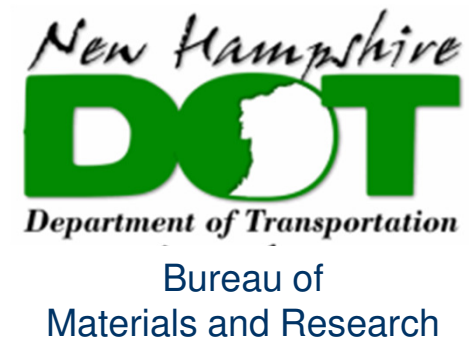


Surface Resistivity Test

as a Replacement to the Rapid Chloride Ion Penetration Test

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Bridge Engineer
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Rapid Chloride Ion Penetration Test vs. Surface Resistivity

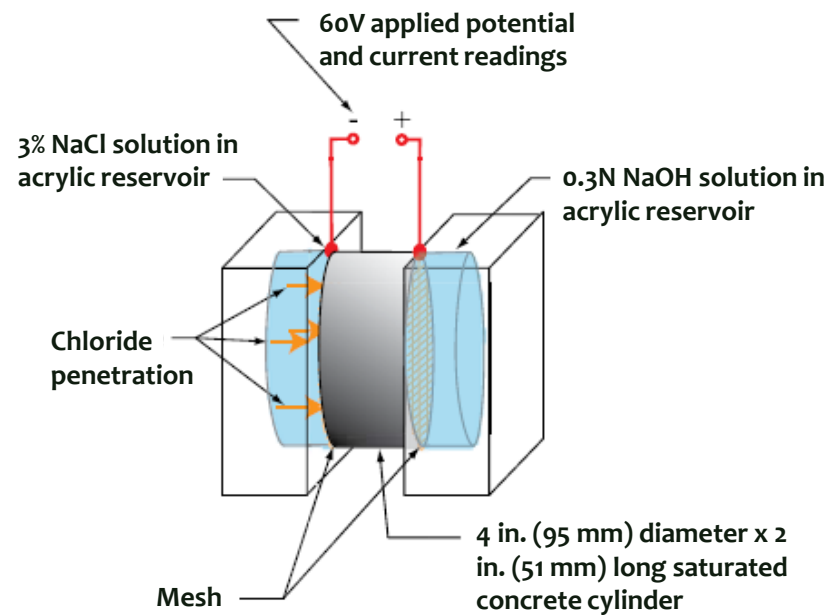
- Testing Purposes

- Indication of concrete's ability to resist chloride ion penetration, leading to:
 - Corrosion of reinforcing steel
 - Freeze-thaw damage issues

- Why Change Methods

- Time & Cost savings
- Simpler method
- Existing equipment age, etc.

How it works: RCPT (AASHTO T 277)



- Vacuum pump
- Voltage
- Solution
- Current

Use at NHDOT

- Pay factor for QC/QA concrete

TABLE 1 Chloride Ion Penetrability Based on Charge Passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4,000	High
2,000–4,000	Moderate
1,000–2,000	Low
100–1,000	Very Low
<100	Negligible

