

ICRI 320.3, REPAIR MATERIAL DATA SHEET PROTOCOL: GOING FROM GOOD TO BETTER

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The Material Data Sheet Protocol (DSP) was an outcome of Vision 2020, the strategic plan for the concrete repair industry. The DSP was further developed and accepted by ICRI as Guideline No. 320.3 to address the current state of confusion in the concrete repair industry and establish order of information by providing a consistent, logical, and systematic methodology for testing and reporting information for cement-based repair materials. A very similar document was recently approved by the American Concrete Institute (ACI): 364.3R-09, "Guide for Cementitious Repair Material Data Sheet." The purpose of Vision 2020 was to establish a set of goals to improve the efficiency, safety, and quality of concrete repair and protection activities. By focusing on the most important industry goals, it is hoped that the repair industry will achieve these goals faster than if we let the industry evolve on its own. This focus on goals for repair was also related to the major issue of sustainability, because extending the useful life of existing installations is a key factor in producing a sustainable environment. Over 100 industry leaders, including contractors, engineers, material manufacturers, researchers, educators, owners, and industry association executives, participated in focused workshops to define the most important industry issues and needs used to establish the goals in Vision 2020.

As most of us agree, repair of concrete is situational, requiring a balancing of the properties of the repair material for substrate compatibility, application constraints, mechanical/electrochemical/compositional performance, cost (material and installed), market and regulatory requirements, and durability during service. This situation has resulted in the development of multiple specifications to provide acceptance limits for material performance in a multitude of repair situations. Nearly every governmental agency has its own repair material specifications, manufacturers produce "guide" specifications to influence unique selection of a particular material and, frequently, repairs are

performed outside of any specifications that may actually exist.

Selecting and specifying the most appropriate concrete repair materials based on product literature can be a daunting task because of the variety of test methods and material properties used to characterize these materials. A number of examples of this confusion can easily be found in any manufacturer's literature, such as incorrect, obscure, proprietary, or missing test methods that provide insufficient details to verify published values. It is very tempting to only report data on properties favorable to a particular material. Also, test procedures used to determine material properties vary widely and modifications are often poorly documented. Specimen sizes and representative replicate testing are not documented, raising issues including: the specimen size can influence many properties, such as length change. Was the material tested "typical," "special," or "average"? How many specimens were tested and were the worst performing specimens deleted from the reported values? Such information does not provide great user confidence in the reported properties, and it is not a credible basis for selection of materials that will result in durable repairs. From personal experience, a great deal of time has been and continues to be spent trying to explain, obtain, correct, rationalize, and investigate these issues both for our own products as well as those of competitors. Therefore, the engineer often has very limited, sometimes misleading, information on which to base selection and specifications of materials for a particular repair project. When the ACI 562 Repair Code is eventually adopted (scheduled to occur in 2012), the DSP will hopefully be used to provide guidance for a consistent method for evaluating material properties.

The DSP allows the specifier to choose verifiable properties optimized for their selected requirements of a particular repair situation. The applicator can obtain useful information about yield, working time, surface preparation, application temperature range, curing, and compatibility, as well as verify

the material performance. The material producer can optimize products based on market needs and technology improvements, rather than concentrating on closely passing acceptance levels of an existing specification in a commodity-based market.

DESCRIPTION OF THE PROTOCOL

The protocol is divided into five sections. A brief introduction of the contents of each section will be discussed in the following and several proposed changes are described. These changes are based on suggestions from committee members, but they have not yet been proposed to ICRI Committee 320, Concrete Repair Materials and Methods, so significant modifications may still occur during the planned revision to the document.

SECTION 1, REPAIR MATERIAL DESCRIPTION

The first section, “Repair Material Description,” is divided into three subsections:

- Recommended Use
- Benefits
- Limitations

Recommended use is intended to describe if the material is intended for orientations and methods such as vertical/overhead, self-consolidating, form-and-pour/pump, shotcrete, or screed. Benefits include claims such as shrinkage compensated, colored, or rapid hardening. Limitations are intended for 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. Most data sheets published cover this sort of information fairly adequately, especially when favorable terms and buzzwords can be included in the descriptions. Therefore, the current DSP is relatively vague about what should be included. One change being considered to this section in the next version of the DSP is to clarify what is meant by “rapid hardening,” perhaps by using terminology from ASTM C928.

