MEASURING CONCRETE SURFACE PH— A PROPOSED TEST METHOD

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WHY TEST CONCRETE SURFACE PH?

The pH test of a concrete surface is primarily required prior to installation of vinyl flooring over a concrete slab. Per many product manufacturers, the adhesives used to install vinyl flooring are not suitable for concrete surfaces with a pH greater than 9. A majority of vinyl flooring manufacturers mandate that a concrete surface pH test be performed prior to using their product.

ASTM International has published a standard test method to measure concrete surface pH. A brief summary of ASTM F710-11, "Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring," is as follows:

1. Place several drops of distilled or deionized water on a clean surface of concrete to form a puddle approximately 1 in. (25 mm) in diameter.
2. Allow the puddle to set for 60 ± 5 seconds, and then dip the pH paper into the water.
3. Remove the pH paper immediately and compare with chart to determine pH reading.

The pH test method provided in ASTM F710 is faulty. It does not measure pH of a concrete surface. It primarily measures pH of water. No wonder testing personnel have reported inherently high alkaline concrete surface pH, such as an acidic pH of 6, as shown in Fig. 1.

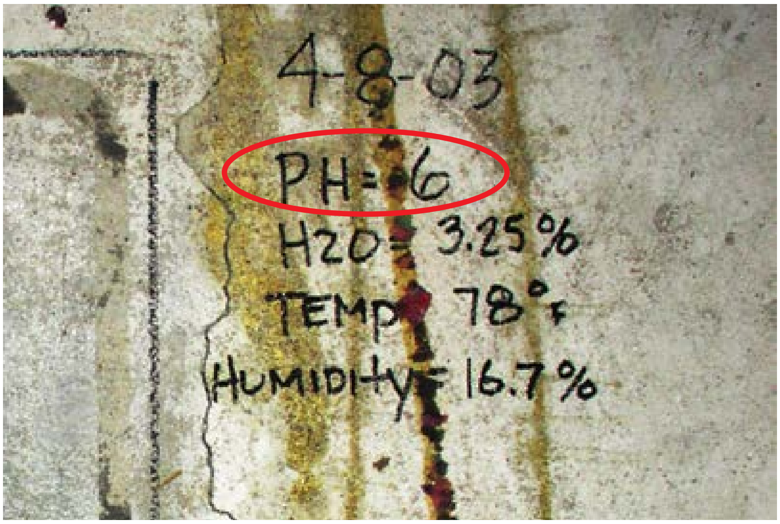


Fig. 1: Test results by testing company on concrete slab-on-ground. After performing the test per ASTM F710, the technician identified the pH of the concrete surface as 6

FUNDAMENTALS OF PH

Simply speaking, pH is a measure of acidity or alkalinity and is defined as a negative logarithm of the hydrogen ion concentration. The pH scale ranges from 0 to 14. A value ranging from 0 to 6 represents acidic pH, a value of 7 is considered neutral, and a value of 8 to 14 represents alkaline pH. It is important to note that the pH scale is logarithmic. For example, a pH of 9 is 10 times more alkaline than a pH of 8.

Concrete is known to be a highly alkaline material. Depending on the concentration levels of Na^+, K^+, and OH^- ions, the pH values of freshly placed concrete made from Type II cement are above 12.5. Concrete made with high-alkali cement has a pH value above 13 and concrete made with high alumina cement would have a pH ranging from 11.4 to 12.5.

The surface pH of concrete can reduce once it is exposed to atmospheric carbon dioxide. Carbon dioxide generates carbonic acid in the pores of concrete and reduces the surface pH of concrete. This process is known as carbonation. The carbonation of concrete is known to lower the concrete surface pH to a value around 9; however, the process is slow and typically takes a year or two of atmospheric exposure to carbonate the concrete surface to a depth of 0.04 in. (1 mm).

MEASURING PH OF CONCRETE

The pH is measured of a solution; however, concrete is a solid substance. This creates a fundamental challenge of how to accurately measure the pH of hardened concrete. Fundamental research on pH measurement of concrete was conducted by Grubb et al.[1] to determine the influence of various variables, such as: 1) type of concrete; 2) sample size; 3) particle size; 4) dilution ratio; 5) soaking or waiting time; 6) sample gradation; and 7) temperature. Their research concluded that the dilution ratio, particle size, and temperature had the most pronounced effect on measured pH values. The graphs in Fig. 2 and 3 depict the influence on pH as related to temperature and dilution ratio.

