THE SEAL/NO SEAL GROUP
Research of Test Methods to Evaluate Joint Preparation for Sealing

West Coxsackie, NY

Final Report
July 1, 2013
WJE No. 2011.0050

Prepared for:
Mr. Scott Eilken
The Seal/No Seal Group
12573 Route 9W
West Coxsackie, NY 12192

Prepared by:
Wiss, Janney, Elstner Associates, Inc.
330 Pfingsten Road
Northbrook, Illinois 60062
847.272.7400 tel | 847.291.9599 fax

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Matt Gries
Project Engineer

Paul D. Krauss, PE
Project Manager

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Wiss, Janney, Elstner Associates, Inc. (WJE) has completed research to develop practical field tests procedures that can measure and indicate when a sawcut joint is clean and dry enough to accept sealant. Our effort included three tasks:

Task 1: Literature Review and Testing Scope Development
Task 2: Evaluation of Test Methods
Task 3: Compile Data and Report of Findings

Reproducibility and ease of use are primary elements necessary for any practical test. To promote acceptance, the test must be simple, quick, and not costly to perform. Upon development of the practical tests, WJE was requested to establish a rational basis for test sampling rates based on statistical tools and the quantitative data from laboratory data. This report provides the findings of the research and also includes draft test methods for consideration or further development.

Literature Review

Relevant publications were reviewed that discuss test methods and technologies that are potentially useful for detecting and measuring moisture and contamination of concrete surfaces. The publications, listed in Appendix A, included ASTM standards, SSPC standards, and technical journal articles. Most of the literature, research efforts, and technologies related to the evaluation of concrete moisture and cleanliness are tailored to the flooring and coating industry, thus the methods are typically carried out on large, flat surfaces. One of the challenges in adopting current strategies of detecting moisture and determining cleanliness of concrete surfaces to concrete joints is the limited access to the vertical surface of the joint. A summary of the most relevant findings of our literature review follows.

Surface Moisture Conditions

Six test methods are typically referenced in the literature for determining moisture levels in concrete slabs. Their applicability to assessing moisture content within joints varies.

1. *Plastic sheet test* - ASTM D4263 "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method" provides a qualitative go/no-go test based on trapping visible moisture in a plastic sheet. This test requires a large surface area and is performed over a minimum of 16 hours, thus it is not considered practical for our study.

2. *Calcium chloride absorption (Moisture vapor transmission) rate test* - ASTM F1869 "Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride" involves measuring the amount of moisture over a set covered area absorbed by a known quantity of calcium chloride. This test requires 72 hour test duration, thus is not considered practical for our study.

3. *Carbide test* - The carbide test is used more frequently in Europe than in the United States and is similar to the soils moisture test in ASTM D4944 "Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester". This modified test involves taking a small chipped sample of concrete and crushing it with a hammer. Placing a known mass of the concrete powder in a sealed vessel with an excess of calcium carbide. Shaking the vessel causes a reaction between the moisture in the sample and the calcium carbide that results in a measurable pressure from released acetylene gas. This test causes minor destruction of the joint and sampling the critical surface within the joint is difficult, making this test likely not practical for application to joints.

4. *Relative humidity test* - This test uses a relative humidity (RH) probe in a sealed hole in the concrete. Over time, the RH of the air within the hole will equilibrate to that of the surrounding concrete and can be measured. ASTM F2170 "Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes" provides a standard for performing this test on concrete slabs. The Society for Protective Coatings and NACE International publication SSPC-SP 13/NACE No. 6 "Joint Surface Preparation Standard" provides suggested acceptance criteria for this test. WJE has often used this test or a modification of the test to evaluate moisture in concrete structures and pavements. Adapting this strategy to joints may be straightforward if a modified version of the standard RH probe is placed within a sealed section of the joint. This method was explored in our preliminary lab investigation and is discussed below.

5. *Resistivity probe* - This method measures the resistance of a low-voltage current between two to four conductive probes placed in soils or on the surface of concrete. Results provide a quantitative reading of electrical resistance that can be correlated to moisture content; however, results can be affected by differences in conductivity based on cement-to-aggregate ratios as well as variable resistance of different aggregate types. Therefore, while it may be able to differentiate between wet and dry concrete, it may be difficult to develop a universally acceptable resistance value for all concretes. This method was explored in our preliminary lab investigation and is discussed below.

6. *Radio wave meter* - Radio wave moisture meters measure an induced radio frequency field in the concrete to quantitatively determine moisture content. Unlike the resistivity probe, the device does not require a probe, but rather has a flat transmitter and receiver. There are no devices currently that can measure surfaces within a sawcut directly. The level of accuracy with placing the device adjacent to the joint on the top surface of the slab is not expected to be adequate to differentiate joint surface conditions. Radio wave frequency is affected by the dielectric properties of the concrete, which is affected by moisture content as well as concrete properties such as aggregate type and age of concrete. It is suspected that differences in dielectric constant due to properties of the concrete materials and age would make calibration difficult and negatively affect the accuracy of evaluating moisture content to the point that the test would not be able to be compared to an absolute threshold for acceptance. A typical meter can be found at http://www.ndtjames.com/Aquameter-p/t-m-170.htm. This test method was not explored in our lab investigation, as current meters would need to be significantly modified to work accurately within joints.

In addition to the commonly referenced methods above, moisture sensitive paper and pH paper were researched as potentially useful test methods. When wet, moisture sensitive paper changes color. pH-detecting paper was also tested. Water leeching from the surface of the concrete at the joint surface has a pH similar to that of concrete, usually greater than 10. A reading on the pH-paper in this range indicates that water moisture from the concrete is present at the joint surface. These methods were explored in our preliminary lab investigation discussed below.

Cleanliness

Literature regarding assessment of concrete surface cleanliness is less specific than moisture testing. Typical suggested methods include wiping the surface with a dark cloth or rubbing tape against the prepared surface to pick up dust or dirt. ASTM D5295 specifically mentions the use of a "variably aggressive material such as mystic tape". It is not clear what is intended by the term "mystic tape", but other literature specifically mentions the use of translucent adhesive tape. The use of dark cloth and various types of tapes were explored in our preliminary lab investigation and are discussed below.

Additionally, literature indicates that oils or chemicals on the concrete can be detected by using ultraviolet light in accordance with ASTM E1135. This would require building a special inspection box to observe joint conditions outdoors. This test method was not evaluated as it is expected that oils are not likely prevalent within prepared joints and locations of spilled oils or chemicals would be identified through visual inspection of the pavement surface or the other developed test methods.

Laboratory Evaluation of Test Methods

Our laboratory investigation was intended to provide insight into the potential usefulness of several test methods. In our labs, we sawcut multiple concrete samples to simulate joints, shown in Figure 1. Some joints were thoroughly rinsed during cutting then cleaned through shotblasting and dried with compressed air, as shown in Figure 2, while others were left unrinsed and uncleaned. Several tests were then conducted to get a sense of the sensitivity of test results to the widely different joint conditions.

Figure 1. Typical sawcut joints used during laboratory testing.

Figure 2. Sawcut joint being cleaned and dried with compressed air.

Relative Humidity Meter (Moisture)

A relative humidity probe was modified to fit into the sawcut joint, shown in Figure 3. An area of the joint was sealed by placing foam rod in the joint and a plastic dish at the top, shown in Figure 4. Testing was performed on both wet and dry joints and after equilibrating, the results were distinctly different between the two test conditions although not by a large margin, as shown in Table 1.

Figure 3. Relative humidity probe modified to fit into sawcut joint.

