Repair-Material Data-Sheet Protocol

By Fred Goodwin

The Guideline for Inorganic Repair-Material Data-Sheet Protocol (Protocol) has evolved over the past 10 years in response to a recognized industry need for a standardized method of reporting descriptions and properties of concrete repair materials. Frequently, test data have been reported or required in specifications that are inappropriate for the material, or use modified or in-house test methods. Descriptions of material limitations, packaging, storage, label contents, application instructions, material composition, and material properties can be inconsistent, confusing, missing, or misleading. The Protocol is a first in the industry to provide this information in a standardized, logical, and consistent format so that repair materials can be appropriately selected and specified.

The concept of the Protocol first appeared in “Performance Criteria for Concrete Repair Materials Phase II, Field Studies” (REMR-CS-60) in 1998 as the result of a detailed comparison of the published information from 12 proprietary repair materials. A draft document was included in the subsequent report REMR-CS-62. The Protocol document was discussed and refined at the 1999 workshop “Predicting the Performance of Concrete Repair Materials” that was hosted by the National Institute of Standards and Technology (NIST) and sponsored by Conproco, Master Builders, Sika, W.R. Grace & Co., and Structural Preservation Systems. One of the outcomes of the workshop was the formation of a task group to develop the Protocol that consisted of representatives from material suppliers, specifiers, and academics. Over the next several years, the task group refined and identified the appropriate industry organizations for adoption of the document. At the time of writing this paper, the Protocol has undergone ballot for adoption by the International Concrete Repair Institute (ICRI) and, upon completion of the review by their Technical Activities Committee, will become a publication of this organization. ACI Committee 364 has formed a task group to take the ICRI document and incorporate it into their publications.

The Protocol

The Protocol is divided into five sections. A brief introduction of the contents of each section is described here:

Section 1, Repair Material Description, is divided into three subsections: Recommended Use; Benefits; and Limitations. Examples of Recommended Use include repair materials designed for vertical application, traffic bearing surfaces, cosmetic repairs, and structural components. Benefits include claims such as shrinkage compensated, colored, and rapid hardening. Limitations require reporting the minimum and maximum application thickness, the minimum and maximum application temperature, any material modifications (that is, aggregate extension), and the recommended curing regimen.

Section 2, Compositional Data, provides a means of classifying the binder chemistry, defines the number of components, and requires determination of possible deleterious components within the proprietary composition. Examples of typical binder chemistries might be ordinary portland cement, high alumina cement, alkali-activated pozzolan, calcium sulfoaluminate cement, or combinations of these materials. The levels of sulfate, sodium equivalent alkali, and total chloride are to be reported based on a percentage by weight basis of the cementitious content, which is defined as the portion of the dry material passing a 0.1 mm (170-mesh) sieve. Analytical methods for the determination of these levels are specified by referencing ASTM C 114 for sulfate and alkali, and ASTM C 1142 for total chloride. The reporting of these three components is not intended to disclose proprietary information, but is based on references to compositional limits from ASTM C 150 and ACI 222.

The intent of reporting the pH is to determine if steel passivation can occur when the repair material is applied onto reinforcing steel in the concrete. The pH of the repair material when freshly mixed with water is to be reported by mixing 10.0 g of the dry powder with 90.0 g of distilled water, allowing to settle for 1 min and determine the pH with either pH papers or a pH meter. Likewise, the pH of the hardened repair material is to be reported by crushing a sample of the hardened material to pass a 0.1-mm (170-mesh) sieve and stirring into distilled water, and then using the same method as with the dry powder.

The aggregate characteristics in the repair material are described in accordance with the sections of ASTM C 33 using the material retained on a 0.1-mm (170-mesh) sieve. For fine aggregates the description should include the reportable parameters from the section requirements of General Characteristics, Grading, Deleterious Substances, and Soundness. For coarse aggregates the description should include those items covered by the section headings of General Characteristics, Grading, and Deleterious Substances.
**Section 3. Material Properties.** Typically specifies different tests for mortar and concrete materials. The test method used for the reported result must also be reported, and some results may be determined by specified alternate methods. Plastic properties are reported first and include:

- Density and Yield (ASTM C 1859 [mortar] or C 13810 [concrete])
- Setting Time (ASTM C 26611 or C 19112) at both the minimum and maximum stated application temperatures (the mortar fraction should be sieved from concrete materials for setting time)
- Air Content (ASTM C 1859 [mortar] or C 23113 [concrete])

The hardened properties are also reported in Section 3. A different demolding and curing regimen is specified based upon the speed of hardening and polymer modification (Table 1).

