

1 Technical Guidelines
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7 International Concrete Repair Institute
8 3166 S. River Road, Suite 132, Des Plaines, IL 60018
9 Phone: 847-827-0830 Fax: 847-827-0832
10 Web: www.icri.org
11 E-mail: info@icri.org

12 **About ICRI Guidelines**

13 The International Concrete Repair Institute (ICRI) was founded to improve the durability of concrete repair and enhance
14 its value for structure owners. The identification, development, and promotion of the most promising methods and
15 materials are primary vehicles for accelerating advances in repair technology. Working through a variety of forums, ICRI
16 members have the opportunity to address these issues and to directly contribute to improving the practice of concrete
17 repair.

18 A principal component of this effort is to make carefully selected information on important repair subjects readily
19 accessible to decision-makers. During the past several decades, much has been reported in the literature on concrete repair
20 methods and materials as they have been developed and refined. Nevertheless, it has been difficult to find critically
21 reviewed information on the state of the art condensed into easy-to-use formats.

22 To that end, ICRI guidelines are prepared by sanctioned task groups and approved by the ICRI Technical Activities
23 Committee. Each guideline is designed to address a specific area of practice recognized as essential to the achievement of
24 durable repairs. All ICRI guideline documents are subject to continual review by the membership and may be revised as
25 approved by the Technical Activities Committee.

26 **Technical Activities Committee**

27 Rick Edelson, Chair

28 David Akers

29 Paul Carter

30 Bruce Collins

31 Bud Earley

32 Garth Fallis

33 Tim Gillespie

34 Fred Goodwin

35 Scott Greenhaus

36 Bob Johnson

37 Ken Lozen

38 Kevin Michols

39 Joe Solomon

40 This document is intended as a voluntary guideline for the owner, design professional and concrete repair contractor.
41 It is not intended to relieve the professional engineer or designer of any responsibility for the specification of concrete
42 repair methods, materials or practices. While we believe the information contained herein represents the proper means
43 to achieve quality results, the International Concrete Repair Institute must disclaim any liability or responsibility to
44 those who may choose to rely on all or any part of this guideline.

45 **Producers of this Guideline**

46 This document was prepared by a task group consisting of individuals representing the repair industry. Task Group
47 members who contributed to the creation of this document are:

48 B. Bissonnette

49 E. Brenner

50 C. Brown

51 T. Gillespie

52 F. Goodwin

53 A. Rossi

54 S. Sprouts

55 A. Vaysburd

56 P. Watson

57

58 The Repair Materials and Methods Committee finalized and approved this document. Voting Members are:

59 Bud Earley, Chair

60 Bonin, Dick

61 Bruns, Doug

62 Daley, Joe

63 De Stefano, Mark

64 Earley, Bud

65 Emmons, Peter

66 Gillespie, Tim

67 Goodwin, Fred
68 Karins, David
69 Kolf, Peter
70 McDonald, James
71 Michols, Kevin
72 Porter, Jr., Clyde
73 Roberts, Bob
74 Swan, Bob
75 Verona, Frank
76 Watson, Patrick “Doc”

77 **Synopsis**

78 The purpose of this document is to provide a standardized protocol for testing and reporting of data for inorganic
79 repair materials. It does not address all of the issues associated with material selection. It is the responsibility of the
80 user of this document to determine the suitability of the repair material prior to use. Commentary and supplemental
81 information in this document is *italicized*. The test methods for the determination of the reported data must be
82 reported from the methods listed in this document and the method used listed adjacent to the reported data. Test data
83 must be reported in the order and sections as listed in this document.

84 **Keywords:** Data Sheet Protocol, Material Properties, Material Specifications, Repair Material, Test
85 Methods

86 **Contents**

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94 **Repair Material Description**

95 1. Recommended use

96 Examples: Horizontal, vertical, overhead, traffic wearing surface repairs, etc.

97 2. Benefits

98 Examples: Rapid strength development, shrinkage compensated, polymer modified, etc.

99 3. Limitations

100 Examples: Minimum/maximum placement depth with/without aggregate, application temperature range, moisture
101 exposure, etc.