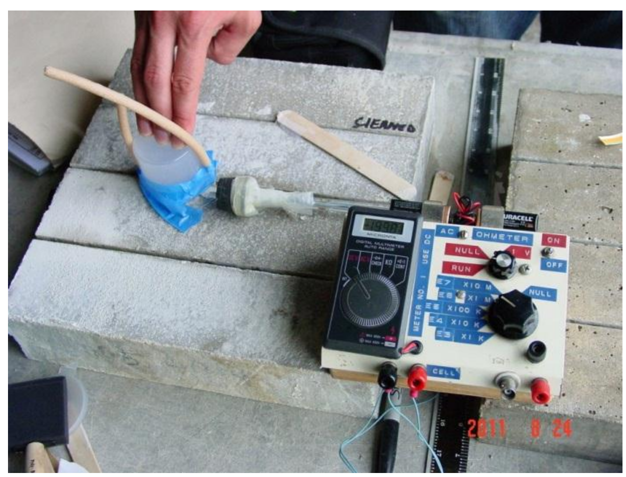

Figure 4. Relative humidity probe test.

Table 1. Relative humidity probe test results

Time (minutes)	Wet Joint Sensor Impedance (x^6 ohms)	Dry Joint Sensor Impedance (x^6 ohms)	Wet Joint Approximate* Relative Humidity (%)	Dry Joint Approximate* Relative Humidity (%)
Start	23.0	32.5	32	29
2	17.0	34.9	33	28
4	14.7	26.8	35	30
6	12.8	23.9	36	32
8	11.3	20.5	37	33
10	10.8	20.3	38	33

* rough approximation - gage not calibrated to actual RH

With further testing, it may be possible to correlate results with a minimum threshold value with moderately short test periods. The equilibration time of over 10 minutes for each test is one downside to this procedure. There may be ways to shorten this time, however, we suspect that at least 5 minutes or more will be required to allow enough time for the air humidity to reasonably represent the concrete joint conditions. Additionally, the difference in probe impedance and approximate relative humidity between the saturated (wet) joint and dry joint was generally small. Delineations between damp joints and dry joints would be even smaller. While the results using RH measurement were promising; due to the need for equilibration time and concern over precision of the RH results, this test method was not developed further within this study.

Resistivity Probe (Moisture)

An AC resistivity probe (Wenner soil box in 4 pin mode) was used to measure the electrical resistance of the concrete within the joint as a means to differentiate between wet and dry joints. Threaded rods were sharpened and sized to fit snugly within the joint. The test setup is shown in Figure 5. The results can be easily and rapidly obtained by inserting the 4 pin probe into the joint. The correlation between initial test results and joint moisture were as expected, with dry joints measuring about 800 ohm and wet joints about 200 ohm. However, the overall scale or difference of these resistivity results is actually quite small when considering the large difference between the moisture contents of the two slabs tested. Further, repeated testing of a single joint condition showed variability of 100 to 200 ohms or more. Therefore, this test's sensitivity might not be appropriate for field application. Additionally, different concrete mixes provide different resistance based on aggregate type and water to cement ratios, which makes developing

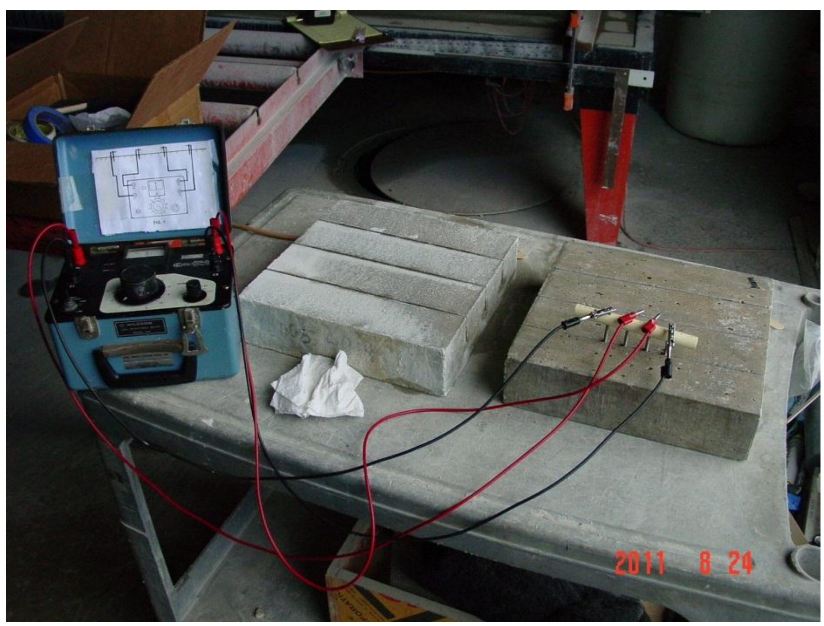

Figure 5. AC resistance test.

a universal test method and threshold criteria difficult. As such, resistivity probe testing is a promising technique but it was not developed further within this study.

Moisture / pH Sensitive Paper (Moisture)

Moisture sensing paper appeared promising as a qualitative go/no-go test for determining the presence of free moisture in the joint. Figure 6 and Figure 7 shows testing with one type of moisture sensing paper. The specific paper used in preliminary testing is reusable and returns to its initial color after air drying, which may not be desirable because test results cannot be accurately retained for record keeping. Other test papers which permanently change color may be preferable. Based on testing different moisture conditions within the joints, it is clear that the moisture paper will only identify free water on the surface of the concrete and does not provide information regarding damp concrete where high moisture content is present within the concrete but free water is not present on the surface. A standardized test method for using moisture sensitive paper was developed and tested in the field. Field staff reported that it only measured water that was already visible within the joint by careful observation.

Figure 6. Moisture sensitive paper test. Purple indicates the detection of moisture.

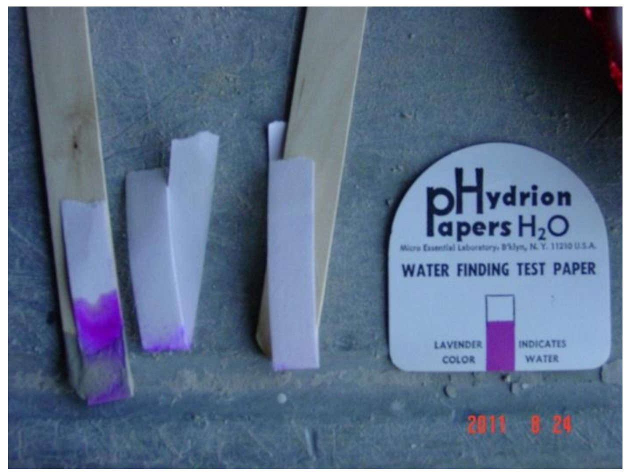

Figure 7. Moisture sensitive paper test results.

pH paper was also tested, as shown in Figure 8. Preliminary testing showed that this test also appears to work as a qualitative go/no-go test for detection of free moisture, but does not appear to offer an additional benefit to the moisture sensing paper.

Figure 8. pH sensitive paper test result.

Wipe Test (Cleanliness)

A dark cloth was used to wipe the surface of the joint to determine the presence of contaminants. The delineation between clean and unclean joints, shown in Figure 9 and Figure 10, indicated that this test is effective at detecting concrete powder and debris on the surface of the joints. One potential downside to this test is that handling of the cloth can significantly affect results. The cloth may pick up contaminants through inadvertent contact with the top surface of the slab or contaminants picked up during the test might be inadvertently removed by rough handling of the cloth. Regardless, this test is very rapid and simple to use and provides useful information. A test method was developed for identifying contaminants by visually assessing cloth wipe test results.