Slab-on-ground concrete has a large surface area to volume ratio. Therefore, if the construction schedule is delayed, the slab surface has high potential to carbonate and reduce the surface pH to a value around 9. However, the concrete surface is generally shotblasted in preparation for installing new flooring. The process of shotblasting easily removes 0.04 in. (1 mm) of the concrete surface layer exposing the high-alkaline concrete. Even if the shotblasted surface is vacuumed, the fine concrete dust still remains on the slab surface. When water-based adhesives are used for installing the flooring and the flooring is installed before the excess water in the adhesive is allowed to evaporate (flashed off), the excess water from the adhesive is available on the concrete surface to form a high alkaline solution with the fine concrete dust. Once the non-breathable flooring, such as sheet vinyl, is installed on the concrete slab, the slab moisture can condensate under the flooring, providing additional water for the formation of a high-alkaline concrete solution. Thus, the flooring adhesive is exposed to a high-alkaline environment, which can affect its properties. This condition can lead to loss of bond between the adhesive and concrete or the adhesive and flooring, subsequently causing a flooring failure (Fig. 4 and 5). Therefore, it is important to measure pH of the concrete surface correctly and then select an appropriate adhesive for the flooring.

CHALLENGES FOR THE TEST PROCEDURE

It is evident that the pH test needs a concrete solution. A concrete solution combines concrete powder from the concrete surface with deionized or distilled water. The powder sample from the concrete surface can be obtained easily by lightly grinding the concrete surface with a sandpaper. However, there are three main questions:

1. How rough should the sandpaper be?
2. How deep should the scarification be to get the powder sample?
3. How much concrete powder to use?

To answer these questions, two 10 in. (250 mm) diameter concrete samples were prepared for testing. A pea-gravel concrete mixture with a 28-day compressive design strength of 2500 psi (17 MPa)

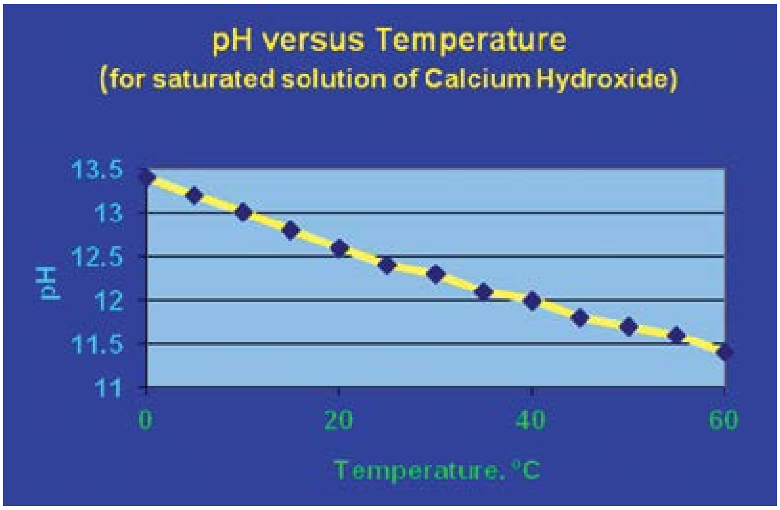


Fig. 2: Influence of temperature on pH

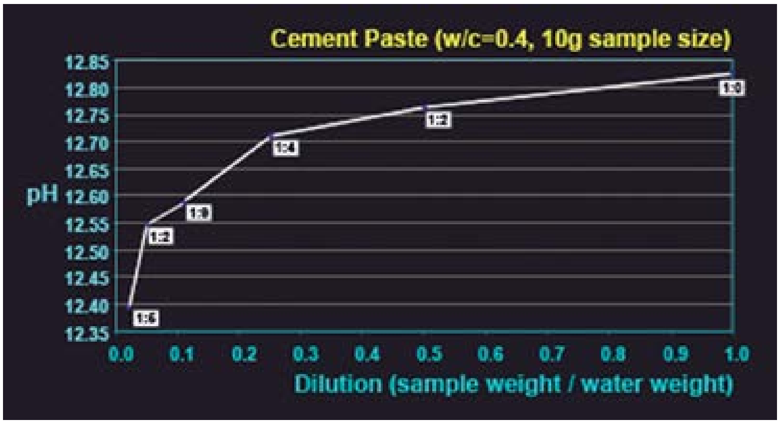


Fig. 3: Influence of dilution ratio, concrete powder to water weight, on pH of concrete