102 **Material Composition**

103 1. For the purposes of this guideline, consider cementitious material to be that fraction of the inorganic repair
104 material passing a 90 μ (micron) (No. 170 mesh), and mortar to be a material consisting of an inorganic binder
105 with the only aggregate being fine aggregate according to ASTM C 33¹.

106 2. Extended mortar is concrete produced by the addition of coarse aggregate to a mortar product.

107 3. Extended mortar and concrete shall be considered to be those materials that contain both fine and coarse
108 aggregate per ASTM C 33¹.

109 Example: This repair mortar is composed of a precise blend of portland cement, microsilica, graded aggregates,
110 redispersible polymer, and fine fibers.

- 111 • Total sulfur trioxide (SO₃), %—ASTM C 114¹:

112 State the percentage total SO₃ contained within all cementitious materials stated as a percentage by mass. If
113 sulfate levels are above those contributed from portland cement, the material producer shall provide data and
114 methods used to establish suitability for the recommended uses stated in Part 1.

- 115 • Total alkali content, kg/m³ (lb/yd³)—ASTM C 150¹:

116 State the total sodium equivalent alkalis contained within all cementitious materials as a percentage by
117 weight.

118 *The typical means by which the alkali content has been controlled with concrete mixtures in the United States*
119 *has been to establish a maximum limit only on the portland cement. Cement with an alkali content of less than*
120 *0.6%, expressed as equivalent Na₂O, is referred to as low-alkali cement. This provision proved satisfactory*
121 *for concrete. The disadvantage of establishing an alkali limit based on the alkali of the portland cement alone*
122 *for repair materials is that many proprietary repair materials contain blends of different cements, additives,*
123 *admixtures, and other constituents that contain alkali. It is the sum of the alkalis from all sources that is*
124 *pertinent to the potential reaction with a reactive aggregate.*

125 *Past research conducted in Germany and Canada led to the conclusion that when the alkali in a mixture is*
126 *kept below a maximum of 3.0 kg/m³ (5.0 lb/yd³), there will be no alkali-aggregate reaction (AAR)*
127 *(Publication No. FHWA-SA-97-045, Gress, D., "Early Distress of Concrete Pavements," Jan. 1997).*

- 128 • Chloride content—

129 State the total water-soluble chlorides per ASTM C 1218¹ and acid-soluble chloride content per C 1152¹ as a
130 percentage by weight of the material. The considerations of chloride-ion content discussed in ACI 222 Section
131 3.23 shall be considered and may require a cautionary statement on the packaging if an oxidizable metal
132 such as iron, steel, zinc or aluminum is allowed to be embedded in proximity of a chloride containing
133 concrete repair material.

- 134 • pH—

135 Report the pH of the fresh and hardened repair material.

136 *Crush a hardened sample of the inorganic repair material to pass a No. 170 (90 μ) mesh sieve, stir 10 g of the*
137 *crushed material into 90g distilled or deionized water for 1 min. and, after settling, use pH paper or suitable*
138 *pH meter per the recommendations of the supplier of the pH equipment.*

- 139 • Characteristics of aggregate—ASTM C 33¹:

140 For prepackaged products, use the +170 mesh fraction obtained by wet sieving according to ASTM C117¹ for
141 the tests specified in the section titled "Methods of Sampling and Testing" of ASTM C 33.

142	Fine aggregate
143	General characteristics
144	Grading
145	Deleterious substances
146	Soundness
147	Coarse aggregate
148	General characteristics
149	Grading
150	Deleterious substances

151 **Material Properties**

- 152 1. Material's unit weight
- 153 • Mortar—ASTM C 185¹ calculated from "mass per 400 mL of mortar" using the calculations for yield from
- 154 ASTM C 138.
- 155 • Extended mortar and concrete—ASTM C 138¹.
- 156 2. Setting time
- 157 • Minimum application temperature—ASTM C 266¹ or C 191¹.
- 158 • Maximum application temperature—ASTM C 266¹ or C 191¹.
- 159 3. Air content
- 160 • Mortar—ASTM C 185¹.
- 161 • Extended mortar and concrete—ASTM C 231¹.
- 162 4. Yield
- 163 • Mortar—ASTM C 185¹.
- 164 • Extended mortar and concrete—ASTM C 138¹.
- 165 5. Density, absorption, and voids—ASTM C 642¹.
- 166 *Use the same air-stored specimens from the length change test as described in the "Property and Test Method"*
- 167 *section.*