Figure 9. Dark cloth wipe test on cleaned joint.

Figure 10. Dark cloth wipe test on uncleaned joint.

Tape Contamination Test (Cleanliness)

Various types of tapes were used in an attempt to identify contaminants in joints. The different tapes used in preliminary testing, shown in Figure 11, included white plastic tape (3M), white masking tape, clear scotch tape, blue painter's tape, and black electrical tape (3M Super 33+). Test results were promising, as shown in Figure 12. Contaminants observed in the lab were typically the slurry and powder from saw cutting. The blue and black tapes appeared most effective at showing these lighter colored contaminants and were sensitive enough to show minor contaminants in the clean joints, as shown in Figure 13 and Figure 14. A test method was developed for identifying contaminants by visually assessing tape test results using black electrical tape.

Figure 11. Tapes used for preliminary laboratory contamination testing.

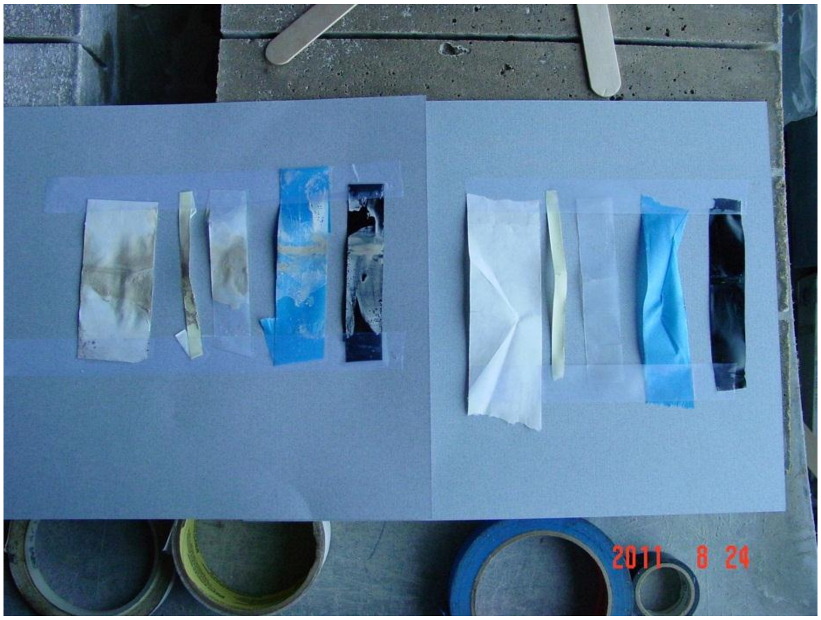

Figure 12. Tape test results for uncleaned (left) and cleaned (right) joints.

Figure 13. Electrical tape test result on cleaned joint.

Figure 14. Blue painters tape test result on cleaned joint.

Tape Pull Off Test (Cleanliness & Moisture)

During the laboratory investigation of the tape contamination test, it was found that the tape pulled off at different strengths depending on the level of cleanliness and moisture condition of the joint. Pull off strength tests were performed in the laboratory by modifying the tape contamination test by using a scale to capture the peak load when pulling the tape from the joint after burnishing. The scale was attached to a wood tongue depressor inserted into the joint through a pair of vise grips, as shown in Figure 15. The test was repeated for joint depths of 1 to 4 inches and with different preparation conditions. Joint preparations included none; powerwashed and airblown; and powerwashed, sandblasted, and airblown. The uncleaned samples and fully prepared samples were evaluated at two different moisture levels, dry and damp. The damp moisture level represents a saturated-surface-dry condition which is not detectable by the moisture sensitive paper. 3M Super33+ electrical tape was initially selected as the tape for trial laboratory testing due to its being readily available across the country as well as its black color; being useful for the visual tape contamination test. However, this tape was discovered to be undesirably ductile in tension and we also found it to have poor adhesion characteristics at elevated temperatures up to 110°F. An alternative tape was selected for testing, Cross Hatch Tape by SEMicro (http://www.semicro.org/testtape.aspx). This tape is used in ASTM D3359 "Standard Test Methods for Measuring Adhesion by Tape Test" and is certified by the manufacturer for consistency, helping to assure reproducible adhesive properties. The tape demonstrated a stiff response in tension and did not show a change in pull-off strength when adhered to surfaces with temperature ranging between 40°F and 110°F.

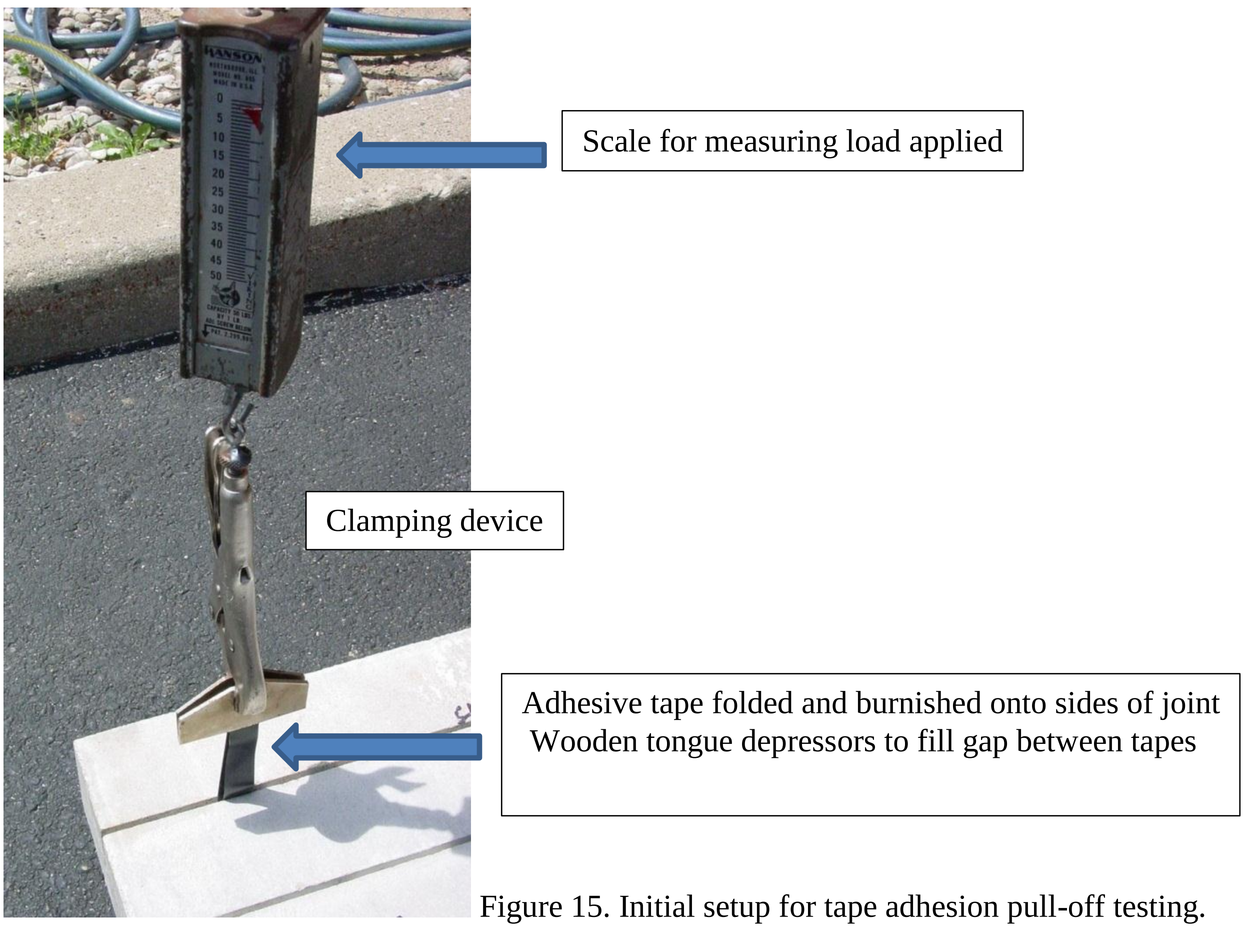

Figure 15. Initial setup for tape adhesion pull-off testing.