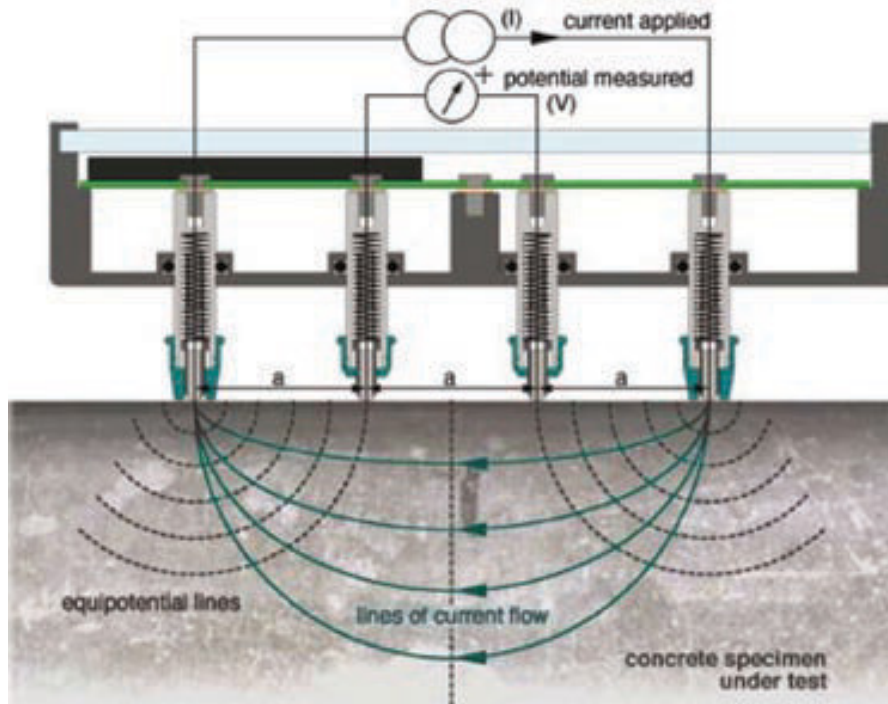
Class AA PERMEABILITY INDEX	PAY FACTOR
CHARGE PASSED (COULOMBS)	
> 0 and \leq 1000	1.05 - 0.00005 (1000 - C)
>1000 and \leq 3000	1.05
>3000 and \leq 4000	1 + 0.00005 (4000 - C)
>4000 and \leq 7000	1+0.0000833(4000-C)

Surface Resistivity Tester



- A battery operated handheld device equipped with a 4-pin Wenner probe array
- Measures resistance to chloride ion penetration in concrete
- On-board data storage

How it works: SRT (AASHTO TP 95)



- AC current is applied between the two outer probes
- The two inner probes measure the resultant potential difference
- **Resistivity = $2\pi aV/I$ [$k\Omega \cdot cm$]**

Sampling Matrix

Mix #	Location	Supplier	Product Description	Water/Cement	Pozzolan
Mix 1	Hudson, NH	CSI	5000 PSI SCC	0.35	20% Fly Ash
Mix 2	Henniker, NH	Michie Corp.	5000 PSI Bridge Rail	0.319	40% Fly Ash
Mix 3	Salem, NH	Aggregate Industries	4000 PSI 3/4" NH QCQA	0.38	30% Fly Ash
Mix 4	Dover, NH	Redimix Companies, INC.	NHDOT 3/8" AAA	0.422	50% Slag
Mix 5	Hudson, NH	CSI	5000 PSI SCC	0.33	20% Fly Ash
Mix 6	Henniker, NH	Michie Corp.	Redirock	0.382	60% Fly Ash

- 6 different mixes were tested
- Each mix was batched on 3 different days
- The cylinders were immediately labeled and placed in the wet room

SRT Testing



- RCPT were run at 28, 56, and 91 days
- Surface Resistivity measured the previous day
- One sample is taken out of the wet room at a time

