Pervious in Practice

Methods, materials, mixtures

PIP 3 – Acceptance Testing of Pervious Concrete

The primary function of pervious concrete pavement is to percolate stormwater through the system and to support traffic loads while maintaining durability in its service environment. Acceptance testing of pervious concrete should assure achieving these objectives when the pavement is installed. However, normal construction inspection practices that base acceptance on slump and cylinder strengths are not meaningful for pervious concrete. Tests on pervious concrete include measuring density from which the void content is determined, thickness, infiltration and evaluation of durability of the mixture. ***ACI 522.1-13: Specification for Pervious Concrete Pavement*** addresses testing and acceptance of pervious concrete. This PIP summarizes some of the standard test methods established for pervious concrete. Persons performing acceptance tests on pervious concrete must possess a current ACI Field Testing – Grade 1 certification AND hold, at a minimum, the NRMCA Pervious Concrete Technician certification.

Strength

While compressive strength is commonly used for acceptance of conventional concrete, it is not appropriate for pervious concrete. A nominal strength of pervious concrete, suggested in ACI 522R, can be assumed when designing pavement thickness for anticipated traffic loads. When strength is specified, targeting a higher strength level to ensure compliance will result in reduced permeability and detract from the primary function of pervious concrete. There are no standardized procedures to make and test strength specimens of pervious concrete. It is, therefore, inappropriate to specify compressive strength requirements for pervious concrete or to use such tests as a basis of acceptance.

Density of Fresh Pervious Concrete

The primary characteristic of pervious concrete to percolate stormwater is the volume of interconnected voids. Pervious concrete mixtures are designed to possess desired durability and permeability at a particular void content, usually around 20 percent. The density of pervious concrete can vary greatly from mix to mix, depending on mixture proportions, and ingredient relative densities (specific gravity). For this reason, density should not be specified. The measured density of fresh pervious concrete provides a means of determining the void content of the mixture when consolidated in a standard manner. The density of fresh concrete is measured for the final proposed mixture that establishes the basis for acceptance of pervious concrete supplied to a project. It will not, however, represent the void content that will be in the installed pavement which may will receive a different compactive effort.

Density of fresh pervious concrete is measured in accordance with ***ASTM C1688: Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete.*** The test is performed using a 0.25 cubic foot [7 L] calibrated cylindrical measure. The pervious concrete is filled in the measure and compacted with either a Proctor (Procedure A) or Marshall (Procedure B) hammer in two equal layers and struck off using a strike-off plate. The same compaction procedure should be used for comparison of delivered concrete to the proposed/approved mixture. The density and void content of the fresh pervious concrete mixture are calculated based on the measured mass of the consolidated concrete, the volume of the measure, and the total mass of materials used in the concrete mixture. Initial testing frequency may be at the rate of every truck. The frequency of testing can be reduced when results are consistent between loads. However, when visual inspection indicates a change in the concrete, testing should be resumed. At a minimum, one test per day should be performed throughout the placement.

The fresh density of pervious concrete generally varies between 90 lb/ft^3 and 130 lb/ft^3 (1600 kg/m^3 and 2080 kg/m^3). In accordance with ACI 522.1 specification, acceptance criteria require that the density of the fresh concrete be within +/- 5 lb/ft^3 (+/- 80 kg/m^3) of the density measured on the approved mixture in the laboratory. These acceptance criteria for density of fresh pervious concrete apply to test panels and the actual pavement

Density of Hardened Pervious Concrete

ACI 522.1 establishes a basis for acceptance of the constructed pavement based on density of cores extracted from the pavement. It recognizes that there is a difference between the density of fresh pervious concrete and that of the hardened concrete in a pavement. The specification requires the construction of two test panels on the project site. The test panels should be placed on a subgrade and subbase prepared as specified, using the material and construction requirements for pavement per the project specifications. Each panel must have an area of at least 225 ft2, and a width and thickness as specified for the pavement in the project's Contract Documents. The density of cores from acceptable test panels are measured for quality assurance and acceptance for the remainder of the placement. Additionally, the test panels should be inspected for permeability and raveling. If the pavement drains adequately and surface and edge raveling is not occurring, then the mock-up is considered acceptable and used as the baseline for acceptance of the installation.

The density of hardened concrete can be measured on cores extracted from the pavement. Cores should be extracted from pavement at least seven days after installation. Nominal 4 in. (100 mm) diameter cores are extracted in accordance with *ASTM C 42: Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*. The density of cores is measured in accordance with ***ASTM C1754: Density and Void Content of Hardened Pervious Concrete***. The volume of the core is determined from its measured dimensions. The specimen is dried to constant mass and immersed in water to determine the volume of solids. The void content is determined as the difference between the total volume and the volume of the solids. Two drying methods are used that will provide different results, so the same method should be consistently used. Method A dries the specimens in an oven at 100°F (38°C), while drying temperature used in Method B is 230°F (110°C). Specimens are dried for at least 24 hours.