The results of lab testing are presented in Figure 16 as the peak force measured by the scale and in Figure 17 as the peak force over the area of the tape adhered to one side of the joint. The results in Figure 17 are presented as the force over the area of one-side of the adhered tape due to the observation that the peak load does not occur at a simultaneous pull-off of the tape from both sides of the joint, but rather occurs when the adhesion of the tape on one side of the joint fails before the second side fails. The results demonstrate an increase in pull-off strength with increased level of cleanliness as well as a clear delineation between dry and damp joints when the joint is clean. The pull force varies with test depth (area of bonding surface), although results become less correlated when the test is performed at a depth beyond 3 inches. At 1 inch depth, the pull-off force for poorly cleaned or damp joints was 10 lbs. or less while the clean and dry joints was 40 lbs. or greater. At 2 inch depth, the pull-off force for poorly cleaned or damp joints was about 35 lbs. or less while the clean and dry joints was about 70 lbs. or greater. When normalized to one-side area of the adhered tape, it appears that the delineation between poorly cleaned or damp joints and clean, dry joints occurs at 20 psi for depths up to 3 inches, as shown in Figure 17.

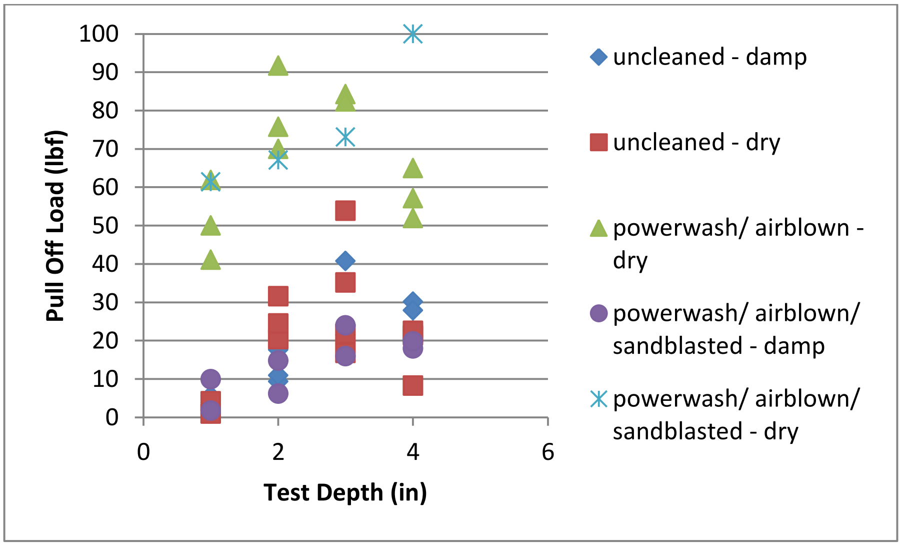

Figure 16. Tape pull off test results from laboratory testing using double-sided test method.

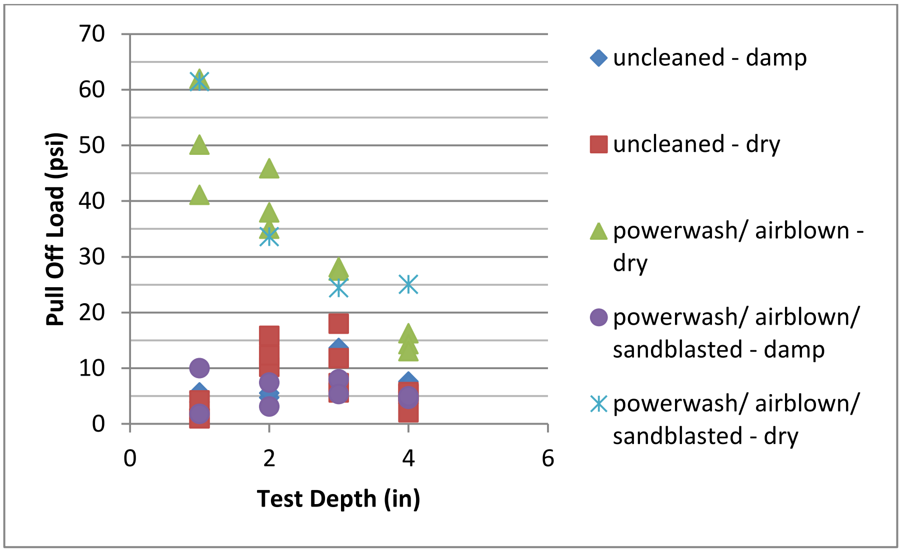

Figure 17. Tape pull off test results in psi (load/one-sided area) from laboratory testing using double-sided test method with test depth.

It is recommended that the test be performed in excess of the required installation bonding depth as established by the sealant manufacturer, by say approximately 1/2 deeper than the bond depth; but not less than 1 inch or more than 3 inches. A default test depth of 1 inch is currently recommended. Also, as an alternative to performing the tape pull test by adhering the tape to both vertical surfaces of the joints, performing the test on one side of the vertical surface also exhibited similar test results for the clean and dry joints as shown in Figure 18 and Figure 19. When performing the single-side pull test method, doubling the thickness of the tape by adhering one piece of tape to the back of another piece of tape prior to testing proved effective at avoiding breaking the tape during the test. Based on the promising data from laboratory testing, a standard test method was developed for pull off strength testing.

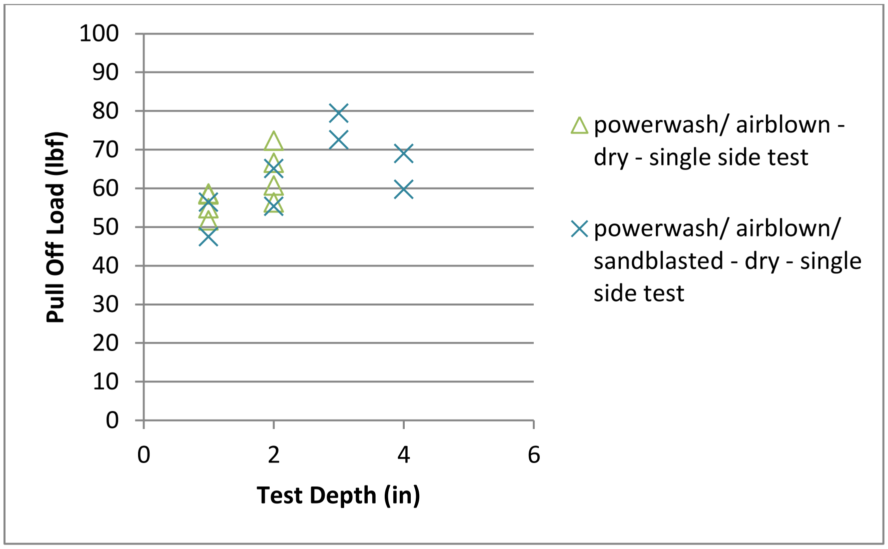

Figure 18. Tape pull off test results from laboratory testing using single-side test method for properly cleaned and dry joints.

