ASTM C1202

Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Understanding ASTM International Test Procedures for Cement and Concrete - Staying Up to Standard

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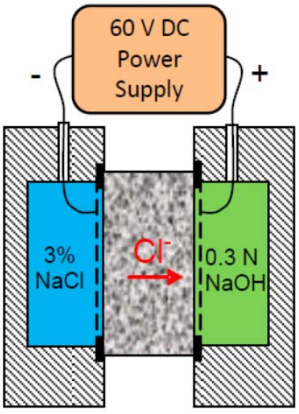
CTLGROUP

Scope/Significance and Use

- ***Scope:*** This test method covers the determination of the electrical conductance of concrete to provide a rapid indication of its resistance to the penetration of chloride ions. This test method is applicable to types of concrete where correlations have been established between this test procedure and long-term chloride ponding procedures such as those described in AASHTO T 259.



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How and Why Was this Test Developed?

- Developed for US FHWA in 1980s
- Techniques to nondestructively measure chloride permeability
- Prior: chloride ponding test used AASHTO T259
  - Takes 90 days or longer
  - Profile grinding, chemical analysis, and chloride profile
- Good correlation to ponding tests
- Electrical current used to accelerate the test

Description of Test

- 100 mm diameter cores or cylinders cut to 50 mm length
- Vacuum specimens for 3 hrs and submerge for 18 hrs
- System is then connected in direct current with 3% NaCl and 0.3 N Na OH
- Apply 60-volts potential for 6 hours and measure current every 30 mins.

Factors that Influence Results

- Age and curing (drastically affect results)
  - Older specimens lower coulombs
- Presence of admixtures with ionic salts
  - Salts act as transport media
  - Typ. Accelerators with Calcium Nitrite, Calcium Nitrate, and Calcium Chloride
- Others:
  - cement factor, air content, water/cement ratio, aggregate source/type

Apparatus: Vacuum Saturation Apparatus

- Vacuum Desiccator – Two Connections
- Vacuum Pump – must maintain less than 50 mm Hg (6650 Pa)
- Vacuum Gauge or Manometer

Apparatus: Coating Apparatus and Materials

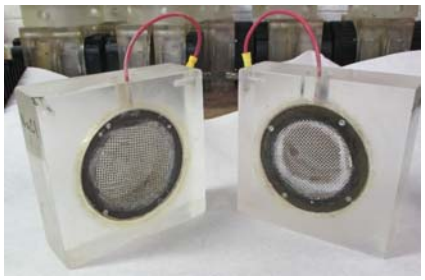
- Rapid setting, electrically nonconductive, capable of sealing side surface of concrete cores.
- Water-Cooled Diamond Saw

Apparatus: Reagents

- Sodium Chloride Solution (NaCl) – 3.0 % by Mass
- Sodium Hydroxide Solution (NaOH) – 0.3 N

Apparatus: Testing Cell

- Test Cells - symmetric poly (methyl methacrylate) chambers, each containing electrically conductive mesh and external connectors.



Test Specimens

- Cores: 100-mm diameter from field structures
  - Prepared per ASTM C42
- Cylinders: 100-mm cast in laboratory
  - Prepared per ASTM C192 and ASTM C31

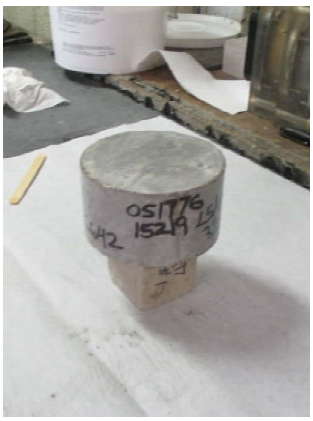
Curing Cylinders

- Moist Curing – 28 days for *Only Portland Cement*
  - Per ASTM C192 for laboratory cast specimens
  - Per ASTM C31 for field cast specimens
- Extended Moist Curing – 56 Days *for SCMs*
  - Allows extra time for SCMs to hydrate
- Accelerated Moist Curing – *for SCMs*
  - 7 days Moist cured followed by 21 days in lime-saturated water at 38.0 ± 2.0 °C.

Sample Preparation

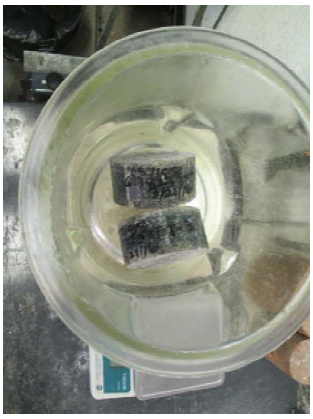
1. Cut a 50 ± 3 mm slice from the top of the core or cylinder

2. Prepare 10g of rapid setting coating and brush side surface of specimen

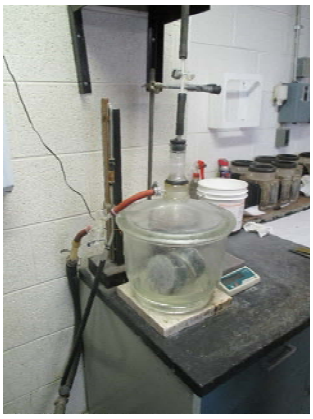


3. Allow coating to cure until no longer sticky

Conditioning Specimens



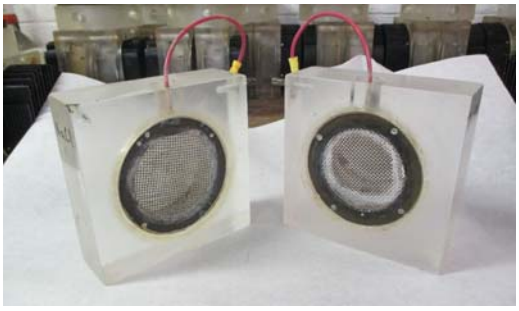
3. Place specimens in desiccator so that both end faces are exposed