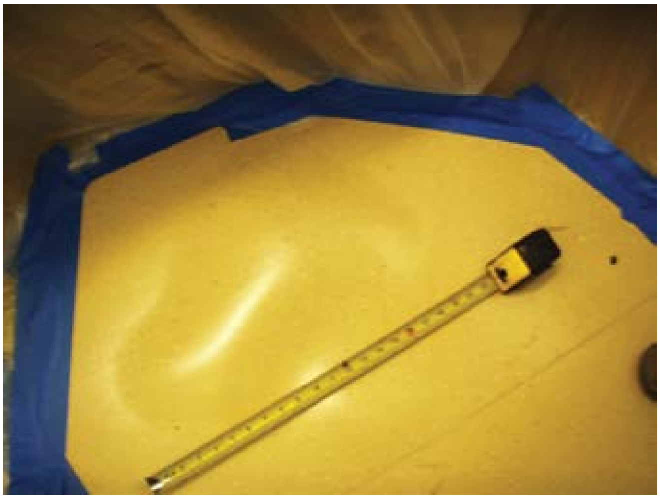


Fig. 4: Bubble in sheet vinyl flooring

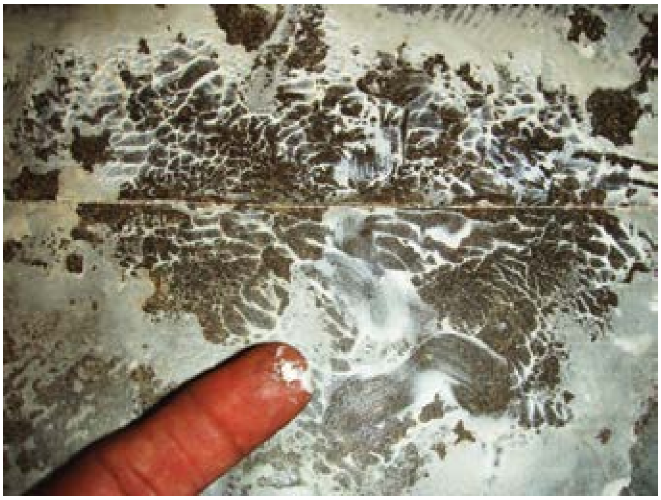


Fig. 5: Soft, uncured adhesive under bubbled sheet vinyl flooring

was used to cast the specimens. The water-cement ratio (*w*/*c*) of the concrete was about 0.45. The specimens were finished with a light steel trowel (Fig. 6) and cured for 7 days in water before initiating the experimental testing.

The specimens were sanded (scarified) using two types of sandpaper: 50- and 100-grit (refer to Fig. 7). The sanding was done manually for 30, 60, and 120 seconds to determine the depth of scarification and quantity of concrete powder. The depth of scarification was measured at a total of 21 locations roughly spaced at 2 in. (50 mm) on center. The average depth of scarification stated in Tables 1 and 2 represent an average of 21 measurements. The measurements were taken using a vernier caliper with an accuracy of 0.0001 in. (0.0025 mm).