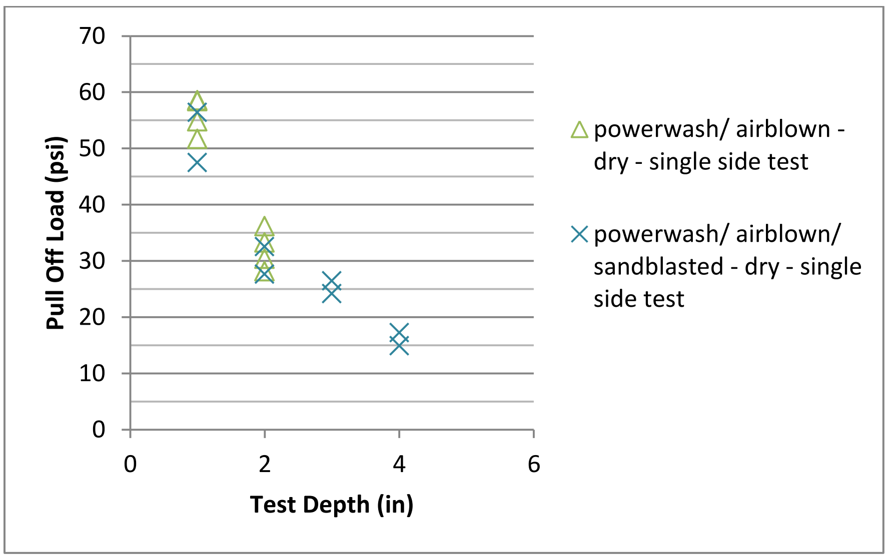

Figure 19. Tape pull off test results in psi from laboratory testing using single-side test method for properly cleaned and dry joints with test depth.

Development and Field Evaluation of Draft Test Methods

Four primary test methods were developed based on the preliminary laboratory study:

- Moisture Paper Test (Moisture)
- Wipe Test (Cleanliness)
- Tape Contamination Test (Cleanliness)
- Tape Pull Test (Cleanliness and Moisture)

The developed draft test methods, provided in Appendix B, include explicit written instructions, pictorial depiction of the test process, and visual standards for scoring the test. In addition to the draft test methods, a form was created for recording test data, also provided in Appendix B.

To better evaluate the test methods a test kit was created (Figure 20) and the draft test methods were evaluated on field jobs by Quality Saw and Seal staff. The field testing demonstrated consistent results, with some of the testing shown in Figure 21 and Figure 22. The field staff provided valuable feedback regarding the speed and ease of testing which was useful for determining test practicality and acceptance thresholds.

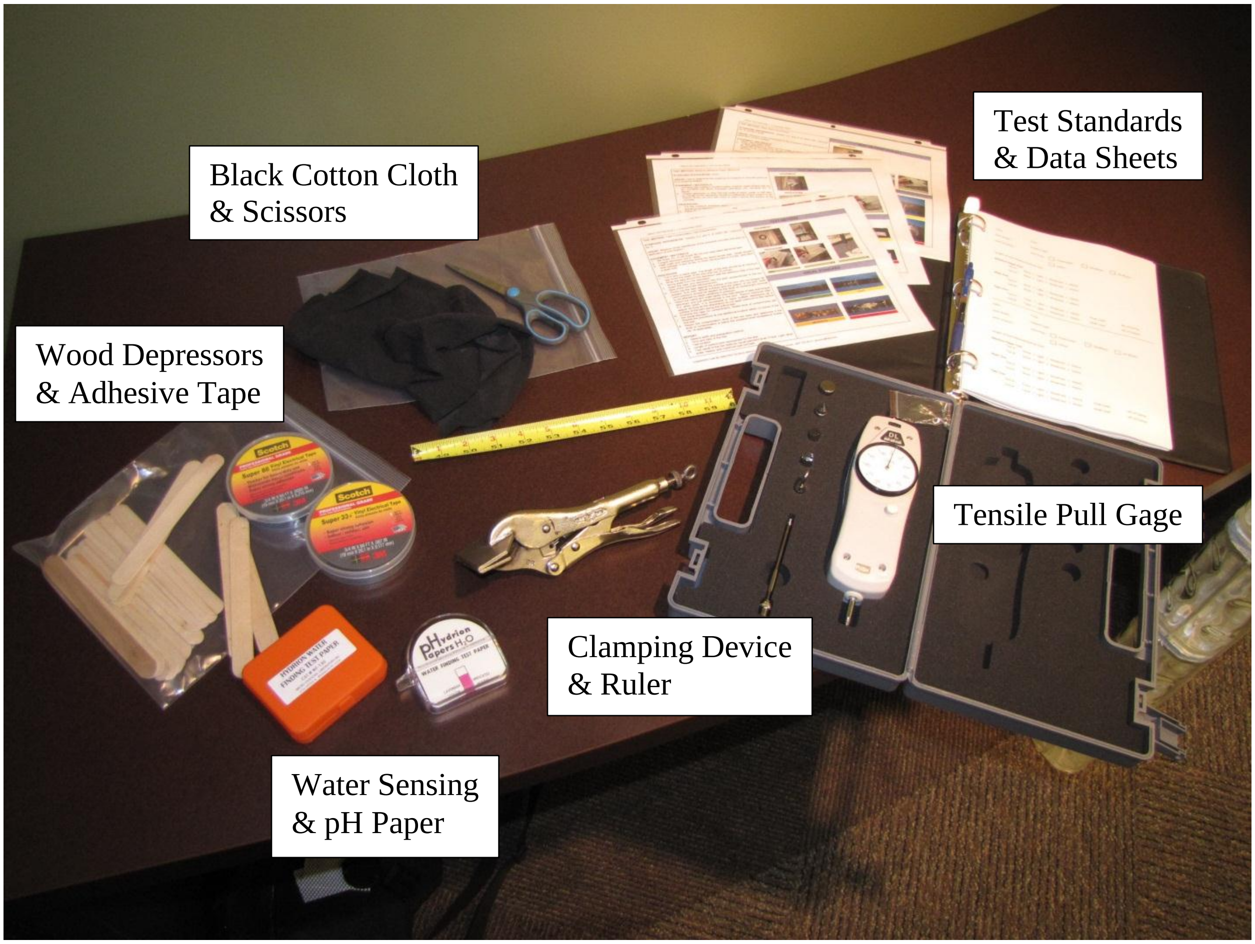

Figure 20. Test kit created for field evaluation of draft test methods. Pull gage has automatic peak hold feature.

Figure 21. Wipe test results from field testing. Top to bottom: Not cleaned; powerwashed; and powerwashed and sandblasted.

Figure 22. Tape test results from field testing showing cleaned (top) and uncleaned (bottom) joint test results.

Discussion of Testing Frequency

Statistical Basis for Sample Size

In order to determine appropriate rates for testing in the field, WJE leveraged statistical tools and the quantitative data from laboratory pull tests to establish a rational basis for test sampling rates. Because the goal of the testing is to determine whether a joint is clean and dry enough to receive sealant, the pull test data for properly cleaned and dried joints is of statistical interest. Specifically, because the experimental stress threshold between acceptable and unacceptable pull tests is determined to be approximately 25 psi, the testing frequency should sample the joint often enough to be confident that the mean pull test value for the whole population is suitably above this threshold (e.g. 1 or 2 standard deviations).

