# Construction Specification 35—Concrete Repair

## 1. Scope

The work shall consist of removal of unsuitable concrete; surface and face preparation; forming; and furnishing, placing, finishing, and curing concrete repair material as required to repair structures designated in section 18 of this specification.

The following BioPreferred® product category is applicable to this specification:

— Concrete release fluids (aka form-release agents)

## 2. Material

**Aggregates** shall conform to the requirements of Material Specification 522, Aggregates for Portland Cement Concrete, unless otherwise specified. The grading of coarse aggregates shall be as specified in section 18, shown on the drawings, or as specified by the manufacturer of a proprietary repair material.

**Portland cement** shall conform to the requirements of Material Specification 531, Portland Cement, for the specified type. Only one brand of any type of cement shall be used in any single repair as defined in section 18.

**Water** used in mixing and curing of the concrete repair shall be clean and free from injurious amounts of oil, salt, acid, alkali, organic matter, or other deleterious substances.

**Fly ash** shall conform to the requirements of Material Specification 532, Supplementary Cementitious Materials.

**Air-entraining admixtures** shall conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete. If air-entraining cement is used, any additional air-entraining admixture shall be the same type as that in the cement.

**Chemical admixtures** for water-reducing, retarding, or water-reducing and retarding shall conform to the requirements of Material Specification 533, Chemical Admixtures for Concrete.

**Curing compound** shall conform to the requirements of Material Specification 534, Concrete Curing Compound.

**Shotcrete**, Construction Specification 33.

**Proprietary concrete repair material** shall be subject to review and approval of the engineer before use. The material shall meet all specified salient features for repair material and not react detrimentally with the existing concrete or associated member of the structure being repaired.

**Replacement concrete repair material** shall be a material that consists essentially of a binding medium of Portland cement and water that will meet all the specified salient features for repair material and not react detrimentally with the existing concrete or associated members of the structure being repaired. This may be, but is not limited to, a conventional concrete mix with or without admixtures, shotcrete, preplaced aggregate concrete, or grout.

## 3. Preparation of areas to be repaired

All loose, cracked or otherwise unsuitable or defective concrete shall be removed from the existing structure as shown on the drawings or specified in section 18. The final extent of removal shall be determined by the engineer after inspection of prepared surfaces.

Feathered edges at the surface are not permitted. The surface edge of the repaired area shall be cut with a saw, drilled, or chipped to leave a sharp edge with a minimum of a 0.75-inch depth face perpendicular to the face of the wall.

The top side of the repair hole shall be shaped to a uniform, fairly straight face that is sloped upward on a 1-inch rise for each 3 inches of depth of cut toward the face from which the repair material will be placed. The repair hole shall be conical in shape with the large end at the surface from which repair material will be placed.

The bottom and vertical or near vertical sides of the hole shall be cut sharply and approximately perpendicular to the face of the wall. All interior corners shall be rounded to a minimum radius of 1 inch.

Where reinforcement is encountered, the concrete directly in contact with the sides of the reinforcement shall be removed to provide at least 1-inch clear distance between the reinforcement and the inplace concrete.

Before the concrete repair material is placed, all oil and grease shall be steam or solvent cleaned from all reinforcement and surfaces to which the repair material is required to bond. If solvent cleaning is used, solvents and solvent residue shall not impair the repair material or its bonding strengths.

After removal of all oil and grease, the reinforcement shall be cleaned to remove any loose, flaky rust, mill scale, and other coatings or foreign substances that would impair bonding of the repair material to the reinforcement. The prepared faces of the repair hole shall be cleaned by high pressure water jets or compressed air jetting with water to remove all loose particles and dust. The repair hole shall be free of chips, sawdust, debris, free water, ice, snow, or other harmful substances or coatings.

## 4. Disposal

Unless otherwise specified, all concrete and other debris resulting from the repair works shall be removed from the site and disposed of at location(s) of the contractor's selection. The contractor is responsible for complying with all local, State, and Federal regulations pertaining to the disposal of such waste.

## 5. Selection of concrete repair material

Only one brand of proprietary concrete repair material shall be used in any single repair operation unless compatibility between brands can be proven with actual test or performance data.

