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:	**Epoxytec CPP RC3**	
TEST LOCATION:	**University of Houston, CIGMAT**	
COMPANY:	**Epoxytec International Inc.**	
ADDRESS:	**P.O. Box 3656** **West Park, FL 33083**	**PHONE: 877-GO-EPOXY (463-7699)** **FAX: (954) 961-2395**
WEB SITE:	**http://www.epoxytec.com**	
EMAIL:	ETV@epoxytec.com	

The U.S. Environmental Protection Agency (EPA) created the Environmental Technology Verification (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 EPA, operates the Water Quality Protection Center (WQPC), one of six centers under the ETV Program. The WQPC recently evaluated the performance of the Epoxytec CPP™ concrete polymer paste for wastewater infrastructure protection and rehabilitation. The Epoxytec coating was tested at the University of Houston's Center for Innovative Grouting Materials and Technology (CIGMAT).

TECHNOLOGY DESCRIPTION

The following description of the Epoxytec CPP™ RC3 coating material (CPP) was provided by the vendor and does not represent verified information.

CPP is a two-component moisture sensitive, adhesive, chemical resistant, 100% solid strength epoxy paste that can be used as an adhesive, patching filler, or a protective high-build, stand-alone protective liner. CPP is designed to bond to concrete, steel, stone, wood, brick, and many other construction materials. The coating bonds vertically and overhead, and contains no solvents. Typical cure time for the coating is 12 hours.

VERIFICATION TESTING DESCRIPTION - METHODS AND PROCEDURES

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

Verification testing was conducted using relevant American Society for Testing and Materials (ASTM) and CIGMAT methods (ASTM[(1)] G20-88; C321-94; D4541-85 and CIGMAT[(2)] CT-1; CT-2; CT-3 respectively). 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. Epoxytec 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

CPP coated concrete cylinders and clay bricks were tested with and without holidays (small holes intentionally drilled through the coating) 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 were 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 in the coating 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)				3% 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.

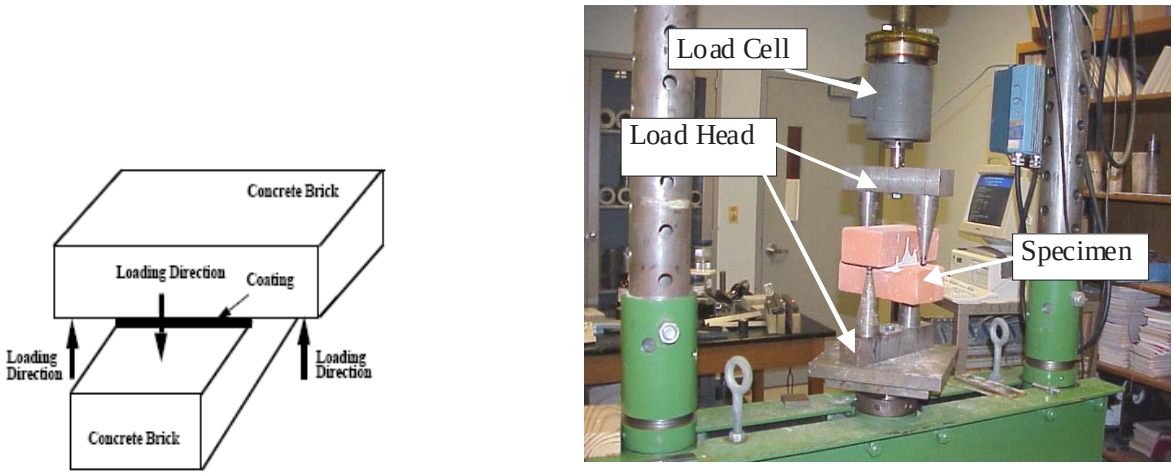
A specimen made only of CPP was submerged in water for 10 days, showing no weight change over the period. Likewise, over an exposure time of 180 days, weight changes in specimens with no holidays showed less than 0.25% gain in DI exposure and less than 0.45% in acid solution exposure. Without holidays, coated concrete specimens showed, 0.45% weight gain, while dry-coated clay bricks showed increases of 8-10% and wet-coated clay bricks showed 1.5-2.5% gains. Changes in the appearance of the specimens at the holiday levels were negligible after 180 days of exposure.

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

Bonding strength tests were performed to determine the bonding strength between the CPP coating and concrete/clay brick specimens over a period of six months. Eight sandwich (4 dry-condition, 4 wet-condition) and 16 pull-off (8 dry-condition, 8 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. CPP 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 CPP.



(a) Test specimen configuration **(b) Load frame test setup**

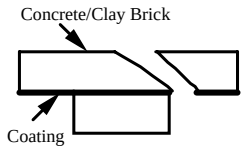
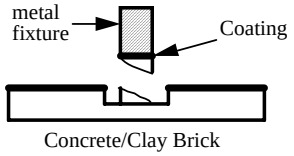
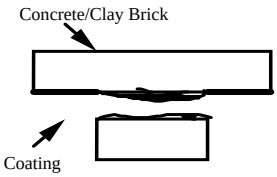
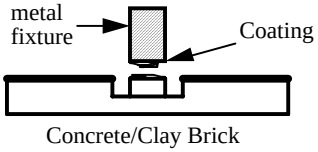
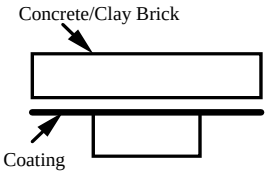
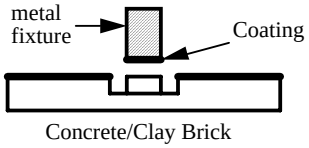
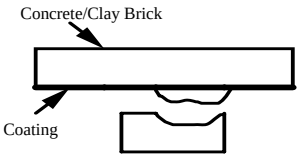
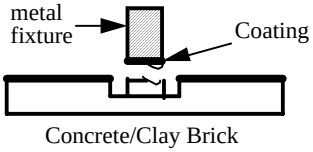
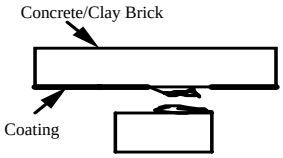
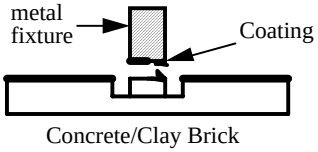
Figure 1. Bonding test arrangement for sandwich test.