Only the data from 1 and 2 inch tape test depths were used to establish the sample population because these results showed a clear differentiation in pull test stress from properly prepared joints to uncleaned or damp specimens and are the basis for the suggested field test procedures. WJE calculated the mean pull test stress and standard deviation of this target laboratory population (consisting of 20 tests). The acceptable joints had a mean pull test stress of 44 psi, with a standard deviation of 12 psi. The cleaned and dried samples in the laboratory study were developed to accurately replicate performance of properly prepared joints in the field. It is not unreasonable to assume the laboratory mean and standard deviation values as first-order statistical estimates of what acceptable conditions should be in the field.

Once this assumption is made, statistical analysis using a t-distribution can be used to determine an appropriate test sample size for a population in the field that has an unknown variance. Specifically, WJE used a t-distribution to examine what amount of testing is required to produce a given level of confidence that the mean of the field population is above a certain value (a lower one-sided confidence interval on the mean). The sample size (n) needed to produce this confidence level is calculated by the following equation:

$$n = \left(\frac{t_\alpha}{H/_S}\right)^2$$

where α is a parameter that corresponds to the amount of confidence desired in the result (e.g. for 90% confidence, $\alpha = 0.1$; for 95% confidence, $\alpha = 0.05$). As seen in Figure 23, which illustrates a generic t-distribution, t_α is the limiting value that cuts off the "tail" of the distribution such that the probability that the value of the variable being considered will be above t_α is equal to α. S is the standard deviation of the sample (estimated for our application with the laboratory data). H is the half-width of the confidence interval; a wider interval will require fewer tests for a certain level of confidence, but will correspondingly assume more possible deviation in population mean from the estimate. In this case of a one-sided confidence interval where the interest is in identifying lower bound of the mean, H represents the amount that the mean pull test stress for the whole population could be below the mean computed from the sample data. Though not strictly accurate because the mean and variance of the laboratory data may not fully represent field conditions, this methodology yields an estimate of the confidence a given rate of testing produces on the average pull test result for properly prepared joints in the field.

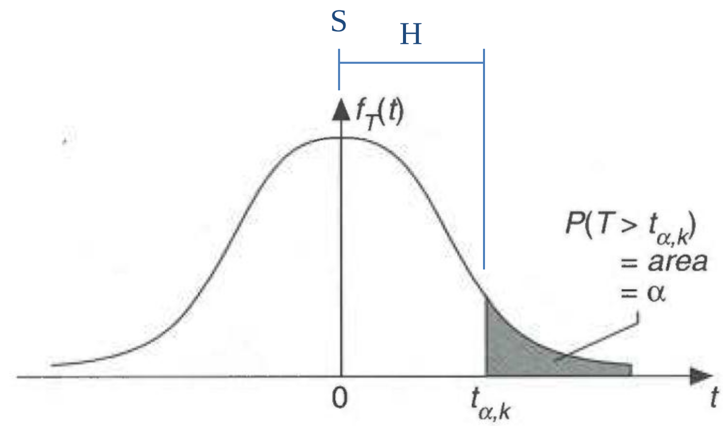

Figure 23. Generic t-distribution showing relevant variables for determining sample size and confidence level on a population mean.

Recommended Testing Frequency

Based on the statistical analysis and production rates of crews and field conditions, WJE formulated practical recommendations for testing frequency to yield a statistically meaningful assessment of joint suitability in the field. While the population of joints being represented by the test sample could be defined a number of different ways, WJE suggests that joints prepared by the same crew and cleaning equipment on the same day may be reasonably expected to perform similarly, unless significant variations in site conditions or weather are encountered (e.g. rain, steep pavement grades). Based on the assumed daily production output of a work crew, the population of joint to be sampled in the field is roughly 20,000 linear feet (per crew, per day); the recommended frequency of testing should establish the adequacy of this population.

Using the t-distribution statistical model described above, a sample set of 8 tests would yield a 90% confidence level that the mean pull-test value of the entire population would be above 38 psi. This value of the mean, considered with the variance observed in our laboratory pull-testing, indicates that the vast majority of the joint population being sampled (roughly 85%) should be statistically expected to have a pull-test strength in excess of the target threshold of 25 psi, indicating proper joint preparation. Given the level of precision of the test methodology, the purpose of the tests (demonstrating effectiveness of the preparation techniques and readiness of the joints to accept sealant), and the consequences associated with inadequately prepared sections of a joint not being captured by the testing (potential sealant failure), it is our view that a 90% level of confidence in the results is both meaningful and practicable for use in the field. Of course, the actual mean and variance of joint performance for a given work crew, project, and daily conditions may be well above what is statistically demonstrated by the testing, but this framework provides a rational basis for determining sample size.

With 8 tests appropriately defining a joint population of 20,000 linear feet (provided similar conditions exist), WJE asserts that smaller populations might be similarly represented by the same rate of testing. In other words, projects smaller than 20,000 linear feet may be reasonably sampled at a rate of 1 set of tests per 2,500 feet of joint. Table 1 summarizes our recommended rates of testing; a minimum of 2 test sets is recommended to ensure a minimum level of consistency even on very small projects. Tests should be distributed evenly over the length of the job with tests every 2,500 feet or less. Tests should be performed at the beginning of work as soon as practical after joints preparations are complete to assess the effectiveness of the joint preparation. Tests should also be performed immediately before sealing if delays between joint preparation and sealing occur. Joints should be dried and retested after any rain event or if left unsealed overnight.

Also, a significant change in conditions (e.g. weather, crew member, equipment, bird baths in pavements, etc.) should always be regarded as a change to a new joint population for testing purposes, even if the joints being sampled are part of the same project. This will ensure an appropriate amount of testing is performed to demonstrate continued suitability of joint preparation as conditions change in the field.

Table 1. Recommended Sampling Rates per Production Day

Population Size	Sets of Tests
< 5,000 feet	2
5,000 to 7,500 feet	3
7,500 to 10,000 feet	4
10,000 to 12,500 feet	5
12,500 to 15,000 feet	6
15,000 to 17,500 feet	7
17,500 feet to 20,000 feet	8

In the event of a failed pull test (the average value of the pulls is less than 25 psi); WJE suggests that re-testing of that section of joint be permitted. To re-test, 2 pull-test sequences (3 pulls each) should be performed within 12 inches to either side of the failed test area; if both sets pass, the initial result is overturned and the location may be accepted. If one or both re-tests also fail to average 25 psi or above, the test location shall not be accepted.

Wherever a failed tape pull test occurs, re-preparation of the joint is required. The entire area of joint between adjacent passing tests should be re-cleaned, unless additional testing is performed on each side of the failed test area to establish a smaller re-cleaning zone (i.e. the limits of the neighboring appropriately prepared regions of joint).

Conclusions and Future Course of Action

The intent of this test program was to develop reliable and practical test methods for assessing the cleanliness and moisture conditions in sawcut concrete joints to determine their preparedness for accepting sealants. The program did not seek to establish thresholds or tolerances for acceptance for any particular type of sealant, but to rather focus on delineation of wet verse dry and unclean verse clean conditions within the joint. Four test methods were developed as a result of the test program: Moisture Paper Test, Wipe Test, Tape Contamination Test, and the Tape Pull Test. Conclusions with regards to each test are as follows:

Moisture Paper Test - Serves as a go/no-go test for determining if the joint has free moisture but does not differentiate differences in surface-dry conditions. It may be adequate for sealants that are generally insensitive to moisture but many not be adequate for sealants sensitive to damp surfaces. This test does not evaluate cleanliness and field staff reported that it only indicated moisture when liquid water could be visually seen by careful inspection of the joint. Therefore, this test may be useful to confirm the presence of liquid water within the joint but may not be useful for determining dampness and if the joint conditions are suitable for sealant installation. We do not recommend making this test a “standard” but suggest that it be made available as a means for use by field staff or inspectors to verify the presence of liquid water within joints.