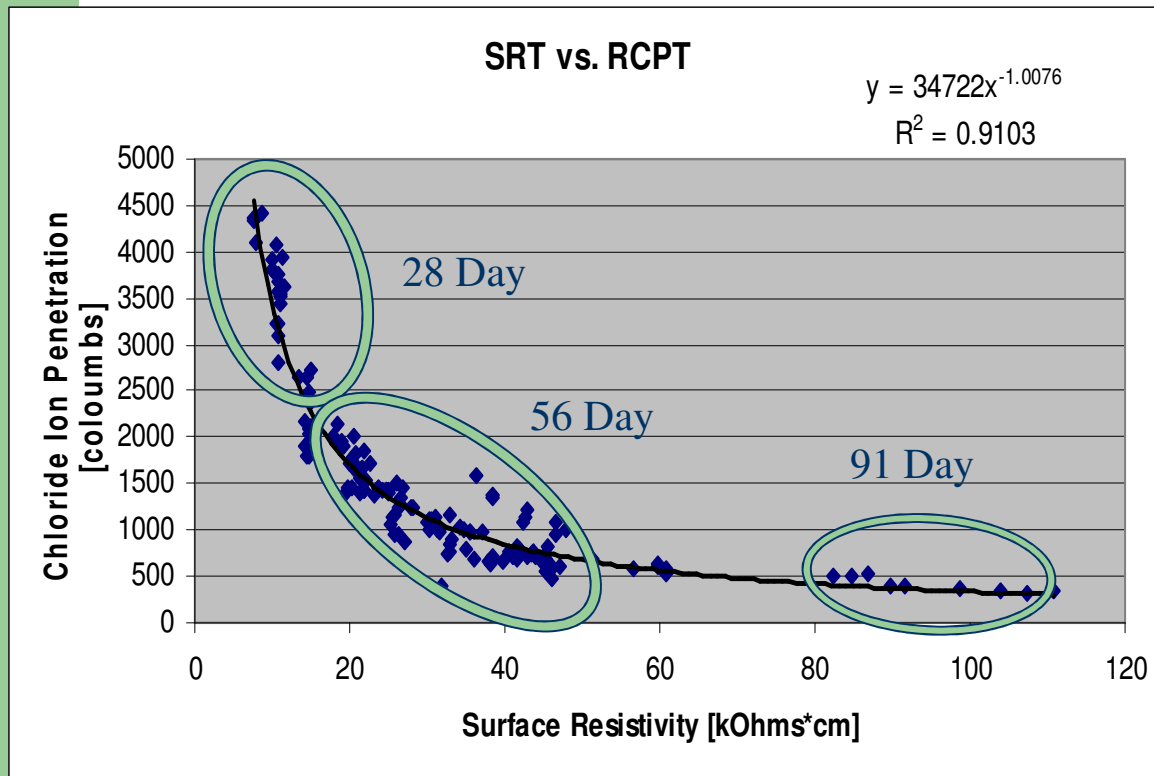
Testing

Time Until Critical Evaporation

ID	Name	Date & Time	Mean Value	Total	Std. Deviation
4	0min	03/05/2012 3:06...	7.5 kΩcm	8	0.30
5	5min	03/05/2012 3:06...	8.7 kΩcm	8	3.47
6	10min	03/05/2012 3:06...	8.0 kΩcm	8	2.52
7	15min	03/05/2012 3:06...	10.3 kΩcm	8	7.70

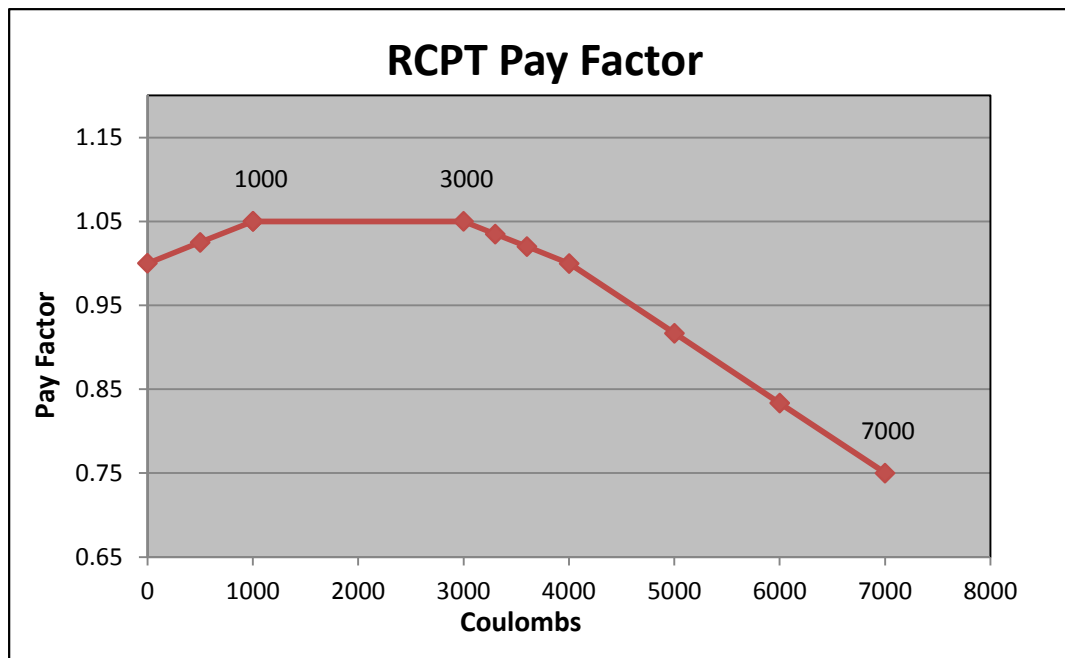
- Increase in resistivity values
- Increase in standard deviation