SECTION 2, COMPOSITIONAL DATA

Section 2, titled “Compositional Data,” provides a means of classifying the binder chemistry, defines the number of components, and suggests determination of possible deleterious components within proprietary compositions. The reporting of these components is not intended to disclose proprietary information but is based on references to compositional limits of compounds from ASTM C150 and ACI 222 that are thought to be potentially detrimental. Sulfate level, chloride level, and alkali levels are to be reported based on the cementitious portion of the repair material so that the aggregate quantity does not affect comparison of these levels (the references in ASTM C150 and

ACI 222 are based on ratios to the binder). All portland cement contains sulfate as an additive from interground gypsum as well as trace levels of alkalis (sodium and potassium) and minor levels of chlorides. Formulated proprietary products may increase these background levels. High levels of sulfate are often thought to be associated with uncontrolled expansion and poor durability. Chloride content is well associated with the potential for conventional reinforcing corrosion. Elevated alkali levels may lead to efflorescence as well as contribute to alkali aggregate reactions. Providing information about these potentially deleterious ions allows comparison between materials based on the importance that the specifier feels necessary for their repair installations without disclosing ingredients felt to be proprietary by the producer.

Reporting the pH is necessary to determine if steel passivation can occur when the repair material is used to embed reinforcing steel in the concrete. The pH of the repair material when freshly mixed is to be reported as well as the pH of the hardened repair material because some materials can undergo significant changes in pH during hydration as well as possibly provide some guidance for personal protective equipment during installation. No generally accepted test method was available for reference of a pH test method; therefore, the DSP contains an embedded method.

The aggregate characteristics in the repair material are described in accordance with the sections of ASTM C33 using the material retained on a 170 mesh (0.1 mm) sieve considered as aggregate. The grading is to be documented, as this indicates some limitations for the depth of placement and provides an indicator of adulteration or extension following installation. Even more important in the DSP is the reporting of deleterious or unstable aggregates in the product.

SECTION 3, MATERIAL PROPERTIES

Section 3, titled “Material Properties,” typically recommends different tests for mortar and concrete materials. The test method used for the reported result must also be reported, as some results may be determined by specified alternate methods. Plastic properties are reported first and include:

- Density and yield (ASTM C185 [for mortar] or C138 [for concrete and extended mortar]);
- Setting time (ASTM C266 or C191) at both the minimum and maximum stated application temperatures (the mortar fraction should be sieved from concrete materials for setting time); and
- Air content (ASTM C185 [mortar] or C231 [concrete]).

Density and yield are useful for determining the coverage of the material when applied, as well as providing a baseline check for proper mixing,

because the material density will change as the ratio of powder to mixing liquid changes or air is entrapped from over mixing.

Setting time is a useful indicator of the working time of the material once mixed. There is no industry standard for cementitious materials for working time. It has been suggested to replace ASTM C266 and/or C191 with ASTM C807, which is quite similar to ASTM C191 but uses a different-sized needle to perhaps better test aggregate containing mortars. Additionally, ASTM C403 is being considered as a method for setting time based on a plot of penetration resistance using a series of standard needles for extended mortars and concretes. Alternatively, merely referencing that portion of ASTM C403 describing the procedure for sieving of coarse aggregate could clarify the existing document on this point.

Air content is a useful indicator of the resistance to deterioration from freezing-and-thawing cycles. A proposed clarification to the revision of the DSP is to require the mixing liquid quantity to be used in the air content calculations in situations where the liquid is not water.

The hardened properties are also reported in Section 3 of the protocol. A different demolding and curing regimen is specified based on the speed of hardening and polymer modification. Different hardened property tests are typically specified for mortar and concrete mixtures and include direct and splitting tensile, flexural, compressive strengths, modulus of elasticity, bond strength, length change, coefficient of thermal expansion, resistance to freezing and thawing, deicer scaling resistance, compressive creep, rapid chloride ion permeability, chloride permeability, sulfate resistance, chemical resistance, and cracking resistance. A list of these tests with some minimal detail is shown in Table 1; however, the user of the DSP is cautioned to obtain the full document from ICRI before attempting to use or produce data according to the DSP.

Several changes are being discussed to further clarify the testing for hardened properties in the DSP. ICRI has changed their document numbering system since the publication of the DSP, which will be corrected editorially in the next edition. ASTM International has adopted a test method for bond strength and for chloride ponding that will be referenced in addition to the ICRI method. Clarification is also needed on the length of testing of length change specimens, such as requiring reporting of values up to 1 year in duration. Freezing-and-thawing resistance using the composite beams described in the DSP should include a description of the location of the driving unit and pickup unit for the forced resonance equipment and impactor and accelerometer for the

impact resonance equipment used for ASTM C666 so that the test is conducted to establish the durability of both the repair material and the bond of the repair material to the specified substrate. In the chemical resistance test method, a statement is needed describing that the selection of the chemicals and duration of exposure of the testing is situational depending on the repair material exposure environment.