168 **Property and Test Method**—Performed at 1, 7, and 28 days of age

- 169 1. Compressive strength
- 170 • Mortar—ASTM C 109¹: 2-in. (51-mm) cubes.
- 171 • Extended mortar and concrete—ASTM C 39¹: 3 x 6-in. (76 x 152-mm) cylinders.
- 172 *Report the method of capping of the cylinders and the dimensions of the cylinders used, in addition to the*
- 173 *other requirements of the report section of ASTM C 39¹.*
- 174 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 175 one of the four regimens, depending on the setting time and polymer modification of the material.
- 176 2. Flexural strength
- 177 • Mortar—ASTM C 348¹.
- 178 • Extended mortar and concrete—ASTM C 78¹.
- 179 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 180 one of the four regimens, depending on the setting time and polymer modification of the material.
- 181 3. Splitting tensile strength—ASTM C 496¹
- 182 • Mortar—2 x 4-in. (51 x 102-mm) specimen.
- 183 • Extended mortar and concrete—3 x 6-in. (76 x 152-mm) specimen unless otherwise indicated.
- 184 *If coarse aggregate larger than 3/8 in. is used, then refer to ASTM C 39¹ for appropriate specimen size.*
- 185 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 186 one of the four regimens, depending on the setting time and polymer modification of the material.
- 187 4. Direct tensile strength—CRD C 164⁵
- 188 • Mortar—2 x 4-in. (51 x 102-mm) specimen.
- 189 • Extended mortar and concrete—3 x 6-in. (76 x 152-mm) specimen.
- 190 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 191 one of the four regimens, depending on the setting time and polymer modification of the material.