Results



- Good correlation at all tested ages, and whole spectrum of expected coulomb values
- R^2 value of 0.91 proves good correlation

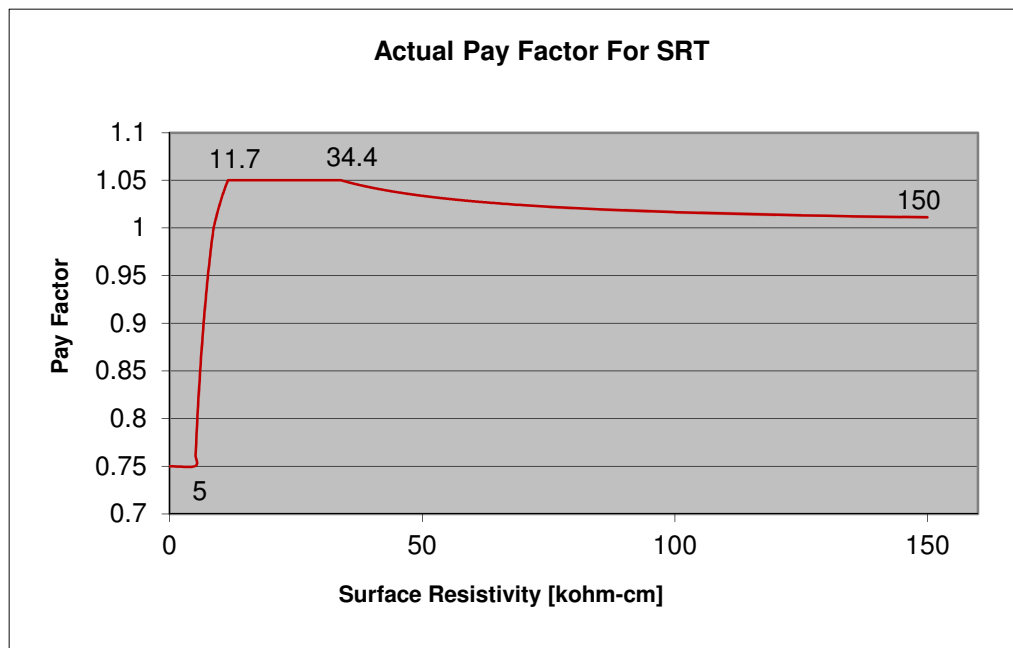
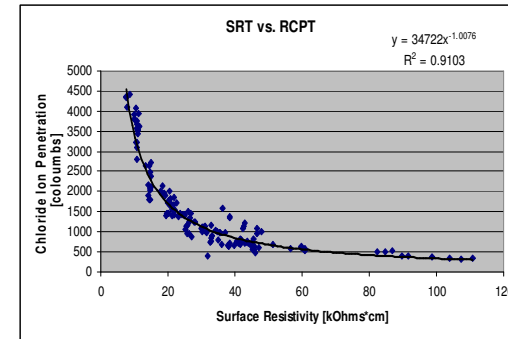
Pay Factor Development