Wipe Test - Serves as a quick and effective means of capturing concrete dust, slurry, and contaminants in the joint. Requires that the cloth be clean prior to testing and handled carefully during and after testing to avoid altering results. This test is the simplest and quickest means to evaluate joint cleanliness.

Tape Contamination Test - Using black electrical tape, serves as a visual assessment for cleanliness, similar to the wipe test. While this is a useful means to assess joint cleanliness, the same information can be gained by careful application of the cloth Wipe Test.

Tape Pull Test - This test is the most comprehensive method found to assess joint preparation for sealants. It quantifiably records the peak load for pull off of burnished tape to assess both joint cleanliness and moisture conditions. Testing is straightforward and can be performed rapidly. Accurate peak load necessitates that the correct spacers (depressors) be used; enough spacers should be used so that the tape is held in the same plane as the vertical joint surface while the spacers are still free to move in the joint without applying axial force to the side walls. The pull force divided by one-side area, for a test depth between 1 and 2 inches, allows for determination of a threshold pressure between acceptable and unacceptable joint conditions of about 20 to 25 psi. The Tape Pull Test provides the best means to assess and compare both cleanliness and moisture within the joint in a single test.

Each proposed test method is capable of capturing adverse conditions for joint sealants, but may in rare instances give false test results indicating favorable conditions. Therefore, multiple tests should be performed at intervals along the prepared joint to properly assess joint preparedness. At a minimum, two adjacent tests per location are suggested for the Wipe Test and Tape Contamination Test. It is suggested that three tests should be performed and averaged for the Tape Pull Test per test location. Statistical tools and the quantitative data from laboratory pull tests were used to establish a rational basis for test sampling rates. A minimum of 8 tests for single-crew, daily production rates of 20,000 linear feet provide reasonable testing confidence (about 90%) provided similar conditions exist.

These test methods provide a means to more accurately assess the conditions of the joint than current conventional means of visual assessment. Implementation of the cloth Wipe Test and Tape Pull Test should provide useful information on the joint condition in preparation for sealant. It may be useful to establish acceptance threshold values and tolerances for these tests considering the different types of sealants used in practice. This could be done within a laboratory study by testing the various adhesion properties of the commonly used joint sealants within varying joint conditions.

APPENDIX A: LITERATURE REVIEW BIBLIOGRAPHY

Literature Review

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APPENDIX B: TEST METHODS

TEST METHOD: Moisture Sensitive Paper (Moisture)

STANDARD REFERENCES: None

USAGE: Test to determine the presence of moisture in concrete joints prior to applying sealant.

EQUIPMENT / MATERIALS:

1. One-time use moisture sensitive paper (Hydrion water finding test pater, CAT#WF-130, Micro Essential Laboratory, Inc., Brooklyn NY, or equal).
2. Tongue depressor or other flat tool made of wood, metal, or stiff plastic. Length of the depressor should be sufficiently long to extend to the bottom of the cut joint with room to hold it above the surface of the concrete.

PROCEDURE:

1. Cut the moisture sensitive paper into strips. The length of the strips should be at minimum two times the depth of the joint plus 2 inches.
2. Place the moisture sensitive paper strip around the tongue depressor and insert into the joint, perpendicular to the surface of the concrete slab/pavement.
3. Press the paper against the surface of the joint with the tongue depressor. Press against both vertical surfaces and the bottom of the joint. Hold paper down against each surface for 10 seconds.
4. Remove the depressor and tape. Examine if the tape indicated significant moisture. Grade moisture per the visual standard.
5. Repeat the procedure at one additional location within 12 inches of the first test.
6. Report the moisture level of the two tests.

REPORT:

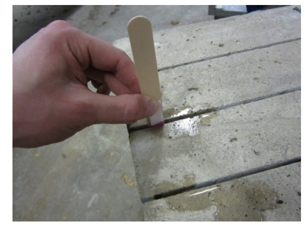
1. Sawcut width and depth
2. Joint preparation methods
3. Time and date of the test
4. Test location
5. Length of sawcut joint represented by the test
6. Depth of test, in.
7. Test results of the two tests by visual standard level (None, Light, Moderate, Heavy)

TEST METHOD (VISUAL)

EQUIPMENT

PROCEDURE

Step: 1



2, 3

4

VISUAL STANDARD

NONE

LIGHT

MODERATE

HEAVY

COMMENTS CAN BE DIRECTED TO PAUL KRAUSS at Wiss, Janney Elstner Assoc., 847-753-6517, pkrauss@wje.com

TEST METHOD: Wipe Test (Cleanliness)

STANDARD REFERENCES: Section 5.4 and 6 of SSPC-SP 13/NACE No. 6; ASTM D 5295

USAGE: Measure of the cleanliness of the prepared concrete joint prior to application of joint sealant.

EQUIPMENT / MATERIALS:

1. Black 100% cotton cloth, tee shirt material.
2. Tongue depressor or other flat tool made of wood, metal, or stiff plastic. Length of the depressor should be sufficiently long to extend to the bottom of the cut joint with room to hold it above the surface of the concrete.

PROCEDURE:

1. Cut the cloth into 2-inch wide strips. The length of the cloth strips should be at minimum two times the depth of the joint plus 2 inches.
2. Place the cloth strip around the tongue depressor and insert into the joint, perpendicular to the surface of the concrete slab/pavement.
3. Firmly rub the entire width of the cloth against the surface of the joint with the tongue depressor over a 2 in. length of the joint. Rub both vertical surfaces and the bottom of the joint. Sufficient pressure should be applied so the level of contaminant removal is not affected by slight variations in pressure.
4. Remove the depressor and cloth. Use caution when handling the cloth to avoid dislodging contaminants.
5. Examine the cloth for contaminants. Grade contamination per the visual standard.
6. Repeat the procedure at one additional location within 12 inches of the first test.
7. Report the contamination level of the two tests.

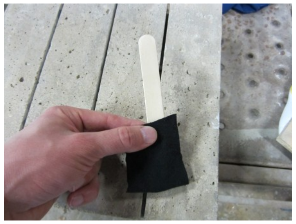
REPORT:

1. Sawcut width and depth
2. Joint preparation methods
3. Time and date of the test
4. Test location
5. Length of sawcut joint represented by the test
6. Depth of Test, in.
7. Test results of the two tests by visual standard level (None, Light, Moderate, Heavy).

TEST METHOD (VISUAL)

EQUIPMENT

PROCEDURE

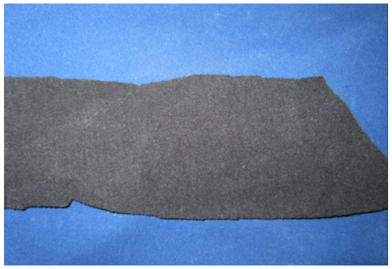


Step: 1

2, 3

4, 5

VISUAL STANDARD



None

LIGHT

MODERATE

HEAVY

COMMENTS CAN BE DIRECTED TO PAUL KRAUSS at Wiss, Janney Elstner Assoc., 847-753-6517, pkrauss@wje.com

TEST METHOD: Tape Contamination Test (Cleanliness)

STANDARD REFERENCES: Section 5.4 and 6 of SSPC-SP 13/NACE No. 6

USAGE: Measure of the cleanliness of the prepared concrete joint prior to application of joint sealant.