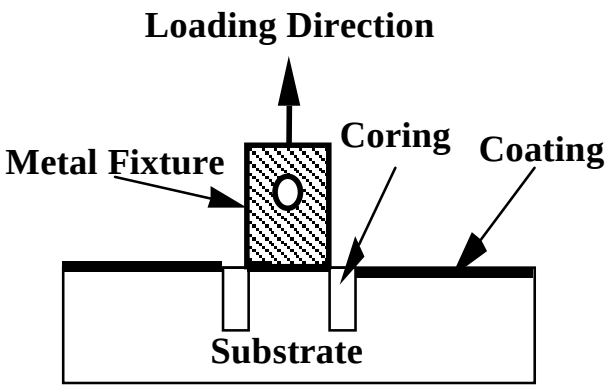
Dry-coated specimens were dried at room temperature conditions for at least seven days before they were coated, while wet-coated specimens were immersed in water for at least seven days before they were coated. Specimens were brush-cleaned before coating application. Bonded specimens were cured under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

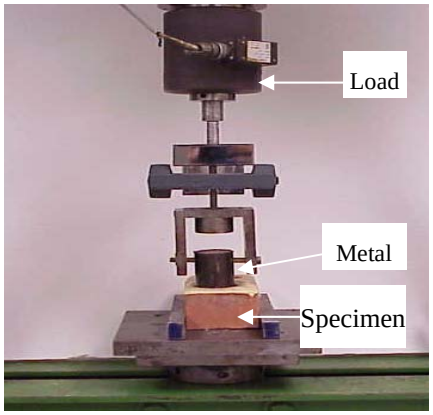
Pull-Off Method (CIGMAT CT 2)

CIGMAT CT 2, a modification of ASTM D4541-85 was used for the testing. A 2-in. diameter circle was cut into coated concrete 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 CPP. 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	3			1		218 – 280	255
	Pull-off	8					153 – 235	190
Concrete – Wet	Sandwich					4	164 – 235	204
	Pull-off			8			92 – 236	142
Clay Brick – Dry	Sandwich	2				2	231 – 364	286
	Pull-off	8					190 – 284	251
Clay Brick – Wet	Sandwich	2				2	267 – 318	295
	Pull-off	6			2		184 – 342	282

[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 Epoxytec, Inc. CPP Epoxy Coating for use in wastewater collection systems was evaluated for chemical resistance and the bond strength of the coating with both wet and dry substrate materials, made 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 coating material 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.
- Two-thirds of all bonding tests (32 of 48) resulted in substrate (Type-1) and bonding/substrate (Type-4) failures.
- One-third of all bonding tests (16 of 48) resulted in bonding (Type-3) or bonding/coating (Type-5) failures.

Concrete Brick Substrate

- Weight gain was < 0.30% for any of the coated concrete specimens without holidays.
- Weight gain was <0.45% for wet or dry specimens with holidays for both water and acid exposures; no significant change with holiday size.
- Dry-coated concrete failures were mostly (11 of 12) concrete substrate (Type-1) failures, with one being a bonding and substrate (Type-4) failure.
- Average tensile bonding strength for dry-coated specimens was 212 psi, ranging from 153 to 280 psi.
- Wet-coated concrete failures were bonding and bonding/coating failures; eight of the 12 failures were bonding (Type-3) failures, with the remainder being bonding and coating (Type-5) failures.
- Average tensile bonding strength for wet-coated specimens was 163 psi, ranging from 92 to 236 psi.

Clay Brick Substrate

- Weight gain was < 0.45% for any of the coated clay brick specimens without holidays.
- Weight gain of 8-10% for dry-coated specimens with holidays for both water and acid exposures; 1.5-2.5% weight gain for wet-coated specimens with holidays for both water and acid exposures; no significant change for holiday size.
- Dry-coated clay brick failures were mostly (10 of 12) clay brick substrate (Type-1) failures, with two being a bonding and coating (Type-5) failures.
- Average tensile bonding strength for dry coated specimens was 262 psi, ranging from 190 to 309 psi.
- Wet-coated clay brick failures were predominantly (eight of 12) clay brick substrate (Type-1) failures, with two others being bonding and substrate (Type-4) and the remaining two being bonding and coating (Type-5) failures.
- Average tensile bonding strength with wet-coated specimens was 286 psi, ranging from 184 to 342 psi.

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*	*Original signed by Robert Ferguson*	*October 28, 2010*
Sally Gutierrez	Date	Robert Ferguson	Date
Director		Vice President	
National Risk Management Research Laboratory		Water Systems	
Office of Research and Development		NSF International	
United States Environmental Protection Agency			

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 Epoxytec International Epoxytec CPP Coating for Wastewater Collection Systems* (March 2009), the verification statement, and the verification report (NSF Report Number 10/34/WQPC-SWP) are available from:

ETV Water Quality Protection Center Program Manager (hard copy)
NSF International
P.O. Box 130140
Ann Arbor, Michigan 48113-0140

NSF website: http://www.nsf.org/etv (electronic copy)
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