- Original RCPT Pay Factor
- Paid 1.05 from 1000 to 3000 Coulombs

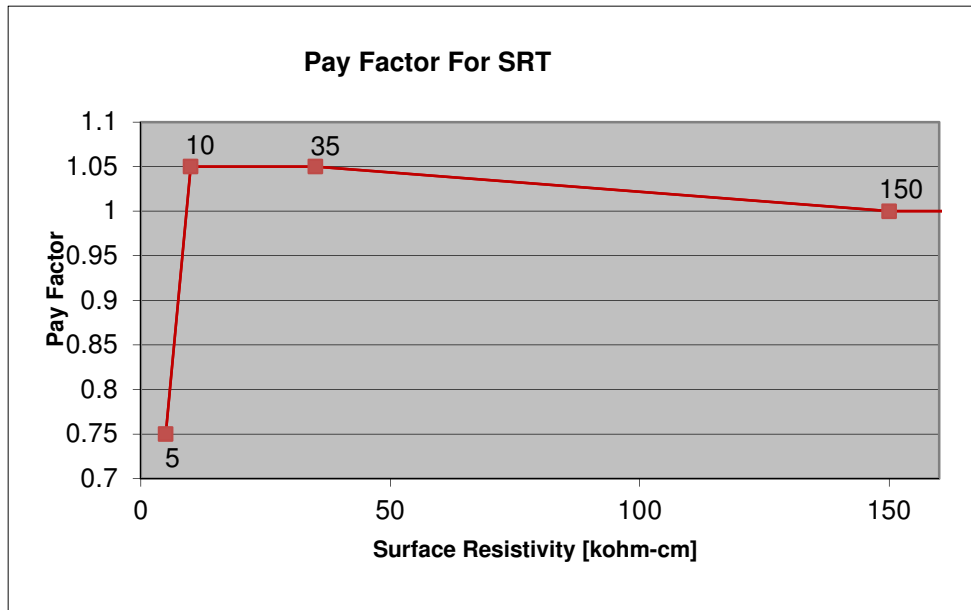
Class AA PERMEABILITY INDEX	PAY FACTOR
CHARGE PASSED (COULOMBS)	
> 0 and ≤ 1000	$1.05 - 0.00005 (1000 - C)$
>1000 and ≤ 3000	1.05
>3000 and ≤ 4000	$1 + 0.00005 (4000 - C)$
>4000 and ≤ 7000	$1 + 0.0000833(4000 - C)$

Pay Factor Development



- Direct conversion to SRT values complicated P.F. equations due to curved graph
- Specification boundaries fall at odd values

Pay Factor Development



- Linear chart simplified P.F. equations
- 1.05 P.F. was expanded slightly to give Spec. boundaries 'round' values

SRT Value		Pay Factor Equation
Less than	5	Rejected
Between	5-10	$1.05 - 0.06(10 - \text{SRT})$
Between	10-35	1.05
Between	35-150	$1.0 + 0.0004347(150 - \text{SRT})$
Above	150	1.0

Estimated Yearly Savings

Estimated Yearly Costs (Average of 280 tests)			
<u>Test Method</u>	<u>Testing one sub-lot [hr]</u>	<u>Labor cost per sub- lot</u>	<u>Yearly Cost</u>
SRT	0.56	\$18.12	\$5,073
RCPT	1.32	\$42.72	\$11,962
Yearly Savings			\$6,890

Based on:

- Average number of tests in past 3 years
- Hands-on labor for RCPT
 - Actual testing duration is 28 hours including waiting periods

Implementation

- Demonstration at DOT lab for contractor buy-in
- Perform SRT for all permeability testing as of February 2013
- For pre-existing contracts, SRT values would be converted and reported in Coulombs
- If 1.05 P.F. was not achieved, RCPT test would also be run, and those values used for pay
- No disputes to date

Benefits

- Time
 - Perform a test in minutes
 - Increase daily testing capacity
- Precision
 - Low standard deviation
- Cost
 - Lower capital cost, no operational supplies
 - RCPT - \$18,000
 - SRT - \$ 3,000

Future Testing

- 28 Day Testing
 - TP 95 requires testing at 28 days.
 - NHDOT specifications are based on 56 days of maturity
 - Further correlation would allow earlier permeability test date with the SRT
- Field Testing
 - Testing on in-place structures

Questions?

Thank You