<table>
<thead>
<tr>
<th>Material</th>
<th>Demold time</th>
<th>Curing regimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal setting non-polymer modified</td>
<td>1 day</td>
<td>ASTM C 51114</td>
</tr>
<tr>
<td>Normal setting polymer modified</td>
<td>1 day</td>
<td>ASTM C 143915</td>
</tr>
<tr>
<td>Rapid hardening non-polymer modified</td>
<td>2 h after final set</td>
<td>ASTM C 51114</td>
</tr>
<tr>
<td>Rapid hardening polymer modified</td>
<td>2 h after final set</td>
<td>ASTM C 143915</td>
</tr>
</tbody>
</table>

Different tests are typically specified for mortar and concrete mixtures. These are detailed in Table 2.

**Section 4. Packaging and Storage.** Requires labelling of the packages in accordance with the “Product Marking” section of either ASTM C 92816 or C 110717. The package label must contain the volume yield of the product as cubic meters (or cubic feet) per package, the shelf life listed as a “use-by” date, and the minimum and maximum storage temperatures and conditions.

**Section 5. How to Use the Material.** Includes reporting the aggregate extension grading requirements per ASTM C 33 and the mass quantity of aggregate to add per unit (if applicable). Concrete surface preparation is described in accordance with ICRI Technical Guideline No. 0373014 and includes the proper Concrete Surface Profile (CSP) for the product application. The type and amount (or range of addition) of mixing liquid is to be listed. Instructions for application of the material, minimum and maximum application and curing temperatures, finishing guidelines, curing regimen, minimum and maximum application thickness, and cleanup recommendations are listed in this section. A safety caveat also is included referencing the manufacturer’s MSDS18 and local regulatory requirements.

Further developments underway with the Protocol are to add a commentary to the document providing additional detail for the significance and use of the test methods selected to characterise concrete repair materials. Several test methods will also be updated as follows:

- The AASHTO T 25919 “Resistance of Concrete to Chloride Ion Penetration” ponding test has been adapted by ASTM as ASTM C 154320 “Standard Test Method for Determining the Penetration of Chloride Ion into Concrete by Ponding.”
- The AASHTO PP 3421 provisionally “Cracking Tendency Using a Ring Specimen” test method has been replaced the ASTM C 158140, “Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage.”
- ACI 503R Appendix A has been replaced with ICRI Technical Guideline No. 0373921 “Guide to Using In-Situ Tensile Pull-Off Tests to Evaluate Bond of Concrete Surface Materials,” since ICRI now has its own test method developed especially for concrete repair materials.

The Protocol, as approved by the ICRI Repair Materials and Methods Committee and reviewed by the Technical Activities Committee, will soon become available for general use by the industry. A task group has also been formed within the ACI 364 Committee on Rehabilitation to adopt the Protocol as one of their consensus documents. The development of similar Protocols for other types of formulated construction materials using this document as a template is being discussed in several organizations. A high level of interest already exists in the North American engineering and specifying communities to allow comparison of different concrete repair materials through the use of the Guideline for Inorganic Repair Material Data Sheet Protocol.