The average density of cores from the test panel set the basis for quality assurance for the pavement. ACI 522.1 criteria states that the hardened density of cores from the pavement should be within ±5% of the of the density of cores obtained from the accepted test panels. The testing frequency recommended in ACI 522.1 is three cores for each 5,000 ft2 (465 m2). Typically, core samples are only extracted from pervious pavements that are expected to experience heavy traffic loading applications.

Once a hardened density of cores is established from the test panels, consistency of fresh density of the delivered

concrete within the acceptance tolerances stated earlier provides adequate quality assurance. Research has shown that consistent fresh density values will provide similarly consistent density of hardened concrete in the installed pavement.

Thickness

ASTM C1754 includes the measurement of the length of cores to estimate pavement thickness. The length of cores is measured with a jaw caliper in accordance with ASTM C1542, Test Method for Measuring Length of Concrete Cores. ACI 522.1 requires the length of cores to be measured in accordance with ASTM C174, Test Method for Measuring Thickness of Concrete Elements using Drilled Concrete Cores. Length of cores is measured to the nearest 0.01 in. (0.25 mm).

ACI 522.1 states the following tolerances from the specified thickness of the pavement:

- Average length of 3 cores: -3/8 in. (-10 mm), +1.5 in (38 mm)
- Each individual core: -3/4 in (-19 mm)

The thickness tolerances are applicable to the test panels as well. It should be noted that pervious concrete pavements may have a higher variability in pavement thickness when placed on an open graded subgrade, compared with conventional concrete pavements.

A much more practical and economical practice for determining thickness is to set a straight edge on the forms and have the inspector measure the depth prior to concrete placement. Inspecting and adjusting base or forms prior to placement is preferred to removing in-place concrete based on core measurements. ACI 522.1 requires the elevation of the pavement to be within ±3/4 in. (±19 mm) of the elevation indicated on the plans.

Infiltration

Maintenance of the pervious concrete pavement is the responsibility of the property owner/manager, and has a direct impact on the infiltration rate of pervious concrete that has been in service. A key step in establishing a plan for scheduled maintenance of pervious concrete is to identify a baseline infiltration rate of the installed pervious concrete system. ***ASTM C1701: Standard Test Method for Infiltration Rate of In-Place Pervious Concrete*** determines the infiltration rate of the pervious concrete system. This method is primarily used to determine the change in permeability of the installed pavement with time and to determine the effectiveness of maintenance procedures. It is not intended for acceptance of the installed pavement. If used for that purpose, it is important to recognize the variability of the measurements due to normal variability of the finished surface. Measurements should be made at several locations and averaged as recommended in ASTM C1701.
Performing an initial test for a baseline is best done as soon as possible after plastic sheeting for curing is removed. This initial baseline measurement will document the optimal performance of the pavement, as constructed, for stormwater management. ASTM C1701 should not be performed on concrete that is less than 7 days old.

A minimum infiltration rate of 200 inches per hour is recommended as a minimum for acceptance.

ASTM C1701 requires three measurements for every 25,000 square feet and an average taken of the three tests. The original testing locations should be marked or noted in the maintenance log so that future tests can be run at the same locations. A change in the infiltration rate with service will determine the appropriate frequency of maintenance. The change in infiltration rate can be used as a basis to set a pavement maintenance schedule for that site and to evaluate the effectiveness of the cleaning procedures used.

Resistance to Mechanical Degradation

A common failure mechanism of pervious concrete pavements is raveling. ***ASTM C1747: Standard Test Method for Determining Potential Resistance to Degradation of Pervious Concrete by Impact and Abrasion*** allows the comparison of the relative potential resistance to raveling of pervious concrete mixtures of varying proportions and raw materials. The procedure uses cast cylindrical specimens at the design density and subjects them to impact, abrasion and grinding in a rotating steel drum. The potential resistance is expressed as the percentage of mass loss after 500 revolutions of the steel drum. Higher resistance to degradation is associated with lower mass loss. By utilizing ASTM C1747, ready mix producers can compare proposed mixture proportions prior to placement to ensure a quality pervious concrete.

However, it should be noted that in the field, raveling is often the result of improper paste consistency, workability loss, inadequate compaction and/or improper curing. A certified pervious concrete contractor will understand the nuances of a pervious concrete mix and will have the experience to make necessary adjustments to avoid many of these issues. Additionally, raveling may be a result of degradation due to deicing chemical attack. There is no known correlation between this test method and the field performance of pervious concrete. Therefore, ASTM C1747 is not intended to be used for mixture qualification or jobsite acceptance testing.

Summary

The success of pervious concrete pavements is to ensure proper hydrological and structural design of the pavement. ACI 522.1 establishes a consensus specification that should be the basis of the designer's specification. Specifications for conventional concrete should not be modified for pervious concrete. Similarly, specific ASTM test methods have been developed for pervious concrete and tests and acceptance criteria used for pervious concrete should not be used.