A conventional concrete mix to be used as a replacement concrete repair material shall be ready-mix concrete that meets all the specified salient features for repair material and conforms to ASTM C94. Option A from section 6 of ASTM C94 shall apply.

The contractor is responsible for the selection and correct application of the concrete repair material. At least 14 days before installation, the contractor shall provide the engineer for approval all technical data for the repair material. The technical data shall include the design mix and test results to verify satisfactory conformance to the salient feature requirements. If a proprietary material is used, the manufacturer's recommended preparation, use, and installation specifications shall also be submitted 14 days before installation. Concrete repair material shall not be placed before approval.

Concrete repair material shall have the following salient features:

a. Be a cementitious material that after hardening will remain stable in wet and moist environments and will not dissolve in water.

b. A 28-day compressive strength of 4,000 pounds per square inch or greater when tested according to ASTM C39, unless otherwise specified.

c. Bond strength of the repair material shall be tested in accordance with ASTM C882 procedures for type V material and shall have the minimum strength of 1,100 pounds per square inch at 28 days unless otherwise specified.

d. Shall be suitable for application at the minimum temperature of 55 degrees Fahrenheit.

e. Shall not contain chlorides, added gypsum, added lime, or high alumina cements. Shall be noncombustible both before and after cure.

f. Color shall be concrete gray unless otherwise specified.

g. Shall not produce a vapor barrier material and shall be thermally compatible with concrete.

h. Shall have a freeze-thaw resistance equal to or greater than 4,000 pounds per square inch, air-entrained concrete designed for severe exposure conditions according to ACI Standard Practice 211.1, unless otherwise specified.

i. Shall exhibit no shrinkage at 28 days and no more than 0.4 percent expansion at 3, 14, or 28 days after placement when tested according to the procedures in Corps of Engineers Specification for Non-shrink Grout, CRD-C621.

Additional site specific requirements for materials are defined in section 18.

## 6. Handling and measurement of material

For all types of repair material, the cementitious components shall be kept dry and protected from contamination until incorporated in the mix. Broken containers or bags of premeasured and premixed components will not be accepted.

Handling and measurement of conventional concrete mix repair material shall conform to ASTM C94.

Handling and measurement of prepackaged proprietary material shall follow the manufacturer's recommendations and requirements. Handling and measurement of components that are not prepackaged or premeasured shall be in accordance with the following requirements and the manufacturer's requirements. A copy of the manufacturer's written requirements will be provided to the engineer 14 days before installation. The handling and measurement requirements are:

- Aggregates shall be stored or stockpiled in such a manner that separation of coarse and fine particles of each size is avoided and that various sizes do not become intermixed before proportioning. Methods of handling and transporting aggregates shall be such as to avoid contamination, excessive breakage, segregation or degradation, or intermingling of various sizes.
- Scales for weighing aggregates and repair material components shall be beam type, electronic, or springless dial type. They shall be accurate within 0.4 percent under operating conditions. All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean and properly maintained.
- The quantities by weight of repair material components and aggregates in each batch of material, as indicated by the scales, shall be within the following percentage of the required batch weights:

  | | |
  |---|---|
  | Aggregates | ± 2 percent |
  | Other components | ± 1 percent |

  Measuring tanks for mixing water or liquid shall be of adequate capacity to furnish the maximum amount of mixing water or liquid required per approved batch. Measuring tanks shall provide the means for readily and accurately measuring the amount of water or liquid required. Accuracy of water measurement shall be plus or minus 1 percent.

## 7. Forms

Forming material shall be wood, plywood, steel, or other approved material and shall be mortar tight. The forms and associated falsework shall be substantial and unyielding and shall be constructed so that the finished repair conforms to the specified dimensions and contours. Form surfaces shall be smooth and free from holes, dents, sags, or other irregularities.

Before the forms are set into place, the surface of the form shall be lined with plastic sheeting or coated with a nonstaining form release agent compatible with the repair material being used. This prevents bonding of the repair material to the forms. If the forms are lined with plastic, the plastic shall be stretched taut to remove all wrinkles and folds and maintain a smooth condition during the placement and curing of the repair material.

Metal ties or anchorage within the forms shall be equipped with cones, she-bolts, or other devices that permit their removal to a minimum depth of 1 inch without injury to the concrete or repair material. Ties designed to break off below the surface of the concrete shall not be used without cones.