Fig. 6: Concrete specimen surface with a light steel-troweled finish

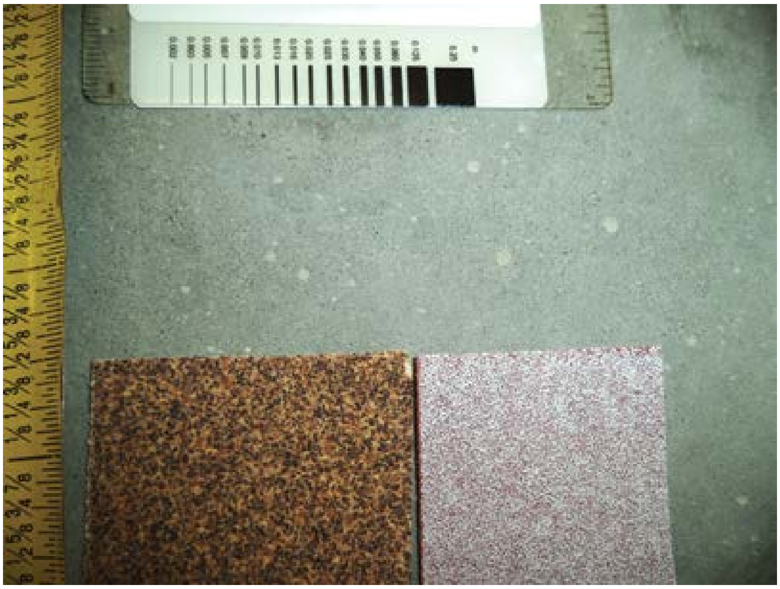


Fig. 7: A coarse 50-grit sandpaper is shown on left with less-coarse 100-grit sandpaper on right. Concrete surface of specimen is shown after 120 seconds of grinding using 50-grit sandpaper

The concrete powder obtained from each scarification process was used to determine the pH of the concrete solution. The pH was measured with a digital pH meter and a wide-range pH paper. The pH paper gave reasonably similar results. For example, if the pH meter read pH as 12.6, the pH paper strip indicated a pH in the range of 12 to 12.5 (refer to Fig. 8). The summary of test results is shown in Tables 1 and 2.

The pH measurements obtained on both concrete specimens using the ASTM F710 method was 9.5, which is hundreds of times less than the actual pH of about 12.5, as measured using the proposed pH test methods.

DISCUSSION ON SANDING

The test results in Tables 1 and 2 show that the average depths of scarification after 60 seconds using 50- and 100-grit sandpapers were 0.0130 in. (0.33 mm) and 0.0176 in. (0.44 mm), respectively. These average depths of scarifications are far less than 0.0394 in. (1 mm). The maximum depth of scarification after 60 seconds was 0.036 in. (0.90 mm) and 0.0660 in. (1.65 mm), respectively. In both cases, the less-coarse 100-grit sandpaper resulted in deeper scarification than 50-grit paper. In fact, the opposite results would have been more logical. There are two possible explanations. First is the psychological mind-set. Knowing that 50-grit sandpaper is coarser, less pressure may have been applied during the scarification as compared to the

Fig. 8: The pH of a concrete powder sample obtained after 60 seconds of surface sanding using 50-grit sandpaper revealed pH of 12 using pH strip and 12.5 using pH meter

TABLE 1: RESULTS OF SCARIFICATION OF CONCRETE SURFACE USING 50-GRIT SANDPAPER

Duration of scarification	Average depth of scarification, in. (mm)	Maximum depth of scarification, in. (mm)	Quantity of concrete powder collected, g (lb)	pH of concrete using pH meter
30 seconds	0.0099 (0.25)	0.036 (0.90)	1.1 (0.0024)	12.6
60 seconds	0.0130 (0.33)	0.036 (0.90)	1.6 (0.0035)	12.5
120 seconds	0.0174 (0.44)	0.047 (1.18)	2.5 (0.0055)	12.6

Notes:
1. The depth of scarification measurement is an average of 21 measurements.
2. A pH measurement of the concrete surface by ASTM F710 resulted in a pH measurement of 9.5.

TABLE 2: RESULTS OF SCARIFICATION OF CONCRETE SURFACE USING 100-GRIT SANDPAPER

Duration of scarification	Average depth of scarification, in. (mm)	Maximum depth of scarification, in. (mm)	Quantity of concrete powder collected, g (lb)	pH of concrete using pH meter
30 seconds	0.0127 (0.32)	0.0810 (2.03)	0.4 (0.0009)	12.6
60 seconds	0.0176 (0.44)	0.0660 (1.65)	1.1 (0.0024)	12.7
120 seconds	0.0222 (0.55)	0.0700 (1.75)	1.7 (0.0038)	12.7

Notes:
1. The depth of scarification measurement is an average of 21 measurements.
2. A pH measurement of the concrete surface by ASTM F710 resulted in a pH measurement of 9.5.

