

# Understanding AASHTO T277 and ASTM C1202 Rapid Chloride Permeability Test

## Introduction

This test method was originally developed by the Portland Cement Association, under a research program paid for by the Federal Highway Administration (FHWA). The original test method may be found in FHWA/RD-81/119, "Rapid Determination of the Chloride Permeability of Concrete." Since the test method was developed, it has been modified and adapted by various agencies and standard's organizations. These include:

- AASHTO T277, "Standard Method of Test for Rapid Determination of the Chloride Permeability of Concrete"
- ASTM C1202, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration"

Many concrete structures are built today with specifications calling for low-permeability concrete. The construction industry accepts this test procedure as a measurement for determining chloride permeability. In this technical bulletin, we hope to answer the following questions:

- How and why was this test method developed?
- How is the test performed?
- How are test results interpreted?
- What are the factors that influence test results?
- What is the precision and accuracy of the test method?

## How and Why Was this Test Method Developed?

As mentioned above, the Rapid Chloride Permeability test was developed in a FHWA research program. The program was created to develop techniques to non-destructively measure the chloride permeability of in-place concrete. Prior to the development of the test, chloride permeability of concrete was measured by a ponding test, such as AASHTO T259-80, "Resistance of Concrete to Chloride Ion Penetration." Ponding tests typically take 90 days or longer and involve taking samples of the concrete at various depths to determine the chloride profile. The FHWA wanted a test that could be done in place and have a good correlation to data that was developed from chloride ponding tests.

Chloride migration through concrete, even in high water/cement ratio concrete, is a very slow process. So researchers looked for a test method that would accelerate this migration. They found that when an electrical current was applied to a concrete specimen it increased and accelerated the rate at which the chlorides migrated into concrete. The researchers also found that if one measured the coulombs (the integral of current vs. time plot) that were passed through the sample and then compared these numbers to results from a ponding test a good correlation existed. From these findings, researchers developed the test procedures that are currently specified in AASHTO T277 and ASTM C1202.

## How is the Test Performed?

The test method involves obtaining a 100 mm (4 in.) diameter core or cylinder sample from the concrete being tested. A 50 mm (2 in.) specimen is cut from the sample. The side of the cylindrical specimen is coated with epoxy, and after the epoxy is dried, it is put in a vacuum chamber for 3 hours. The specimen is vacuum saturated for 1 hour and allowed to soak for 18 hours. It is then placed in the test device (see test method for schematic of device). The left-hand side (-) of the test cell is filled with a 3% NaCl solution. The right-hand side (+) of the test cell is filled with 0.3N NaOH solution. The system is then connected and a 60-volt potential is applied for 6 hours. Readings are taken every 30 minutes. At the end of 6 hours the sample is removed from the cell and the amount of coulombs passed through the specimen is calculated.

## How are the Test Results Interpreted?

The test results are compared to the values in the chart below. This chart was originally referenced in FHWA/RD-81/119 and is also used in AASHTO T277-83 and ASTM C1202 specifications.

**Note:** The authors of this test feel that the test itself is not accurate enough to clearly define exact concrete permeability levels. Five categories were created in which coulomb test results from different test samples that fall in the same category were considered to be equivalent.

### Chloride Permeability Based on Charge Passed

Charge Passed (Coulombs)	Chloride Permeability	Typical of
>4,000	High	High W/C ratio (>0.60) conventional PCC
2,000–4,000	Moderate	Moderate W/C ratio (0.40–0.50) conventional PCC
1,000–2,000	Low	Low W/C ratio (<0.40) conventional PCC
100–1,000	Very Low	Latex-modified concrete or internally-sealed concrete
<100	Negligible	Polymer-impregnated concrete, Polymer concrete

It is important to understand that these ranges were established on laboratory concrete by the test method described above. The ranges should be used only for comparison purposes. The test is meant only to give an indication as to how the concrete tested relates to the values in the chart or to other concrete being tested under the test procedure.

## What are the Factors that Influence Test Results?

There are many factors that may affect the accuracy of the test procedure. We have found that the age and curing of the test specimen affects the results dramatically. In general, the older the specimen, the lower the coulombs, assuming that the sample has been cured properly. Research has also indicated that the presence in the concrete of admixtures containing ionic salts may affect the results obtained. We have found that the presence of ionic salts increases the amount of coulombs passed. It is theorized that the ionic salts act as additional transport medium for the charge. This results in a higher coulomb level even though the concrete's permeability has not changed. Admixtures that contain ionic salts are primarily accelerators composed of the following materials:

- Calcium Nitrite
- Calcium Nitrate
- Calcium Chloride
- Sodium Thiocyanate

It is strongly recommended that if concrete containing these admixtures is to be tested using this method, tests be performed with and without the admixture to see what effect the admixture will have on the results. The following is a partial list of other factors that can affect the test results:

- Cement factor
- Air content
- Water/Cement ratio
- Curing of the test sample
- Aggregate source or type

## What is the Precision and Accuracy of the Test Method?

There has been a great deal of debate over this test method because of large variations in results on companion test specimens. AASHTO T277 states that the results of companion samples tested by the same operator should not vary by more than 19.5%. This is an extremely large variation in allowable results. The ASTM method shows that the results of two properly conducted tests by the same operator on concrete samples from the same batch may differ as much as 42%. On companion samples tested by different laboratories, this percentage is raised to 51%. This large variability in test results indicates the relative inaccuracy of the test method while maintaining that concrete samples which lie within this large acceptable range are essentially equal in quality.

## Conclusion

It is important to remember that:

- This test method does not replicate actual conditions that concrete would experience in the field. There is no condition where concrete is exposed to a 60-volt potential.
- This test method does not measure concrete permeability. What it does measure is concrete **resistivity**. Resistance is calculated as volts divided by current. It has been shown that there is a fair correlation between concrete resistivity and concrete permeability.

At the present time this is the only test method that is widely accepted by the concrete industry. As more and more experience is gained with this test, as well as with other test methods, new procedures may be developed that measure concrete permeability more accurately.

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