THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Infrastructure Rehabilitation Technologies**	
APPLICATION:	**Coatings for Wastewater Collection Systems**	
TECHNOLOGY NAME:	**Standard Epoxy Coating 4553™ (SEC 4553)**	
TEST LOCATION:	**University of Houston, CIGMAT**	
COMPANY:	**Standard Cement Materials, Inc.**	
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EPA created the ETV program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The program's goal is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups, which consist of buyers, vendor organizations, and permitters; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

NSF International (NSF), in cooperation with the U.S. Environmental Protection Agency (EPA), operates the Water Quality Protection Center (WQPC), one of six centers under the Environmental Technology Verification (ETV) Program. The WQPC recently evaluated the performance of the Standard Epoxy Coating 4553™ (SEC 4553), an epoxy coating system marketed by Standard Cement Materials, Inc. The SEC 4553 coating was tested at the University of Houston's Center for Innovative Grouting Materials and Technology (CIGMAT).

TECHNOLOGY DESCRIPTION

The following description of the Standard Cement Materials coating material (SEC 4553) was provided by the vendor and does not represent verified information.

Use the Standard Epoxy Coating 4553™, a 100% solids, solvent-less two-component epoxy coating system with increased bond strength and broad range chemical resistance to protect concrete, steel, masonry and fiberglass structures, and to repair chemical damaged concrete in moist and damp environments.

VERIFICATION TESTING DESCRIPTION - METHODS AND PROCEDURES

The objective of this testing was to evaluate SEC 4553 used in wastewater systems to control the deterioration of concrete and clay infrastructure materials. Specific testing objectives were to (1) evaluate the acid resistance of SEC 4553 coated concrete specimens and clay bricks, both with and without holidays (small holes intentionally drilled through the coating and into the specimens; and, (2) determine the bonding strength of SEC 4553 to concrete and clay bricks.

Verification testing was conducted using relevant American Society for Testing and Materials (ASTM)[(1)] and CIGMAT[(2)] standards, as described below. Product characterization tests were conducted on the coating material and the uncoated concrete and clay specimens to assure uniformity prior to their use in the acid resistance and bonding strength tests. Standard Cement Materials' representatives were responsible for coating the concrete and clay specimens, under the guidance of CIGMAT staff members. The coated specimens were evaluated over the course of six months.

PERFORMANCE VERIFICATION

(a) Holiday Test - Chemical Resistance

SEC 4553 coated concrete cylinders and clay bricks were tested with and without holidays in deionized (DI) water and a 1% sulfuric acid solution (pH=1). A total of 20 coated concrete specimens and 20 coated clay brick specimens was exposed. Specimens were cured for two weeks prior to creation of 0.12 in. and 0.50 in. holidays. The 0.12 in. holidays were exposed to both DI water and acid solution, while the 0.50 in. holidays were exposed only to the acid solution. Observation of the specimens at 30 and 180 days was made for changes in appearance such as blistering or cracks around the holiday or color changes in the coating. Control tests were also performed using specimens with no holidays. A summary of the chemical exposure observations is presented in Table 1.

Table 1. Summary of Chemical Exposure Observations

Specimen Material (Coating Condition)	DI Water (days)				1% H_2SO_4 Solution (days)				Comments
	Without Holidays		With Holidays		Without Holidays		With Holidays		
	30	180	30	180	30	180	30	180	
Concrete – Dry	N (2)	N (2)	N (2)	N (2)	N (2)	N (2)	N (4)	N (4)	Color change in coating submerged in acid solution.
Concrete – Wet	N (2)	N (2)	N (2)	N (2)	N (2)	N (2)	N (4)	N (4)	Color change in coating submerged in acid solution.
Clay Brick – Dry	N (2)	N (2)	N (2)	N (2)	N (2)	N (2)	N (4)	N (4)	Color change in coating submerged in acid solution.
Clay Brick – Wet	N (2)	N (2)	N (2)	N (2)	N (2)	N (2)	N (4)	N (4)	Color change in coating submerged in acid solution.