4. Seal desiccator, start vacuum pump, and maintain for 3 hrs

5. Fill container with de-aerated water, open stopcock, submerge samples, and soak for 18 hrs.

Mounting Specimens – Other than Rubber Gasket



Mounting Specimens – Other than Rubber Gasket

1. Seal the edge to boundary of cell

2. Place specimen in sealant

3. Create a beveled edge to prevent leaks then allow sealant hardened

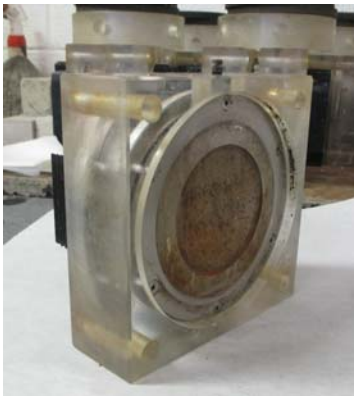
Mounting Specimens – Other than Rubber Gasket

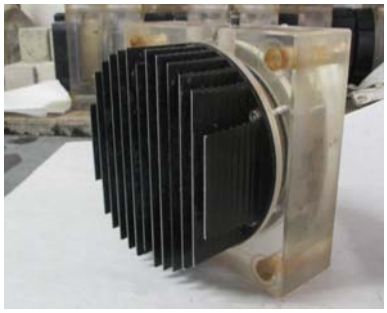
4. Seal the boundary of cell on 2nd side

5. Seat specimen and 1st half of cell on selant

6. Create a beveled edge to prevent leaks then allow sealant hardened

Mounting Specimens –Rubber Gasket





Mounting Specimens –Rubber Gasket

1. **Place rubber gasket and plastic sleeve over specimen**

2. Place specimen in sealant

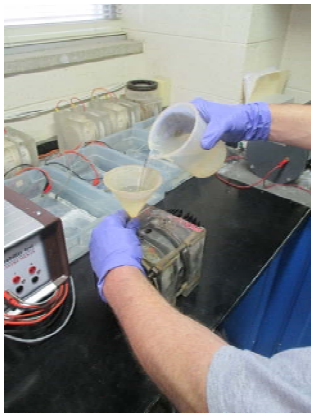
3. Create a beveled edge to prevent leaks then allow sealant hardened

Mounting Specimens –Rubber Gasket

4. Tighten bolts to compress rubber gaskets

5. Specimen prepared for testing

Test Setup – Connecting Wires (For Both Test Setups)



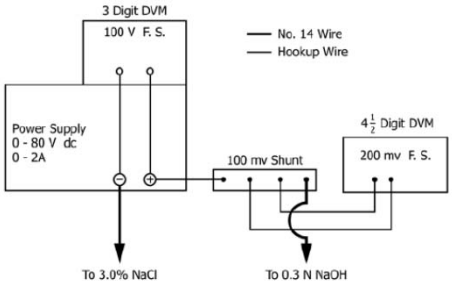
1. Fill Side 1 to top with 3% NaCl solution (Negative Side)

2. Fill Side 2 to top with 0.3 N NaOH) (Positive Side)

3. Attach wire leads and thermocouples (optional)

Test Setup

- Test setup as shown
- Air temperature shall be 20-25ºC
- Apply 60.0±0.1 V
- Read and record every 30 minutes
- Terminate test after 6 hours



Calculation: Total Charge Passed (Conductance)

- Plot amperes per time (sec)
- Determine the area under the curve to get coulombs
  - Using trapezoidal rule for determining area

$$Q = 900(I_0 + 2I_{30} + \cdots + 2I_{300} + 2I_{330} + 2I_{330})$$

Where:

Q = charge passed (coulombs),
I_0 = current (amperes) immediately after voltage is applied, and
I_t = current (amperes) at t_{min} after voltage is applied

Precision and Bias

- Single-Operator Precision: Coefficient of Variation of 12.3%
  - Tested at 11 labs with 3 samples per lab.
- Multilaboratory Precision
  - The average of three tests results may differ by 42%
  - Different laboratories it can vary by as much as 51%

Analysis of Results

- Qualitative indication of the chloride ion penetrability is shown below:

Coulombs	Permeability Class	Typical of
>4000	High	$w/c^* > 0.5$
4000-2000	Moderate	$w/c = 0.4$ to 0.5
2000-1000	Low	$w/c < 0.4$
1000-100	Very Low	Latex-modified concrete
<100	Negligible	Polymer concrete

*w/c = water-cement ratio

- Test is not accurate enough to clearly define permeability levels
- Five categories were created.

Conclusion

- Test method does not replicate actual field conditions
  - There is no condition where concrete is exposed to 60-volt potential
- Test method does not measure concrete permeability
- It measures concrete resistivity
  - Fair correlation between concrete resistivity and concrete permeability
- Only test method that is widely accepted

Questions & Answers