EQUIPMENT / MATERIALS:
1. 3/4-inch wide black electrical tape (3m Super 33+)
2. Tongue depressor (3/4 in. wide) or other flat tool made of wood, metal, or stiff plastic. Length of the depressor should be sufficiently long to extend to the bottom of the cut joint with room to hold it above the surface of the concrete.

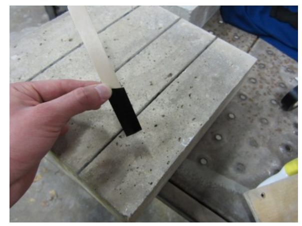
PROCEDURE:
1. Cut a strip of black tape. The length of the strip should be at minimum two times the test depth plus 2 inches.
2. Wrap the tape around the depressor with the adhesive side of the tape facing away from the depressor.
3. Insert the tape and depressor into the joint, perpendicular to the surface of the concrete slab/pavement.
4. Firmly rub the tape against the surface of the joint with the tongue depressor. Rub both vertical surfaces. Sufficient pressure should be applied so the level of contaminant removal is not affected by slight variations in pressure.
5. Remove the depressor and pull both sides of the tape together perpendicular to the joint.
6. Examine the tape for contaminants. Grade level of contaminates per the visual standard.
7. Repeat the procedure at one additional location within 12 inches of the first test.
8. Report the contamination level of the two tests.

REPORT:
1. Sawcut width and depth
2. Joint preparation methods
3. Time and date of the test
4. Test location
5. Length of sawcut joint represented by the test
6. Depth of test, in.
7. Test result of the two tests by visual standard level (Trace, Light, Moderate, Heavy).

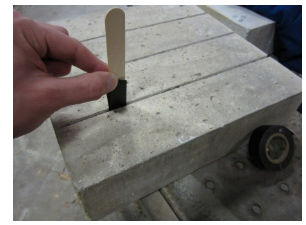
TEST METHOD (VISUAL)

EQUIPMENT

PROCEDURE



Step: 1, 2



3, 4

5

VISUAL STANDARD

TRACE

LIGHT

MODERATE

HEAVY

COMMENTS CAN BE DIRECTED TO PAUL KRAUSS at Wiss, Janney Elstner Assoc., 847-753-6517, pkrauss@wje.com

TEST METHOD: Tape Pull Test (Cleanliness & Moisture)

STANDARD REFERENCES: None

USAGE: Measure of the cleanliness and moisture content of prepared concrete joints prior to application of joint sealant.

EQUIPMENT / MATERIALS:

1. SEMicro CHT Cross Hatch Tape, 1 inch wide (direct substitute for Permacel P99)
2. Wood tongue depressors (3/4 inch minimum width)
3. Field scale and clamping device for direct tensile test. Scale should read between 0 and 100 lbs. or more, be accurate to 0.5 lbs., with a peak hold indicator.

PROCEDURE:

1. Cut a strip of test tape. The length of the strip should be at minimum two times the test depth plus 2 inches. [4 in. length minimum for a 1 in. test depth].
2. Wrap the tape around the depressor with the adhesive side of the tape facing away from the depressor.
3. Insert the tape and depressor into the joint, perpendicular to the surface of the concrete slab/pavement to a known depth. If no test depth is specified, use 1 in.
4. Firmly rub the tape against the surface of the joint with the tongue depressor. Rub both vertical surfaces. Sufficient pressure should be applied so test is not affected by slight variations in pressure.
5. Insert a sufficient number of wood depressors within the joint to support the tape vertically but allow them to freely move without exerting any axial force within the joint. Attach the clamp and scale tightly onto both pieces of tape and depressor(s) and pull perpendicular to the joint. Record maximum load as the force in pounds per square inch (psi) of tape adhered to one side of the vertical surface of the joint:

   Peak Pull-out Load , psi = Peak Force / (Test Depth x Tape Width)

   Note: Alternatively it is acceptable to perform the test by adhering the tape to one side of the joint. If a one sided test is performed, cut and adhere an additional piece of the tape to the back of the test tape prior to inserting to reduce the risk of ripping the tape during the pull test. Note if a one-sided test is performed on the report sheet.
6. Repeat the procedure at two additional locations within 12 inches of the first test.
7. Report the individual and average peak pull-out load of the three tests.

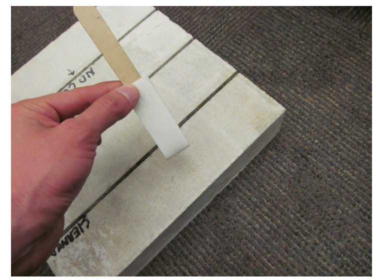
REPORT:

1. Sawcut width and sawcut depth
2. Joint preparation methods
3. Time and date of the test
4. Test location
5. Length of sawcut joint represented by the test
6. Tape Width and Test Depth, in.
7. Peak Pull-out Load for each of the three tests and Average Pull-out Load, psi.

TEST METHOD

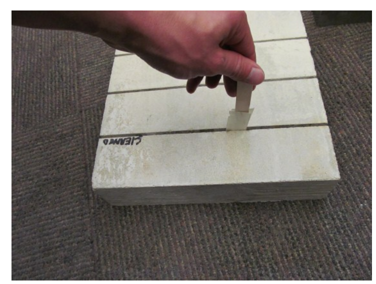
EQUIPMENT

PROCEDURE



Step: 2

3



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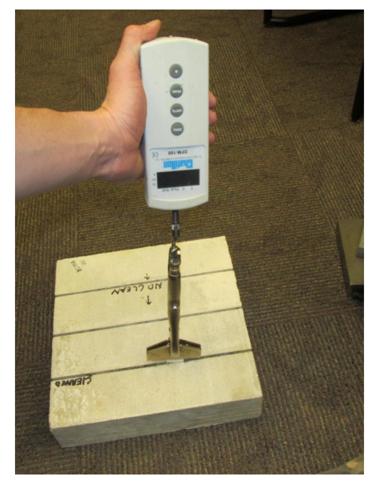

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Project:____ Operator: ____________

Joint Width:___________________ Sealant Type:________________________
Joint Depth:___________________

Joint Prep: ☐ Powerwash ☐ Sandblast ☐ Air Blown
☐ Other:__________________________

Joint Location:________________
Length of Joint Represented by Test:_________________________

Date:__________________ Time:__________________________

Moisture Sensitive Paper Test (optional): Depth of test:_______________

Test A: None / Light / Moderate / Heavy

Test B: None / Light / Moderate / Heavy

Wipe Test: Depth of test:_______________

Test A: None / Light / Moderate / Heavy

Test B: None / Light / Moderate / Heavy

Tape Contamination Test: Depth of test:_______________

Test A: Trace / Light / Moderate / Heavy

Test B: Trace / Light / Moderate / Heavy

Tape Pull Test: Tape width:___________ Depth of test:_______________

	Test A	Test B	Test C	Average
Peak Force (lbs):				
Peak Load (psi):				

Date:__________________ Time:__________________________

Moisture Sensitive Paper Test (optional): Depth of test:_______________

Test A: None / Light / Moderate / Heavy

Test B: None / Light / Moderate / Heavy

Wipe Test: Depth of test:_______________

Test A: None / Light / Moderate / Heavy

Test B: None / Light / Moderate / Heavy

Tape Contamination Test: Depth of test:_______________

Test A: Trace / Light / Moderate / Heavy

Test B: Trace / Light / Moderate / Heavy

Tape Pull Test: Tape width:___________ Depth of test:_______________

	Test A	Test B	Test C	Average
Peak Force (lbs):				
Peak Load (psi):				

Initials:_______________ Checker:_______________