**References**

3. Vaysburd, A. M.; Carino, N.; Bissonnette, B., “Predicting the Performance of Concrete Repair Materials,” (NISTIR 6402), NIST, United States Department of Commerce Technology Administration, 2000
7. ACI Committee 222 “Corrosion of Metals in Concrete,” American Concrete Institute, Farmington Hills, Mich.
8. ASTM C 33, “Standard Specification for Concrete Aggregates,” V. 4.02
10. ASTM C 138, “Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete,” V. 4.02
13. ASTM C 231, “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method,” V. 4.02
15. ASTM C 1439, “Standard Test Methods for Polymer-Modified Mortar and Concrete,” V. 4.02
19. ASTM C 78, “Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading),” V. 4.02
20. ASTM C 496, “Standard Test Method for Flexural Strength of Cylindrical Concrete Specimens,” V. 4.02
21. CRD C 164, “Standard Test Method for Direct Tensile Strength of Cylindrical Concrete or Mortar Specimens,” Handbook for Concrete and Cement, United States Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi
23. ACI 503R, “Use of Epoxy Compounds With Concrete,” American Concrete Institute, Farmington Hills, Mich.,
29. ASTM C 672, “Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals,” V. 4.02
31. ASTM C 1202, “Standard Test Method for Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration,” V. 4.02
32. AASHTO T 259, “Resistance of Concrete to Chloride Ion Penetration,” Standard Specifications for Transportation Materials and Methods of Sampling and Testing
35. AASHTO PP 34-99, “Cracking Tendency Using a Ring Specimen,” Standard Specifications for Transportation Materials and Methods of Sampling and Testing

Table 2: Hardened properties tests

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method for mortar</th>
<th>Test method for concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural strength</td>
<td>ASTM C 348[18]</td>
<td>ASTM C 78[19]</td>
</tr>
<tr>
<td>Direct tensile strength</td>
<td>CRD C 164[1]</td>
<td>CRD C 164[1]</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>ASTM C 469[22]</td>
<td>ASTM C 469[22]</td>
</tr>
<tr>
<td>Bond strength</td>
<td>ACI 503R[23] on CSP 3[24] @ 28 to 34 MPa</td>
<td>ACI 503R[23] on CSP 3[24] @ 28 to 34 MPa</td>
</tr>
<tr>
<td>Length change</td>
<td>ASTM C 157[25] 75 x 75 x 275 mm bar* @ 3, 7, 14, 30, 60, and ultimate per ASTM C 596[26]</td>
<td>ASTM C 157[25] 75 x 75 x 275 mm bar* @ 3, 7, 14, 30, 60, and ultimate per ASTM C 596[26]</td>
</tr>
<tr>
<td>Coefficient of thermal expansion</td>
<td>CRD C 39[27] with C157[25] bars* @ 60 to 5 °C cycle @ 50% relative humidity and &gt; 95% relative humidity</td>
<td>CRD C 39[27] with C157[25] bars* @ 60 to 5 °C cycle @ 50% relative humidity and &gt; 95% relative humidity</td>
</tr>
<tr>
<td>Scaling resistance</td>
<td>ASTM C 672[29] start @ 28 D</td>
<td>ASTM C 672[29] start @ 28 D</td>
</tr>
<tr>
<td>Rapid chloride permeability</td>
<td>ASTM C 1202[31] @ 28 D</td>
<td>ASTM C 1202[31] @ 28 D</td>
</tr>
<tr>
<td>Sulfate resistance</td>
<td>ASTM C 1012[33]</td>
<td>ASTM C 1012[33]</td>
</tr>
<tr>
<td>Chemical resistance</td>
<td>ASTM D 1308[34] with C 157[32] bars*</td>
<td>ASTM D 1308[34] with C 157[32] bars*</td>
</tr>
<tr>
<td>Cracking resistance</td>
<td>AASH[32] PP 34[34]</td>
<td>AASH[32] PP 34[34]</td>
</tr>
</tbody>
</table>

*use specimens from ASTM C 157 length change

Fred Goodwin, Principal Scientist, Research and Development with Degussa Construction Systems, is a member of several ICRI committees, including the Repair Materials and Methods Committee, the Technical Activities Committee, and the Nominating Committee. Goodwin is a member of SSPC, and an active member of ASTM Committees C1, C9, C12, C15, and ACI Committees TRRC, E 760, 351, 364, 515, and 546. He is also Chair of ASTM C09.68, Volume Change, Chair of ACI 364, Rehabilitation, and an American Segmental Bridge Institute Certified Grouting Technician.