HAPPY ST PATRICK'S DAY!

AMERICAN ENGINEERING TESTING, INC.

NEW TEST METHODS FOR PERFORMANCE CRITERIA

MCC SPRING SYMPOSIUM - PRESCRIPTION TO PERFORMANCE

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AMERICAN ENGINEERING TESTING

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OUTLINE

Fresh Properties

- **AASHTO TP118 SAM Meter**
- **BOX Test**
- **ASTM C1646 Making Freeze-Thaw Specimens**

Hardened Properties

- **Early Age Determination of Drying Shrinkage**
- **Methods of Determining Fluid Migration**
  - ✓ **Wenner Probe**
  - ✓ **Nordtest**

FRESH PROPERTIES OF CONCRETE

Fresh Properties

- **AASHTO TP 118 SAM Meter**
- **BOX TEST**
- **ASTM C1646 Making Freeze-Thaw Specimens**

AASHTO TP118 - SAM METER

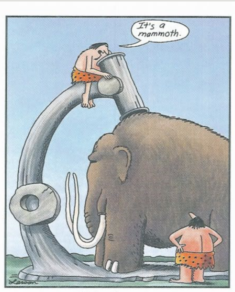
ASTM C231, Pressure Air Meter

Sam

ACI REFERENCE

The American Concrete Institute (ACI) recommends an average air content of 5 to 6% (± 1.5%) for exterior concrete with 3/4" nominal sized aggregate in moderate to severe service conditions (from ACI 201.2R-08).

Additionally, ACI recommends a specific surface value of greater than 600 and a spacing factor <u><</u>0.008" in order for concrete to be considered freeze thaw durable (from ACI 212.3R-10).



Early microscope

SAM TEST RESULTS

- A SAM number of 0.20 shows 94% agreement with laboratory spacing factor limit of 0.008”
- The same limit shows 89% agreement with specific surface limit of 600 in^{-1}
- For the freeze thaw data there is better agreement for a SAM number of 0.25 (89%) then for a SAM number of 0.20 (80%)
- The SAM number had a better correlation with freeze thaw results then the spacing factor

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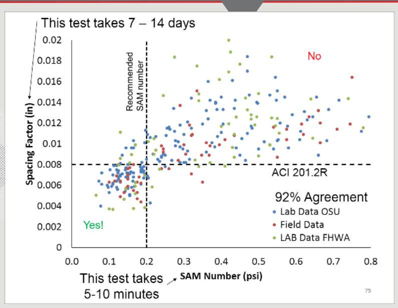
SAM GRAPH



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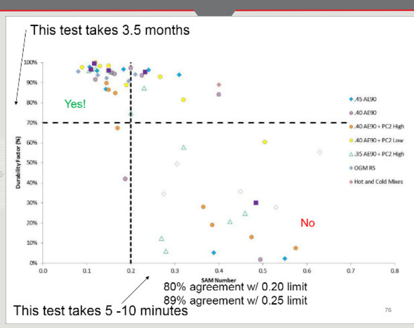
SAM GRAPH



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BOX TEST – PAVEMENT EDGE

BOX TEST

The Box Test

A workability test for slip formed pavements. It evaluates the ability of a mixture to be consolidated and subsequently hold an edge. If the mixture does not perform well, water reducer can be added until it passes This provides a useful way to compare the performance of slip formed paving mixtures.

BOX TEST – PAVEMENT CONCRETE

The box test is a simple test that examines:

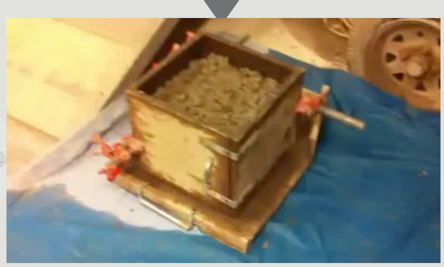
- Response to vibration
- Filling ability of the paste
- Ability of the slip form pavement to hold an edge – cohesiveness

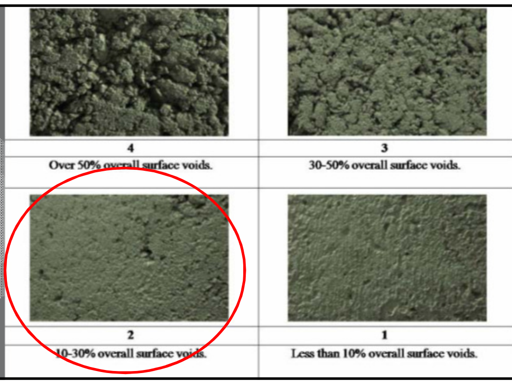
BOX TEST

	Step 1	Gather the different components of the Box Test.
	Step 2	Construct box and place clamps tightly around box. Hand scoop mixture into box until the concrete height is 9.5" (241.3 mm).
	Step 3	Insert vibrator downward for 3 seconds and upward for 3 seconds. Remove vibrator.
	Step 4	After removing clamps and the forms, inspect the sides for surface voids and edge slumping.