100-grit sandpaper. Secondly is the variation in surface hardness of the two samples. The average depth of scarification even after the full 120 seconds of scarification showed that the manual sanding of the concrete did not deeply scarify the surface. The average depth of scarification was 0.0222 in. (0.55 mm), which is also less than 0.0394 in. (1 mm).

The proposed test method in this paper recommends the use of 50-grit sandpaper. The 50-grit sandpaper makes it easier to scarify a hard-troweled dense concrete surface.

PH METER OR PH PAPER?

During the experimental testing, both the pH paper and pH meter gave reasonably similar pH readings using the proposed test methods. The dilution ratio in the pH meter method is higher so that the sensor of the pH meter stays more in contact with liquid than a slurry solution. This will protect the pH meter's sensor from damage due to scratching. Testing should follow manufacturer's instructions for handling both the pH paper and pH meter.

HOW MANY PH TESTS?

To stay consistent with other moisture tests on the concrete slab, it is recommended that at least three surface pH tests be conducted on the first 1000 ft^2 (93 m^2) area of the slab. Additional tests should be performed for each additional 1000 ft^2 (93 m^2), or fraction thereof.

PROPOSED TEST METHOD TO DETERMINE PH OF CONCRETE SURFACE

The following two pH test methods are proposed as field tests for determining the pH of a concrete surface. The test procedure can use either pH paper or a pH meter.

A. TEST PROCEDURE USING PH PAPER

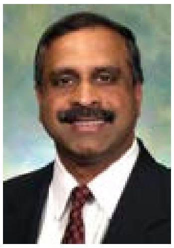
1. Calibrate the pH paper with three pH calibration standards either supplied by the pH paper manufacturer or an independent chemical supplier. The three calibration solutions shall be of pH 7, 10, and 12. Dip pH paper in each of the calibration solutions and determine pH by comparing the color change on pH strip to the pH color chart provided by the manufacturer. Record each of the three pH readings.
2. Use infrared thermometer to measure surface temperature of concrete to the nearest degree Fahrenheit or Celsius.
3. Clean the concrete surface to remove dirt, concrete sealer, and existing adhesive residue.
4. Lightly abrade an approximate 12 in. (300 mm) diameter area of the clean concrete surface for 60 ± 10 seconds with 50-grit sandpaper. Collect and measure 0.5 g (0.0011 lb) of concrete powder using a gram scale and place it within the test area.
5. Thoroughly mix the concrete powder with 0.034 fluid ounces (1 mL), or about 15 drops, of fresh distilled water with a small, flat plastic stirrer. Let the mixture stand for 60 seconds.
6. Insert a pH strip into the mixture. Determine pH by comparing the color change on the pH strip to the pH color chart provided by the manufacturer.
7. Report calibration pH readings, pH of concrete surface, and concrete surface temperature.

B. TEST PROCEDURE USING PH METER

1. Calibrate the pH meter with three pH calibration standards either supplied by the pH meter manufacturer or an independent chemical supplier. The three calibration solutions shall be of pH 7, 10, and 12. The measuring tip of the pH meter shall be cleaned by dipping in a clean container of fresh distilled water and wiped dry with a clean, fresh paper towel before taking the pH readings. Repeat the same cleaning procedure immediately after completing each pH reading. Record each of the three pH readings.
2. Use infrared thermometer to measure surface temperature of concrete to the nearest degree Fahrenheit or Celsius.
3. Clean the concrete surface to remove dirt, concrete sealer, and existing adhesive residue.
4. Lightly abrade an approximate 12 in. (300 mm) diameter area of the clean concrete surface for 60 ± 10 seconds with 50-grit sandpaper. Collect and measure 0.5 g (0.0011 lb) of concrete powder using a gram scale.
5. Add concrete powder in a bottle containing 0.34 fluid ounces (10 mL) of fresh distilled water. Close the bottle lid and shake the bottle for 30 ± 5 seconds. Allow the bottle to rest for 2 minutes.
6. Insert the pH meter into the concrete mixture solution and record the stable pH of the mixture solution to the nearest tenth.
7. Report calibration pH readings, pH of concrete surface, and concrete surface temperature.

REFERENCES

1. Grubb, J. A.; Limaye, H. S.; and Kakade, A. M., "Testing pH of Concrete," *Concrete International*, V. 29, No. 4, Apr. 2007, pp. 78-83.



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