All visible edges and corners included in the repair location shall be shaped the same as adjacent or similar edges or corners of the structure being repaired.

Forms shall be constructed to facilitate consolidation and complete filling of the repair void, and, when all surfaces are formed, to facilitate applying pressure to the repair material immediately after placement.

## 8. Mixing, conveying, and placing

Proprietary repair material shall be mixed and conveyed to the forms according to manufacturer's written recommendations. Material that cannot be placed within the manufacturer's time requirements shall not be placed in the forms and shall be discarded offsite at locations selected by the contractor.

Concrete repair material shall not be placed until the subgrade, forms, and steel reinforcement have been inspected and approved by the engineer.

The contractor shall have all equipment and material required for curing available at the site ready for use before placement of repair material begins.

No concrete repair material shall be placed except in the presence of the engineer. The contractor shall give reasonable notice to the engineer each time concrete repair material is scheduled for placement. Such notice shall be adequate to allow the engineer sufficient time to review and approve the subgrade, forms, steel reinforcement, and other preparations for compliance with the specifications. Other preparations include, but are not limited to, the mixing and delivery equipment and system, placing and finishing equipment and system, schedule of work, workforce, and heating and cooling facilities as applicable. All deficiencies are to be corrected before concrete repair material is mixed for placement.

The concrete repair material shall be deposited as closely as possible to its final position in the forms and shall be worked into the corners and angles of the forms and around all reinforcement and embedded items in a manner to prevent segregation of aggregates or excessive laitance. The depositing of repair material shall be regulated so that the material can be consolidated with a minimum of lateral movement.

Unless otherwise approved, concrete repair material shall not be dropped from a height greater than recommended by the manufacturer or 5 feet, whichever is less.

Unless otherwise specified, all concrete repair material required for each repair location shall be placed in one continuous operation. Successive layers or batches shall be placed at a rate sufficient to prevent setting of material between successive layers.

At the time of placement of repair material, the existing concrete surface shall be damp and without free water unless otherwise specified or required by the manufacturer of the proprietary repair material being used.

## 9. Consolidating

Concrete repair material shall be consolidated to ensure positive contact of repair material with all repair surfaces and reinforcing steel, to remove entrapped air pockets and voids, and to maximize the density of the repair material.

Vibration shall not be applied directly to the reinforcing steel or other embedded items, the forms, or to concrete repair material that has hardened to the degree that it is no longer plastic. The use of vibrators to transport concrete repair material in the forms or conveying equipment is not allowed.

Proprietary repair material shall be consolidated in accordance with the manufacturer's recommendations.

Unless otherwise specified in section 18, conventional concrete mix repair material shall be consolidated in the following manner:

- Conventional concrete mix repair material shall be consolidated with internal type mechanical vibrators capable of transmitting vibration to the concrete at frequencies not less than 8,000 impulses per minute.

Vibration shall be supplemented by spading, rodding, or hand tamping as necessary to ensure smooth and dense concrete along form surfaces, in corners, and around embedded items.

- The location, manner, and duration of the application of the vibrators shall be such as to secure maximum consolidation of the concrete repair material without causing segregation of the mortar and coarse aggregate and without causing water or cement paste to flush to the surface. Vibration shall compact the concrete repair material and bring it into intimate contact with the forms and embedded items while removing voids and pockets of entrapped air.

  The contractor shall provide sufficient vibrators to properly consolidate the concrete repair material immediately after it is placed. Vibration shall be applied to the freshly deposited concrete repair material by slowly inserting and removing the vibrator at points uniformly spaced and not farther apart than twice the radius of action (i.e., the distance that the concrete repair material is visibly effected by the vibration). The area visibly effected by the vibrator shall overlap the adjacent, just vibrated area. The vibrator shall extend vertically into the previously placed layer of fresh concrete repair material at all points. This ensures an effective bond between layers. In thin slabs the vibrator(s) should be sloped toward the horizontal to allow operations in a fully embedded position.

- The internal vibration of thin slabs (less than 9 inches) may be augmented using surface vibrators when approved by the engineer. Consolidation of the concrete repair material from the top surface down, along with a leveling effect to assist the finishing operation, may be provided by vibrating screeds, plate or grid vibratory tampers, or vibrating roller screeds. The contractor's plan, including equipment selection and specifications, shall be submitted to the contracting officer for approval at lease 5 days before concrete repair material placement using surface vibrating methods.