N = No blister or crack; (n) = Number of specimens.

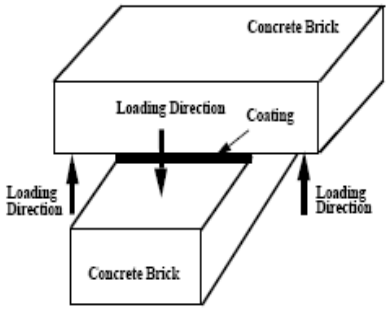
A specimen, made only of SEC 4553 and submerged in water for 10 days, showed no weight change over the period. Likewise, over an exposure time of 180 days, weight changes in coated specimens with no holidays showed less than 1% gain in DI and acid exposures. With holidays, coated concrete specimens showed < 0.75% weight change, while coated clay brick specimens showed 2.5-4.3% gains. Changes in the diameters/dimensions of the specimens at the holiday levels were negligible after 180 days of exposure.

(b) Bonding Strength Tests (Sandwich Method and Pull-Off Method)

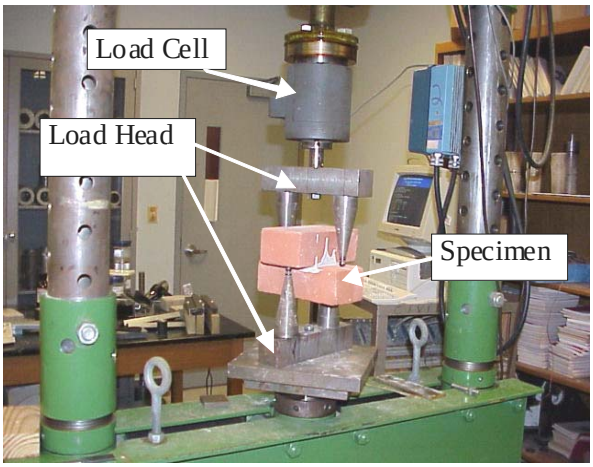
Tests were performed to determine the bonding strength between the SEC 4553 coating and concrete/clay brick specimens over a period of six months. Twelve sandwich (6 dry-condition, 6 wet-condition) and twenty pull-off (10 dry-condition, 10 wet-condition) tests were performed on both coated concrete samples and coated clay bricks.

Sandwich Test Method (CIGMAT CT 3)

CIGMAT CT 3, a modification of ASTM C321-94, was used for the testing. SEC 4553 was applied to form a sandwich between a like pair of rectangular specimens (Figure 1 (a)), both concrete brick and clay brick, and then tested for bonding strength and failure type following a curing period. The bonding strength of the coating was determined using a load frame (Figure 1 (b)) to determine the failure load and bonding strength (the failure load divided by the bonded area). The sandwich bonding tests were completed at 30, 90 and 180 days after application of the SEC 4553.



(a) Test specimen configuration



(b) Load frame test setup

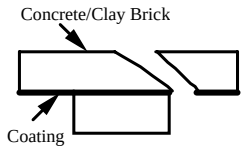
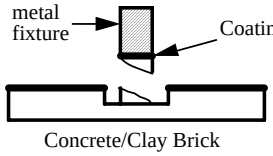
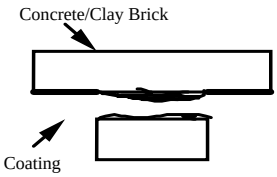
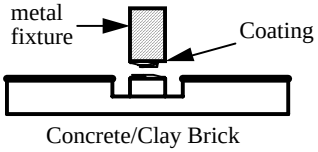
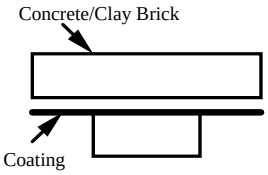
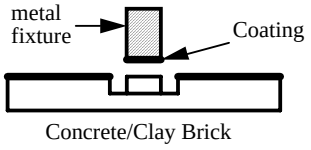
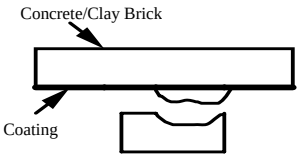
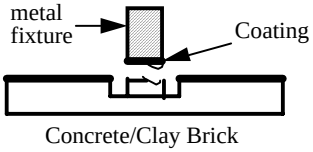
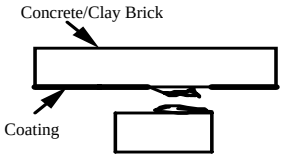
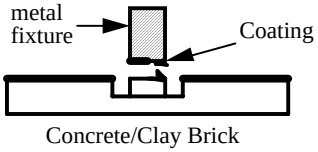
Figure 1. Bonding test arrangement for sandwich test.