- 192 5. Modulus of elasticity—ASTM C 469¹
- 193 • Mortar—2 x 4-in. (51 x 102-mm) specimen.
- 194 • Extended mortar and concrete—3 x 6-in. (76 x 152-mm) specimen.
- 195 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 196 one of the four regimens, depending on the setting time and polymer modification of the material.
- 197 6. Bond Strength— ICRI 03739 - Guide to Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete
- 198 Surface Materials
- 199 • Use a concrete substrate of 4000 to 5000 psi (27.6-34.7 MPa) compressive strength and CSP #3 as defined by
- 200 ICRI Guideline No. 03732, “Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings,
- 201 and Polymer Overlays” for the substrate of the repair material application. Apply the repair material to the
- 202 manufacturer’s recommended thickness (if a range of thicknesses, use the midpoint of the range) using the
- 203 manufacturer’s recommendations for material mixing, placement, and curing.
- 204 *This method is also recommended for evaluation of minimum in-place bond. Comparative data between*
- 205 *materials reported should use identical substrates and preparation techniques with the compressive strength*
- 206 *of the concrete substrate and the ICRI surface profile per ICRI Guideline No. 03732 reported.*
- 207 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 208 one of the four regimens, depending on the setting time and polymer modification of the material. Any
- 209 additions, requirements, or supplemental materials (such as bonding aids) of the material manufacturer shall
- 210 be used and reported when performing the testing in this document.
- 211 • Report the failure mode for each specimen (i.e., cohesive or adhesive through material, at the bond line, or
- 212 within the substrate). If mixed failure modes are found, report the percent adherence to each interface.
- 213 • Report the average bond strength the number of specimens tested, and the standard deviation for the specimen
- 214 set.
- 215 7. Length change—ASTM C 157¹ (Modified)
- 216 Standard specimen size is 3 x 3 x 11-1/4 in. (76 x 76 x 275 mm) for mortar, extended mortar, and concrete.
- 217 • Normal-setting nonpolymer-modified materials—Cure in moist cabinet or room per ASTM C511¹. Remove
- 218 specimens from mold at 23.5 ± 1/2 hours and make initial comparator reading immediately.
- 219 • Normal-setting polymer-modified materials—ASTM C 1439¹.
- 220 *Immediately cover molded specimens with polyethylene film (> 0.1mm thickness) and store at 73±3°F (23 ± 2*
- 221 *°C)*
- 222 *and 50 ± 4% RH. Remove specimens from mold at 23-1/2 ± 1/2 hours and make initial comparator reading*
- 223 *immediately.*
- 224 • Rapid-hardening nonpolymer-modified materials—Cure in moist cabinet or room per ASTM C 511¹. Remove
- 225 specimens from mold at 2 ± 1/4 hours after final set and take initial comparator reading immediately.
- 226 • Rapid-hardening polymer-modified materials—ASTM C 1439¹ except remove specimens from mold at 2 ±
- 227 1/4 hours after final set and take initial comparator reading immediately.
- 228 *Store specimens under the standard conditions for air storage of 23 ± 2 °C (73.4 ± 3 °F) and 50 ± 4% RH and*
- 229 *water storage 23.0 ± 0.5 °C (73.4±1°F)*
- 230 Subsequent comparator readings are to be taken at ages of 3 days, 7 days, 14 days, 1 month, and 2 months;
- 231 measurements shall continue until 90% of ultimate drying shrinkage is reached. Ultimate drying shrinkage is to be
- 232 determined as described in ASTM C 596¹, “Drying Shrinkage of Mortar Containing Portland Cement.”
- 233 8. Coefficient of thermal expansion—CRD C 39⁵ as modified below:
- 234 • Use the same air-stored specimens from the length change test as described above.
- 235 • 3 x 3 x 11-1/4 in. (76 x 76 x 275 mm) for mortar, concrete, and extended mortar.
- 236 • Cycle specimens from 140 to 40 °F (60 to 5 °C) at 50% RH and greater than 95% RH
- 237 9. Freezing-and-thawing resistance—ASTM C 666 Procedure A¹ as supplemented below:
- 238 • Composite beams comprised of a 3 x 1 x 16-in. (76 x 25 x 406 mm) overlay of repair mortar applied per the
- 239 manufacturer’s recommendations on top surface of a freeze/thaw-resistant concrete substrate measuring 3 x 3
- 240 x 16 in. (76 x 76 x 406 mm) that has been prepared in accordance with the "How to Use the Material,"
- 241 section of this document, or if no profile or surface preparation instructions are provided is prepared to CSP
- 242 #3 as defined by ICRI Guideline No. 03732, “Selecting and Specifying Concrete Surface Preparation for
- 243 Sealers, Coatings, and Polymer Overlays” for the substrate of the repair material application.
- 244 • Cure specimens in accordance with the curing provisions of the length change section of this document using
- 245 the appropriate regimen, depending on the setting time and polymer modification of the material. Continue to