## 10. Removal of forms

Unless otherwise approved, forms shall not be removed sooner than the minimum time recommended by the manufacturer of the repair material or 48 hours, whichever is greater.

Forms shall be removed only when the engineer is present. Forms shall be removed in a manner to prevent damage to the concrete repair material. Supports shall be removed in a manner that permits the repair material to take the stresses caused by its own weight, uniformly and gradually.

## 11. Finishing formed surfaces

All repaired surfaces shall be true and even, and shall be free of open or rough spaces, depressions, or projections. Immediately after the removal of forms:

- All bulges, fins, form marks, or other irregularities that in the judgment of the engineer will adversely affect the appearance or function of the structure shall be removed. All form bolts and ties shall be removed to a minimum depth of 1 inch below the surface of the repair. The cavities produced by form ties and all other holes of similar size and depth shall be thoroughly cleaned. After the interior surface has been kept continuously wet for at least 3 hours, the cavities shall be carefully repaired with a compatible patching mortar or packed with a dry patching mortar mixed not richer than one part cement and three parts sand. Dry patching mortar shall be mixed in advance and allowed to stand without addition of water until it has reached the stiffest consistency that will permit placing. Manipulation of the mortar with a trowel during this period shall be performed as required to ensure the proper consistency.

  Holes resulting from form bolts or straps that pass through the wall shall be entirely filled with mortar to form a dense, well-bonded unit. The mortar shall be tamped into place with a rod slightly smaller than the hole being filled. The hardened mortar shall be sound and free from shrinkage cracks.

  All repaired areas shall be cured as specified in section 13.

## 12. Finishing unformed surfaces

All exposed surfaces of the concrete repair material shall be accurately screeded to grade and finished to match adjacent surfaces, unless otherwise specified. Water shall not be sprinkled or in any manner added to the surface of conventional concrete mix repair material during finishing operations.

Proprietary repair material shall be finished in accordance with the manufacturer's recommendations.

Joints and edges on unformed surfaces shall be shaped the same as adjacent or similar edges or corners of the structure being repaired.

### 13. Curing

The repair material shall be protected against premature surface drying, rainfall, and freezing for at lease 72 hours. For proprietary repair material, the manufacturer's recommendations for curing shall be followed. Replacement concrete repair material shall be protected from drying and freezing for 7 days after placement.

If curing compound is used, it shall be nonsolvent type and shall conform to ASTM C309, Type 1-D, Class B, nonpigmented with a fugitive dye, unless otherwise specified. Curing compounds shall not be used if specifically prohibited by the proprietary repair material user guides.

### 14. Removal or repair

When the repaired area is honeycombed, damaged, or otherwise defective, the contractor shall remove and replace the defective repair. The engineer determines the required extent of removal, replacement, and/or repair. Removal and repair activities shall be performed only when the engineer is present.

### 15. Concrete repair in cold weather

For proprietary repair material, the manufacturer's recommendation together with the requirements below will be followed.

For conventional concrete mix repair material, the requirements below shall be followed.

Concrete repairing in cold weather shall be performed in accordance with ACI 306, Cold Weather Concreting, of which some specific interpretations are set forth below.

Cold weather concrete repairing shall apply when the 3-day average daily outdoor temperature at the job site is less than 40 degrees Fahrenheit. When cold weather conditions exist on the job site, the following additional provisions shall apply:

a. The temperature of the concrete repair material at the time of placing shall not be less than 55 degrees Fahrenheit or more than 90 degrees Fahrenheit. The temperature of the mixing water shall not exceed 140 degrees Fahrenheit when the cement is added nor shall aggregate temperature exceed 150 degrees Fahrenheit.

b. Concrete structures shall be immediately protected after placement of the concrete repair material. The temperature of the concrete repair material at the concrete surface shall be maintained at not less than 55 degrees Fahrenheit nor more than 90 degrees Fahrenheit during the 7-day protection period.

c. Proper methods of covering, insulating, housing, or heating concrete structures shall be implemented.

d. Exhaust flue gases from combustion heaters shall be vented to the outside of the heating enclosure.

e. Following the completion of the protection period, the concrete repair material shall be allowed to cool gradually. The concrete repair material surface shall not have a temperature decrease of more than 40 degrees Fahrenheit in a 24-hour period.

f. Concrete repair material placed during cold weather not meeting the cold weather definition above shall be protected by proper methods for a minimum of 24 hours after placement.