BOX TEST – PAVEMENT CONCRETE

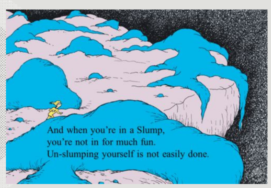
BOX TEST





BOX TEST

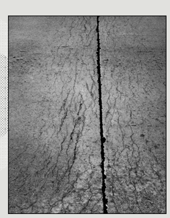
The slump test cannot tell us this information!

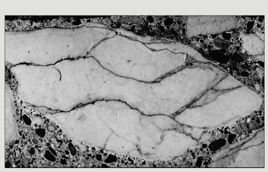


Interesting fact: The origin of the word slump (1700's) is Norwegian and originally meant "to fall into a bog" !

ASTM C1646 MAKING AND CURING FREEZE-THAW SPECIMENS

D-Cracking





ASTM C1646 MAKING AND CURING FREEZE-THAW SPECIMENS

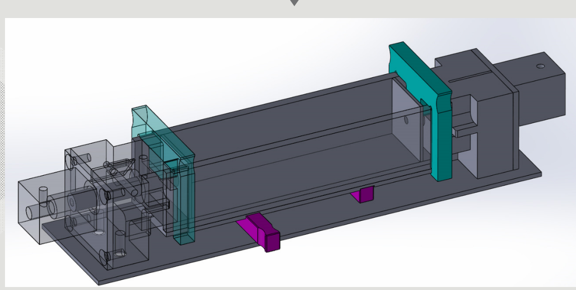
- Make ASTM C666 freeze-thaw beams for durability using a prescribed air-entrained mix design and innocuous complementary coarse or fine aggregate. Do not use the project mix design.
- Specifically tests the aggregate for durability.
- For use when suitability of aggregate is to be determined for prequalification of materials.

HARDENED PROPERTIES OF CONCRETE

Hardened Properties

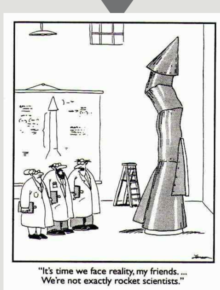
- **Early Age Determination of Drying Shrinkage**
- **Methods of Determining Fluid Migration**
  - ✓**Wenner Probe**
  - ✓**Bulk Resistivity**
  - ✓**Nordtest**

EARLY AGE SHRINKAGE – DRAFT ASTM TEST METHOD



EARLY AGE SHRINKAGE

- Determination of the length change of mortar specimens starting from early age, when exposed to controlled conditions of temperature and humidity.
- Mortar specimens are cast in the molds. The specimens are initially restrained on both ends until measurements are initiated.
- Subsequently, one of the ends is loosened allowing for free length change, which is then measured using contact LVDT type sensors that allow for continuous measurement from an early age.
- The tests are conducted under controlled laboratory conditions.



ASTM C1202 (AASHTO T277) – RAPID CHLORIDE PENETRATION

Chloride migration through concrete, even in high water/cement ratio concrete, is a very slow process. The development of this test method had the goal of accelerating this migration. When an electrical current is applied to a concrete specimen it increased and accelerated the rate at which the chlorides migrated into concrete. 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 an AASHTO T259/T260 ponding test a good correlation existed.

Table: 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

WENNER PROBE

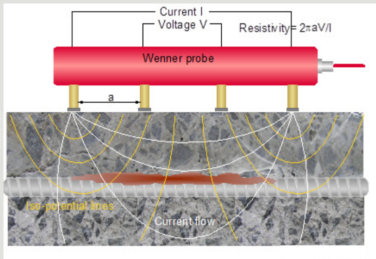
Standard Method of Test for Surface Resistivity Indication of Concrete’s Ability to Resist Chloride Ion Penetration

AASHTO Designation: T358-15

WENNER PROBE

- **This method can determine the electrical resistivity of all types of concrete by providing a rapid indication of its resistance to the penetration of chloride ions.**
- **This test method is suitable for evaluation of materials and material proportions for design purposes as well as research and development.**
- **Sample age may have significant effects on the test results, depending on the type of concrete and the curing procedure.**
- **Most concretes, if properly cured, become progressively and significantly less permeable with time.**

WENNER PROBE



WENNER PROBE

GIATEC SCIENTIFIC

WENNER PROBE

Corrosion is an electro-chemical process. The rate of flow of the ions between the anode and cathode areas, and therefore the rate at which corrosion can occur, is affected by the resistivity of the concrete. To measure the electrical resistivity of the concrete a current is applied to the two outer probes and the potential difference is measured between the two inner probes. Empirical tests have arrived at the following threshold values which can be used to determine the likelihood of corrosion.