SECTION 4, PACKAGING AND STORAGE

Section 4, titled “Packaging and Storage,” requires labeling of the packages in accordance with the “Product Marking” section of either ASTM C928 or C1107. The package label must contain the volume yield of the product as cubic feet (or cubic meters) per package, the shelf life listed as a “use-by” date, and the minimum and maximum storage temperatures and conditions. It is currently unclear in the existing DSP if all tests are required to be run on freshly mixed material at the maximum working time and/or at the extreme application temperatures as required by ASTM C1107 or outside the ranges of ASTM C928. As a practical matter, due to the time required for casting, the quantity of materials needed, and the expense of testing products for the entire DSP, the next version of the DSP will likely only recommend that tests specifically listed or required at these extreme conditions should be run to avoid confusion on this point.

SECTION 5, HOW TO USE THE MATERIAL

The last section, “How to Use the Material,” includes reporting the aggregate extension requirements (if any). Concrete surface preparation is to be reported in accordance with ICRI No. 320.2 (formerly No. 03732), “Concrete Surface Profile (CSP).” The type and amount of mixing liquid, instructions for material application and temperatures, finishing guidelines, curing regimen, application thickness, and cleanup recommendations are also to be listed in this section. Coordinating specific equipment requirements and terminology with the developmental “Pictorial Atlas of Concrete Repair Equipment” is intended to also be included in the next version of the DSP.

THE FUTURE OF PROTOCOLS

Protocols are a new type of document to the concrete repair industry that can help resolve several of the obstacles that exist regarding the development of specifications:

- “One size fits all” for a type of material (certainly not the best case for concrete repair);
- The acceptance that minimum performance limits represent the true level of performance needed for a material, rather than the lowest common

TABLE 1: DSP HARDENED PROPERTIES TESTS

	Test method for mortar	Test method for concrete
Compressive strength	ASTM C109	ASTM C39
Flexural strength	ASTM C348	ASTM C78
Splitting tensile strength	ASTM C496 2 x 4 in. (51 x 102 mm) cylinders	ASTM C496 3 x 6 in. (76 x 152 mm) cylinders
Direct tensile strength	CRD C164 2 x 4 in. (51 x 102 mm) specimen	CRD C164 3 x 6 in. (76 x 152 mm) specimen
Modulus of elasticity	ASTM C469 2 x 4 in. (51 x 102 mm) specimen	ASTM C469 3 x 6 in. (76 x 152 mm) specimen
Bond strength	ICRI No. 210.3 or ASTM C1583 on CSP 3 4000 to 5000 psi (27.6 to 34.7 MPa) concrete substrate	ICRI 210.3 or ASTM C1583 on CSP 3 4000 to 5000 psi (27.6 to 34.7 MPa) concrete substrate
Length change	ASTM C157 3 x 11-1/4 in. (76 x 76 x 275 mm) bar* at 3, 7, 14, 30, 60, and ultimate per ASTM C596	ASTM C157 3 x 3 x 11-1/4 in. (76 x 76 x 275 mm) bar* at 3, 7, 14, 30, 60, and ultimate per ASTM C596
Coefficient of thermal expansion	CRD C39 with C157 bars* 140 to 40°F (60 to 5°C) cycle at 50% RH and >95% RH	CRD C39 with C157 bars* 140 to 40°F (60 to 5°C) cycle at 50% RH and >95% RH
Freezing-and-thawing resistance	ASTM C666A on 1 in. (25 mm) overlay applied to F/T durable substrate	ASTM C666A on 1 in. (25 mm) overlay applied to F/T durable substrate
Scaling resistance	ASTM C672 start at 28 days	ASTM C672 start at 28 days
Compressive creep	ASTM C512	ASTM C512
Rapid chloride permeability	ASTM C1202 at 28 days	ASTM C1202 at 28 days
Chloride ponding	AASHTO T259 or ASTM C1543	AASHTO T259 or ASTM C1543
Sulfate resistance	ASTM C1012	ASTM C1012
Chemical resistance	ASTM D1308 with C157 bars*	ASTM D1308 with C157 bars*
Cracking resistance	ASTM C1581	ASTM C1581

*Use specimens from ASTM C157 length change.

denominator that was agreeable among the industry specification developers (frequently material suppliers); and

- The commoditization of a material type which limits further development of technology to address the application need (that is, once a specification has been developed, the products complying tend to compete upon price with limited further investment in product differentiation).

Several other protocol type documents are currently under development within the repair industry, including one for elastomeric coatings, penetrating sealers, and corrosion mitigation techniques for existing concrete structures (SDC initiative).

CONCLUSIONS

The ICRI Inorganic Material DPS provides useful information to the material purchaser, applicator, and specifier. Advantages of the protocol approach to material property characterization are that standardization organizations can more easily reach consensus, specifiers can select the important material properties and performance based on their experience, and the properties can be verified due to the transparency of the test methods. As with any standardized document, periodic revision, improvement, clarification, and reapproval are both required as well as needed. Hopefully, this article has helped to explain both the existing document

and the planned changes for the next edition to be published by ICRI.

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