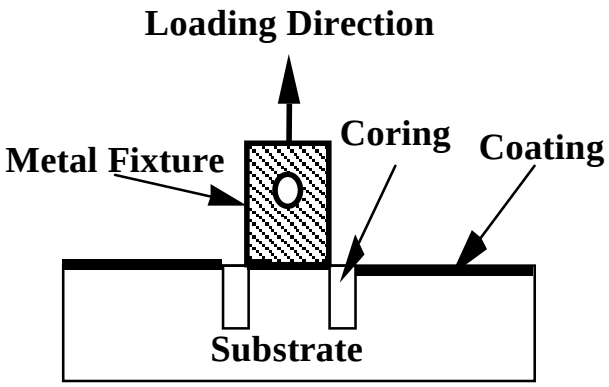
Dry-coated specimens were dried at room conditions for at least seven days before they were coated, while wet-coated specimens were immersed in water for at least seven days before the specimens were coated. Bonded specimens were cured under water up to the point of testing. The type of failure was also characterized during the load testing, as described in Table 2.

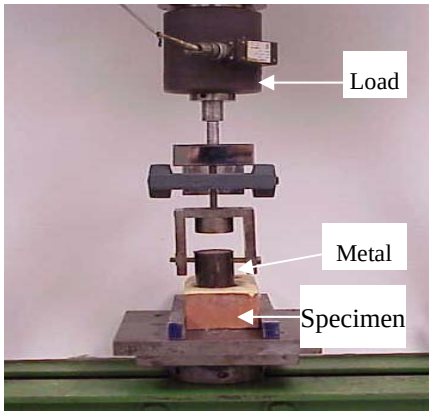
Pull-Off Method (CIGMAT CT 2)

Per CIGMAT CT 2, a 2-in. diameter circle was cut into coated concrete prisms and clay bricks to a predetermined depth to isolate the coating, and a metal fixture was glued to the isolated coating section using a rapid setting epoxy. Testing was completed on a load frame with the arrangements shown in Figure 2, with observation of the type of failure, as indicated in Table 2. The specimens were prepared in the same manner as for the sandwich test. The specimens were stored under water in plastic containers and the coatings were cored 24 hrs prior to the testing. The bonding tests were completed at 30, 60 and 180 days after application of the SEC 4553. Results of the bonding tests are included in Table 3.

Table 2. Failure Types in Sandwich and Pull-Off Tests

Failure Type	Description	Sandwich Test	Pull-off Test
Type-1	Substrate Failure		
Type -2	Coating Failure		
Type-3	Bonding Failure		
Type-4	Bonding and Substrate Failure		
Type-5	Bonding and Coating Failure		





(a) Specimen preparation **(b) Load frame arrangement**

Figure 2. Pull-off test method load frame arrangement.

Table 3. Summary of Test Results for Bonding Strength Tests (12 Specimens for Each Condition)

Substrate – Application Condition	Test [1]	Failure Type [2] – Number of Failures					Failure Strength (psi)	
		1	2	3	4	5	Range	Average
Concrete – Dry	Sandwich	5			1		185 – 260	224
	Pull-off	5			5		78 – 266	188
Concrete – Wet	Sandwich	6					204 – 279	242
	Pull-off	4			6		89 – 256	184
Clay Brick – Dry	Sandwich	6					172 – 279	245
	Pull-off	10					184 – 310	246
Clay Brick – Wet	Sandwich	6					271 – 345	310
	Pull-off	7			3		170 – 287	225

[1]Sandwich test (CIGMAT CT-2/Modified ASTM D 4541-85) or Pull-off test (CIGMAT CT-3/ASTM C 321-94).
[2]See Table 2.

