in the joint or chipping, tearing, or spalling of the concrete occurs at the surface. Discontinue sawing when a crack develops ahead of the saw cut.]

g. [Immediately after the joint is sawed, flush the saw cut and adjacent concrete surface thoroughly with water until all residue from sawing is removed from the joint. Control and dispose of waste water from sawcutting and cleanup in accordance with Section 01 57 19 TEMPORARY

ENVIRONMENTAL CONTROLS.]

3.5 CONCRETE STRENGTHENING

****

NOTE: The goal of strengthening concrete is to increase a structure's or member's capacity in flexure, shear, axial, confinement, and stiffness. Refer to ICRI Guideline No. 03742 for more information about strengthening

****

a. For enlargement of slabs using overlays see the paragraph titled OVERLAYS.

****

NOTE: Bonded overlays are used for strengthening slabs; unbonded are not.

****

b. For all other types of strengthening follow the requirements contained in this paragraph.

3.5.1 Preparation

****

NOTE: The preparation phase is very critical to the success of the operation; an improperly prepared surface can result in debonding or delamination.

****

a. [Use equipment and methods specified in the paragraph titled EQUIPMENT FOR CONCRETE PREPARATION and the Contract Documents to produce a sound, rough, open-pore surface at locations where bonding between existing and new concrete is required.]

****

NOTE: Surfaces that need to be enlarged should be rough enough to provide good bonding between the existing concrete and the new concrete.

The engineer should specify the surface profile required for the repair/strengthening job based on the type of strengthening method used.

****

b. [Round members of existing concrete with corners to minimum 13 mm ½ in. radius. Roughened corners must be smoothed with putty]

****

NOTE: This requirement applies to strengthening using FRP laminates. Delete this requirement if not needed

****

c. Clean all surfaces from contaminant and remove unsound concrete using the prescribed cleaning equipment and methods in the paragraphs titled PRODUCTS. All laitance, dust, dirt, oil, curing compound, existing coatings, and any other matter that could interfere with bonding

concrete to the repair material must be removed.

d. Follow the procedures of the paragraphs titled CRACK REPAIR and CORROSION AND SURFACE REPAIR. The concrete surface must be in good condition and all cracking, surface repair, and corrosion related problems must be adequately addressed prior to proceeding with concrete strengthening procedures.

e. Insure that materials used for repairs are compatible with materials used for strengthening. Consult with the repair material manufacturers for information concerning material compatibility.

f. Surfaces not intended to be strengthened must be covered as needed to protect against contamination and spills.

g. Surfaces intended to be strengthened must be protected before application so that no materials that can interfere with bond are redeposited on the surface.

3.5.2 Application

3.5.2.1 Section enlargement

a. Install dowel reinforcement as required by the Contract Documents. Follow the [adhesive][mechanical anchor] manufacturer's procedures for installing dowels.

b. Install formwork and shoring following the requirements of this section.

c. Install reinforcement and reinforcement supports. Follow the requirements specified in Section [03 30 00 CAST-IN-PLACE CONCRETE] [03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE][_____].

d. Follow the requirements of Section [03 30 00 CAST-IN-PLACE CONCRETE][03 37 13 SHOTCRETE][_____] to place, consolidate, and finish concrete.

3.5.2.2 Externally bonded systems

3.5.2.2.1 Steel Plates

a. Bond steel plates to concrete using the methods and materials specified in the Contract Documents.

b. For bonding steel plates to concrete using an epoxy resin follow the requirements and procedures of ACI 548.12.

c. For bonding steel plates to concrete using mechanical or adhesive anchors, follow the procedures provided by the material manufacturer.

3.5.2.2.2 Fiber-reinforced Polymer Laminates

****
NOTE: Refer to ACI 440.2R for more information about strengthening using externally bonded FRP
****

The following procedures are general procedures used for the installation of FRP laminates. If the FRP system used requires conflicting procedures,

consult with the Contracting Officer before proceeding.

a. Insure that all surfaces that will receive FRP are clean, dry, and free of contaminants.

b. Insure that the workplace is well ventilated and that the repair material is applied at a time when the air temperature, concrete surface temperature, and the relative humidity are as required by the repair material manufacturer.

****

NOTE: Primers, saturating resins, and adhesives should generally not be applied to cold or frozen surfaces. When the surface temperature of the concrete surface falls below a minimum level as specified by the FRP system manufacturer, improper saturation of the fibers and improper curing of the resin constituent materials can occur, compromising the integrity of the FRP system. An auxiliary heat source can be used to raise the ambient and surface temperature during installation.

****

c. Temporary protection of the Work area is required during installation and until the resins have cured. If temporary shoring is required, the FRP system must be fully cured before removing the shoring and allowing the structural member to carry the design loads.

d. [If a primer is required, the primer must be applied uniformly to all areas on the concrete surface where the FRP system is to be placed at the manufacturer’s specified rate of coverage. Protect the primer from dust, moisture, and other contaminants before applying the FRP system]

****

NOTE: Keep the above requirement if a primer is needed for the FRP system being used.

****

e. [Putty must be used in an appropriate thickness and sequence with the primer as recommended by the FRP manufacturer. The system-compatible putty must be used only to fill voids and smooth surface discontinuities before the application of other materials. Rough edges or trowel lines of cured putty must be ground smooth before continuing the installation. Allow the putty to cure as specified by the FRP system manufacturer before proceeding.]

****

NOTE: Keep the above requirement or edit it as required by the FRP system being used.

****

f. Proportion, mix, and apply resins components in accordance with the FRP system manufacturer’s recommended procedures.

g. Install and cure the FRP system per the manufacturer's recommendations.

h. [During installation of wet layup FRP systems, entrapped air between layers must be released or rolled out before the resin sets.

Sufficient saturating resin must be applied to achieve full saturation of the fibers. Furthermore, successive layers of saturating resin and fiber materials must be placed before the complete cure of the previous layer of resin. If previous layers are cured, interlayer surface preparation, such as light sanding or solvent application as recommended by the system manufacturer, is required.]

****
NOTE: The above requirement is for wet layup system. If other systems are used, either delete above requirement and just follow the manufacturer's recommendation (as stated by g), or refer to ACI 440.2R for general procedures of other commonly used FRP systems.
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i. Follow the FRP material manufacturer's recommendations for the application of protective coatings. Do not clean the installed FRP with a solvent before a protective coating is installed.

3.5.3 Quality Control

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NOTE: The requirements of this paragraph only apply to strengthening using FRP.
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The cured FRP system must be evaluated for delaminations or air voids between multiple plies or between the FRP system and the concrete. Methods such as acoustic sounding (hammer sounding), ultrasonics, and thermography can be used to detect delaminations. The following requirements apply to wet layup systems:

a. Small delaminations less than 2 square inch 1300 square millimeter each are permissible as long as the delaminated area is less than 5 percent of the total laminate area and there are no more than 10 such delaminations per 10 square feet square meter.

b. Large delaminations, greater than 25 square inch 16,000 square millimeter, can affect the performance of the installed FRP and must be repaired by selectively cutting away the affected sheet and applying an overlapping sheet patch of equivalent plies.

c. Delaminations less than 25 square inch 16,000 square millimeter must be repaired by resin injection or ply replacement.

For other FRP systems, delamination must be evaluated and repaired in accordance with the material manufacturer direction. Upon completion of the Work, the laminate must be reinspected to verify that the repair was properly accomplished.

-- End of Section --