- 246 cure the specimen in moist cabinet or room per ASTM C 511 until an elapsed time of 28 days from date of
247 casting of the composite specimen has elapsed.
- 248 • Start testing after 28 days of curing.
- 249 10. Scaling resistance—ASTM C 672¹
- 250 • Cure specimens in accordance with the curing provisions of the length change section of this document using
251 the appropriate regimen, depending on the setting time and polymer modification of the material. Continue to
252 cure the specimen in moist cabinet or room per ASTM C 511 until an elapsed time of 28 days from date of
253 casting of the composite specimen. test after 28 days of curing.
- 254 11. Compressive creep—ASTM C 512¹
- 255 • Cure specimens in accordance with the curing provisions of the length change section of this document using
256 one of the four regimens, depending on the setting time and polymer modification of the material.
- 257 12. Rapid chloride permeability—ASTM C 1202¹
- 258 • Start test after 28 days of curing.
- 259 13. Chloride ponding—AASHTO T 259⁶ or alternatively, ASTM C 1543 “Standard Test Method for Determining the
260 Penetration of Chloride Ion into Concrete by Ponding”¹
- 261 • Cure specimens in accordance with the curing provisions of the length change section of this document using
262 the appropriate regimen, depending on the setting time and polymer modification of the material. Continue to
263 cure the specimen in moist cabinet or room per ASTM C 511 until an elapsed time of 14 days from date of
264 casting then dried for 14 days as specified in AASHTO T259 or ASTM C 1543 and then abraded to a CSP #3
265 as defined by ICRI Guideline No. 03732, “Selecting and Specifying Concrete Surface Preparation for Sealers,
266 Coatings, and Polymer Overlays” before beginning the test. Report either AASHTO T259 or ASTM C 1543
267 as the method used.
- 268 14. Sulfate resistance—ASTM C 1012¹
- 269 • Cure specimens in accordance with the curing provisions of the length change section of this document using
270 one of the four regimens, depending on the setting time and polymer modification of the material.
- 271 15. Chemical resistance—ASTM D 1308¹, Spot Test, Covered.
- 272 • Use same-size specimens as used for length change.
- 273 16. Cracking resistance— ASTM C1581 Standard Test Method for Determining Age at Cracking and Induced
274 Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage⁶
- 275 • Description of the ring test
- 276 *This method allows the determination of materials’ sensitivity to cracking caused by restrained volume*
277 *changes. Material in the mold should be consolidated as recommended by the manufacturer. The material*
278 *rings are to be kept in their molds and covered with plastic for the first 24 hours after they are cast. After the*
279 *completion of the recommended curing period, the specimen shall then be kept for a minimum of 60 days*
280 *under the standard laboratory conditions: 73.4 ± 3 °F (24.0 ± 2 °C) and 50 ± 4% RH. The rings should be*
281 *monitored using the prescribed strain gages, as well as visual observation daily for evidence of cracking, and*
282 *the day that cracking is observed the width shall be recorded with precision of 0.04 mm (0.001 in.). Each of*
283 *the cracks that formed should be measured periodically for width at quarter points and in the middle along*
284 *the crack and the average width recorded. Report per ASTM C 1581.*
- 285 • Cure specimens in accordance with the curing provisions of the length change section of this document using
286 one of the four regimens, depending on the setting time and polymer modification of the material.

287 **Packaging and Storage**

- 288 1. Packaging—ASTM C 1107¹ and/or ASTM C 928¹
- 289 • Packages shall be labeled per the Product Marking sections of C 1107¹ or ASTM C 928¹ and the designated
290 specification that was used for product marking.
- 291 2. Volume yield—
- 292 • Mortar—ASTM C 185¹ calculated from "mass per 400 mL of mortar" using the calculations for yield from C
293 138.
- 294 • Extended mortar and concrete—ASTM C138¹.
- 295 *Report as cubic meters or cubic feet per package.*
- 296 3. Shelf life

- 297 • Specify use by date.
- 298 4. Storage requirements
- 299 • Specify minimum and maximum storage temperatures, humidity, and conditions.
- 300 • Specify conditioning of material before use.

301 **How to Use the Material**

- 302 1. Aggregate extension
- 303 • Report grading size number per ASTM C 33¹ and mass quantity of aggregate to add per unit (if applicable).
- 304 • Extend the product (if applicable) in accordance with the manufacturer's instructions.
- 305 2. Concrete surface preparation
- 306 • Specify the CPS number per ICRI Guideline No. 03732⁴, “Selecting and Specifying Concrete Surface
- 307 Preparation for Sealers, Coatings, and Polymer Overlays” Prepare surface in accordance with ICRI Guideline
- 308 No. 03732⁴.
- 309 3. Mixing
- 310 • Mix the repair material in accordance with manufacturer's recommendations.
- 311 • Specify mixing liquid amount and/or range.
- 312 4. Application and finish
- 313 • Indicate working time of material at minimum and maximum application temperatures.
- 314 • Include minimum and maximum application thickness
- 315 • Follow manufacturer's recommendations for applying and finishing the repair material.
- 316 • Indicate return to service time guidelines at maximum and minimum curing temperatures.

- 317 5. Curing
318 • Follow manufacturer's recommendations for curing the repair material.
- 319 6. Cleanup
320 • Follow manufacturer's recommendations for cleanup and disposal of material in accordance with local
321 regulations and requirements.
- 322 7. Safety
323 • Refer to the manufacturer's Material Safety Data Sheet (MSDS).
324 • This document does not purport to address all of the safety concerns, if any, associated with its use. It is the
325 responsibility of the user of this document to establish appropriate safety and health practices and to
326 determine the applicability of regulatory limitations prior to use.

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