- When $\rho \geq 120\ \Omega$-m — corrosion is unlikely
- When $\rho = 80$ to $120\ \Omega$-m — corrosion is possible
- When $\rho \leq 80\ \Omega$-m — corrosion is fairly certain

WENNER PROBE

These values have to be used cautiously as there is strong evidence that chloride diffusion and surface electrical resistivity is dependent on other factors such as mix composition and age. The electrical resistivity of the concrete cover layer decreases due to:

- Increasing concrete water content
- Increasing concrete porosity
- Increasing temperature
- Increasing chloride content
- Decreasing carbonation depth

When the electrical resistivity of the concrete is low, the rate of corrosion increases.

When the electrical resistivity is high, e.g. in case of dry and carbonated concrete, the rate of corrosion decreases.

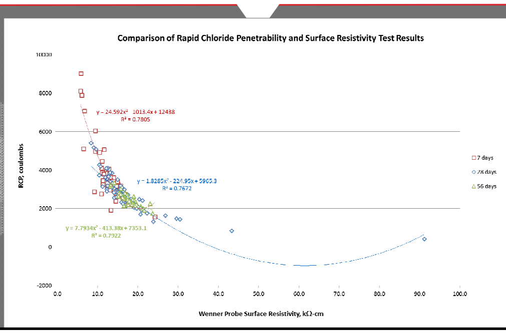
WENNER PROBE

Table 1—Chloride Ion Penetration

Chloride Ion Penetration	Surface Resistivity Test	
	100-by-200-mm (4-by-8-in.) Cylinder (kΩ-cm) *a* = 1.5	150-by-300-mm (6-by-12-in.) Cy (kΩ-cm) *a* = 1.5
High	<12	<9.5
Moderate	12–21	9.5–16.5
Low	21–37	16.5–29
Very low	37–254	29–199
Negligible	>254	>199

a = Wenner probe tip spacing

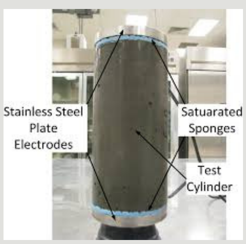
RAPID CHLORIDE VS WENNER PROBE



BULK RESISTIVITY

ASTM C1760: Bulk Conductivity

BULK RESISTIVITY



BULK RESISTIVITY

- The measure of the bulk electrical conductivity, or its inverse, the bulk electrical resistivity, of saturated 100 mm diameter concrete cylinders or cores with lengths up to 200 mm.
- The test is simple to perform and a measurement is obtained within two seconds. The conductivity of a saturated concrete specimen provides information on the resistance of the concrete to penetration of ionic species by diffusion.
- The term bulk is used to indicate that the measurement is made through the specimen as opposed to a surface-based measurement.

BULK RESISTIVITY

Table 5.5: Recommended Chloride Ion Penetrability Based on Resistivity

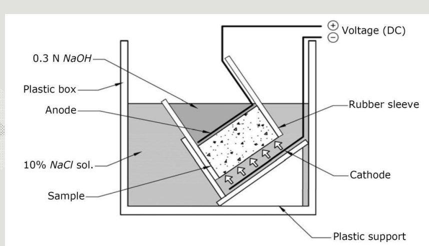
Risk	RCPT (Coulombs)	Wenner (Ω-m)	//Plate – 200mm (Ω-m)	//Plate – 50mm (Ω-m)	AC-Cell (Ω-m)	DC-Cell (Ω-m_
High	>4000	<50	<70	<50	<50	<50
Moderate	2000-4000	100-50	130-70	100-50	80-50	100-50
Low	1000-2000	200-100	250-130	200-100	170-80	200-100
Very Low	100-1000	2300-200	2300-250	2600-200	2000-170	2000-200
Negligible	<100	>2300	>2300	>2600	>2000	>2000

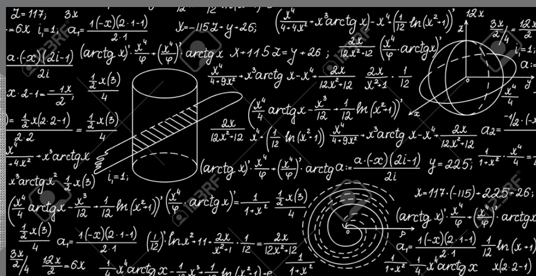
Smith, D. 2004. "The Development of a Rapid Test for Determining the Transport Properties of Concrete." M.Sc.E. Thesis, University of New Brunswick

NORDTEST NTBUILD 492

Nordtest NTBuild 492: Chloride Migration Coefficient from Non-Steady State Migration Experiment

NORDTEST NTBUILD 492





NORDTEST NTBUILD 492

Model Code for Service Life Design (PDF)-fib Bulletin 34 (2006)

fib Bulletin 34 addresses Service Life Design (SLD) for plain concrete, reinforced concrete and pre-stressed concrete structures, with a special focus on design provisions for managing the adverse effects of degradation. Its objective is to identify agreed durability related models and to prepare the framework for standardization of performance based design approaches. May be applied for the design of new structures, for updating the service life design if the structure exists and real material properties and/or the interaction of environment and structure can be measured (real concrete covers, carbonation depths), and for calculating residual service life.

QUESTIONS?

"Mr. Osborne, may I be excused? My brain is full."