(c) Summary of Verification Results

The performance of the Standard Cement Materials, Inc. SEC 4553 Epoxy Coating for use in wastewater collection systems was evaluated for chemical resistance and the bond of the coating with both wet and dry substrate materials, made up of concrete and clay brick. The type of bonding test, whether sandwich test or pull-off test, impact the mode of failure and bonding strength for both substrate materials. The testing indicated:

General Observations

- Samples of the coating material alone showed no weight gain when exposed to water over a 10-day period.
- None of the coated concrete or clay brick specimens, with and without holidays, showed any indication of blisters or cracking during the six-month holiday-chemical resistance tests.
- There were no observed changes in the dimensions of coated concrete or clay brick specimens at the holiday levels for either DI or acid exposures.
- All of the bonding tests (total of 64) resulted in either a substrate (Type-1) failure, (49 tests) or a bonding/substrate (Type-4) failure (15 tests).

Concrete Substrate

- Weight gain was < 0.45% for any of the coated concrete specimens without holidays.
- Weight gain was <0.75% for wet or dry specimens with holidays for acid exposure; no significant change with holiday size.
- Weight gain of about 3.0% for wet and dry specimens with holidays for water exposure.
- Average tensile bonding strength with dry-coated concrete was 202 psi, with individual specimens ranging from 78 to 266 psi; 10 of the 16 failures were in the concrete substrate (Type-1) failures, with the remaining six being a bonding/substrate (Type-4) failure.
- Average tensile bonding strength with wet-coated concrete was 206 psi, with individual specimens ranging from 89 to 279 psi; 10 of the 16 failures were concrete substrate (Type-1) failures, with the remaining six being bonding/substrate (Type-4) failures.

Clay Brick Substrate

- Weight gain was less than 1% for any of the coated clay brick specimens without holidays.
- Weight gain of about 2.5-4% for both dry-and wet-coated specimens with holidays for both water and acid exposures; no significant change for holiday size.
- Average tensile bonding strength for dry-coated clay brick was 247 psi, with individual specimens ranging from 172 to 310 psi; all 16 of the failures were substrate (Type-1) failures.
- Average tensile bonding strength with wet-coated clay brick was 257 psi, with individual specimens ranging from 170 to 345 psi; 13 of the 16 failures were substrate (Type-1) failures, with the remaining three being bonding/substrate (Type-4) failures.

Quality Assurance/Quality Control

NSF completed a technical systems audit prior to the start of testing to ensure that CIGMAT was equipped to comply with the test plan. NSF also completed a data quality audit of at least 10% of the test data to ensure that the reported data represented the data generated during testing.

Original signed by Sally Gutierrez	*October 6, 2010*
Sally Gutierrez	Date
Director	
National Risk Management Research Laboratory	
Office of Research and Development	
United States Environmental Protection Agency	

Original signed by Robert Ferguson	*October 23, 2010*
Robert Ferguson	Date
Vice President	
Water Systems	
NSF International	

Availability of Supporting Documents

Referenced Documents:

1) Annual Book of ASTM Standards (1995), Vol. 06.01, Paints-Tests for Formulated Products and Applied Coatings, ASTM, Philadelphia, PA.
2) CIGMAT Laboratory Methods for Evaluating Coating Materials, available from the University of Houston, Center for Innovative Grouting Materials and Technology, Houston, TX.

Copies of the *Test Plan for Verification of Standard Cement Materials Coatings for Wastewater Collection Systems* (August, 2008), the verification statement, and the verification report (NSF Report Number 10/36 WQPC-SWP) are available from:

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