### 16. Concrete repair in hot weather

For proprietary repair material, the manufacturer's recommendation together with the requirements below shall be followed.

For replacement concrete repair material, the requirements below shall be followed.

For the purpose of this specification, hot weather is defined as the weather condition at the job site that causes acceleration in the rate of moisture loss or rate of cement hydration of freshly mixed concrete, including an ambient temperature of 80 °F or higher, and an evaporation rate that exceeds 0.2 pound per square foot per hour. The rate of moisture loss and rate of cement hydration may be accelerated if one or a combination of the following conditions exists:

- High ambient temperature
- High concrete temperature
- Low relative humidity
- Wind velocity
- Solar radiation

Whenever these conditions exist or when climatic conditions are such that the temperature of the concrete repair material may reasonably be expected to exceed 90 degrees Fahrenheit at the time of delivery to the work site or during the placement operations, the following provisions shall apply:

a. The contractor shall maintain the temperature of the concrete repair material below 90 degrees Fahrenheit during mixing, conveying, and placing.

b. The exposed concrete repair material surface that tends to dry or set too rapidly shall be continuously moistened using fog sprays or other suitable means to maintain adequate moisture during the period between placement and finishing, and following finishing. Water shall not be sprinkled or added directly to the surface of the concrete repair before or during finishing.

c. Finishing of slabs and other exposed or nonformed surfaces shall be started as soon as the condition of the concrete repair material allows and shall be completed without delay.

d. The formed surface shall be kept completely and continuously moist for the duration of the curing period or until the application of the curing compound is completed.

e. Concrete repair material surface, especially flat-work placed with large surface areas, shall be covered with wet burlap or other similar material as soon as the concrete repair material has sufficiently hardened and shall be kept continuously moist for at least 24 hours for the initial curing period. This protective method shall be continued for the required curing period or until the application of curing compound is completed.

f. Moist curing may be discontinued before the end of the curing period if white, or other color selected in section 18, pigmented curing compound is applied immediately.

g. Under extreme conditions of high ambient temperature, high concrete temperature, low relative humidity, wind velocity, and exposure to solar radiation, the engineer may:

   (1) Restrict placement to the most favorable time of day.

   (2) Restrict the depth of layers to assure coverage of the previous layer while it will still respond readily to vibration

   (3) Suspend placement until conditions improve.

   (4) Require removal of forms, repair, patching, and reapplication of wet curing by small areas at a time.

## 17. Measurement and payment

***Method 1***—For items of work for which specific unit prices are established in the contract, concrete repair volume is determined by computing the volume to the nearest 0.1 cubic foot between the neatness shown on the drawings and the approved pay limit.

***Method 2***—For items of work for which specific unit prices are established in the contract, concrete repair volume is determined by counting the number of premeasured, prepackaged units properly used to perform the approved

repair. A premeasured, prepackaged unit is defined as a composite of all components and additives required to be mixed together before the repair material can be properly placed.

When only a part of a unit is needed to complete the filling of a repair void, it is counted as one unit. Units required to fill voids outside the approved pay limits are not counted for payment. Units mixed, but not placed in a repair void because of the contractor's improper construction operation or management are not counted.

***Method 3***—For items of work for which specific unit prices are established in the contract, concrete repair area is determined by measuring the surface treated and computing the area to the nearest 0.1 square foot.

***All methods***—The following applies to all methods of measurement and payment:

Payment for concrete repair is made at the contract unit price for the item. The payment for repair constitutes full compensation for all labor, material, equipment, transportation, tools, forms, false-work, bracing, and all other items necessary and incidental to the completion of the repair work.

Repair material required to fill voids outside the neatness or pay limits not directed or approved by the engineer and resulting from excessive removal by the contractor, damages caused by the contractor's activities, or improper construction operations as determined by the contracting officer is not measured nor paid for under this item.

Compensation for any item of work described in the contract, but not listed in the bid schedule is included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in section 18 of this specification.

## 18. Items of work and construction details