Roller Compacted Concrete Demonstration Project

Joint Effort

- FHWA
- MODOT
- Emery Sapp & Sons, Inc.
- A. G. Peltz Group LLC

Project Details

- 6 inch RCC overlay
- 2 – 10.5 foot lanes
- Approximately 2000 feet long
- Ponderosa Road just south of Gans Road interchange near Columbia, MO
- Contract Amount ~ $143,000

Project Feasibility

- Project Size
- Site Geometry
- End User Needs

Why RCC Paving?

- Speed of Construction
- Early Strength Gain
- Durability
- Cost

RCC paving

Materials

Construction

Testing

Develop Specifications

Existing Condition

Typical RCC Mix Design

- 3400 to 3700 lbs of well graded aggregate
- 400-550 lbs of cementitious material
- 23-30 gallons of water
- W/C Ratio usually between 0.3 and 0.45

Our Mix Design

- 3400 to 3700 lbs of well graded aggregate

  3274 lbs
- 400-550 lbs of cementitious material

  500 lbs
- 23-30 gallons of water

  32 gallons
- W/C Ratio usually between 0.3 and 0.45

  0.53

Mix Design

- Coarse Aggregate 1461.0 lbs. (45%)
- Fine Aggregate 1813.3 lbs. (55%)
- Cement 503.1 lbs (5.35 Sacks)
- Water 266.7 lbs or 32 gallons
- W/C Ratio 0.53

Construction

Construction

Construction

Testing Plan

- Nuclear Density Testing
- Compressive Strength – Cores and Cylinders
- Boil Test
- Rapid Chloride Permeability
- Coefficient of Thermal Expansion (CTE)
- Freeze Thaw Durability

Testing Plan

- Nuclear Density Testing
- Compressive Strength – Cores and Cylinders
- Boil Test (testing in progress)
- Rapid Chloride Permeability
- Coefficient of Thermal Expansion (CTE) (testing in progress)
- Freeze Thaw Durability (testing in progress)

Testing Plan

- Thickness
- Linear Traverse
- Moisture Content
- Macro-texture Depth
- Calculated Density

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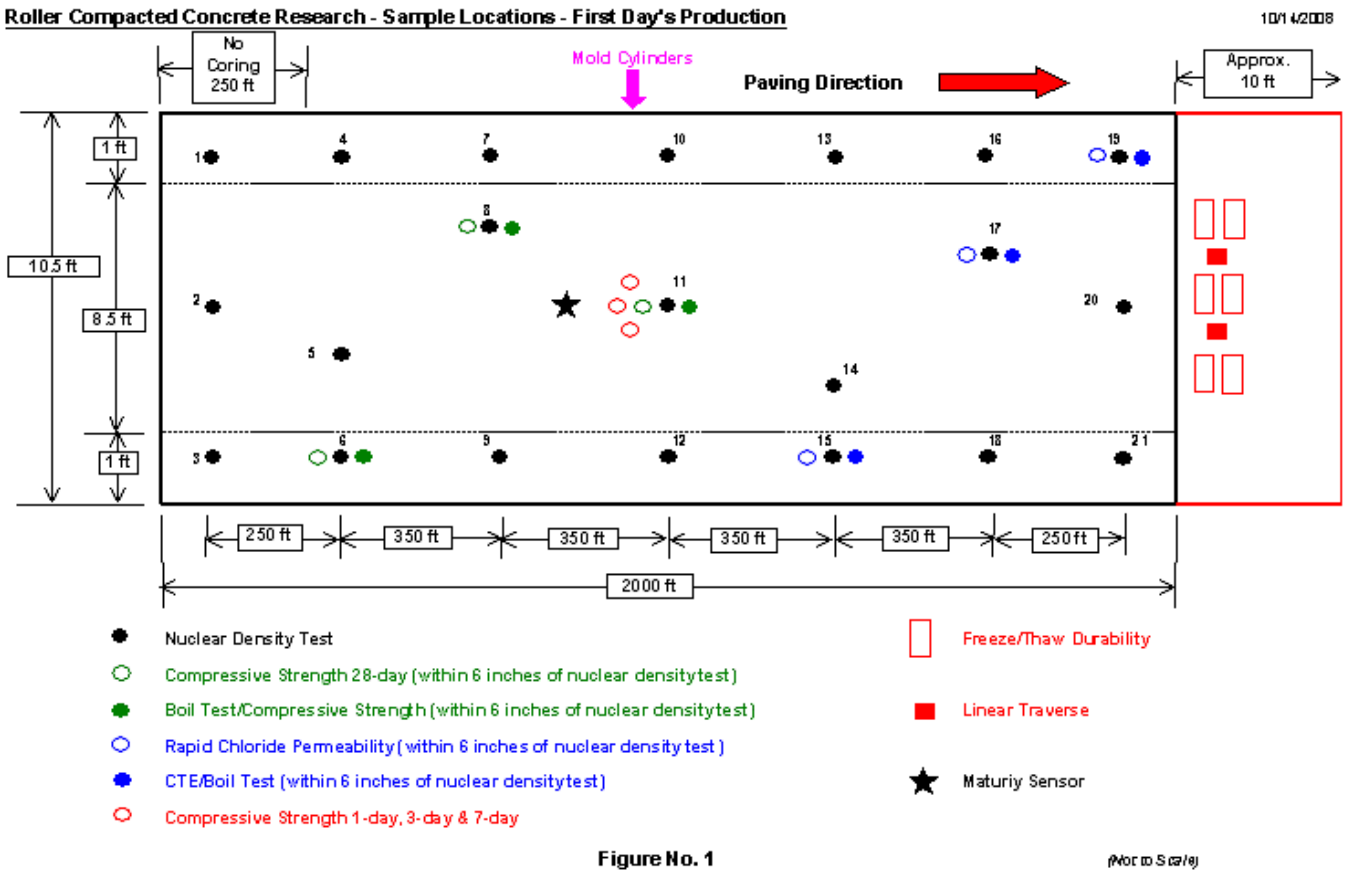
Roller Compacted Concrete Research - Sample Locations - First Day's Production
10/14/2008
No Coring 250 ft
Mold Cylinders
Paving Direction
Approx. 10 ft
1 ft
10.5 ft
8.5 ft
1 ft
250 ft
350 ft
350 ft
350 ft
350 ft
250 ft
2000 ft
Nuclear Density Test
Compressive Strength 28-day (within 6 inches of nuclear density test)
Boil Test/Compressive Strength (within 6 inches of nuclear density test)
Rapid Chloride Permeability (within 6 inches of nuclear density test)
CTE/Boil Test (within 6 inches of nuclear density test)
Compressive Strength 1-day, 3-day & 7-day
Freeze/Thaw Durability
Linear Traverse
Maturiy Sensor
(Not to Scale)

Figure No. 1

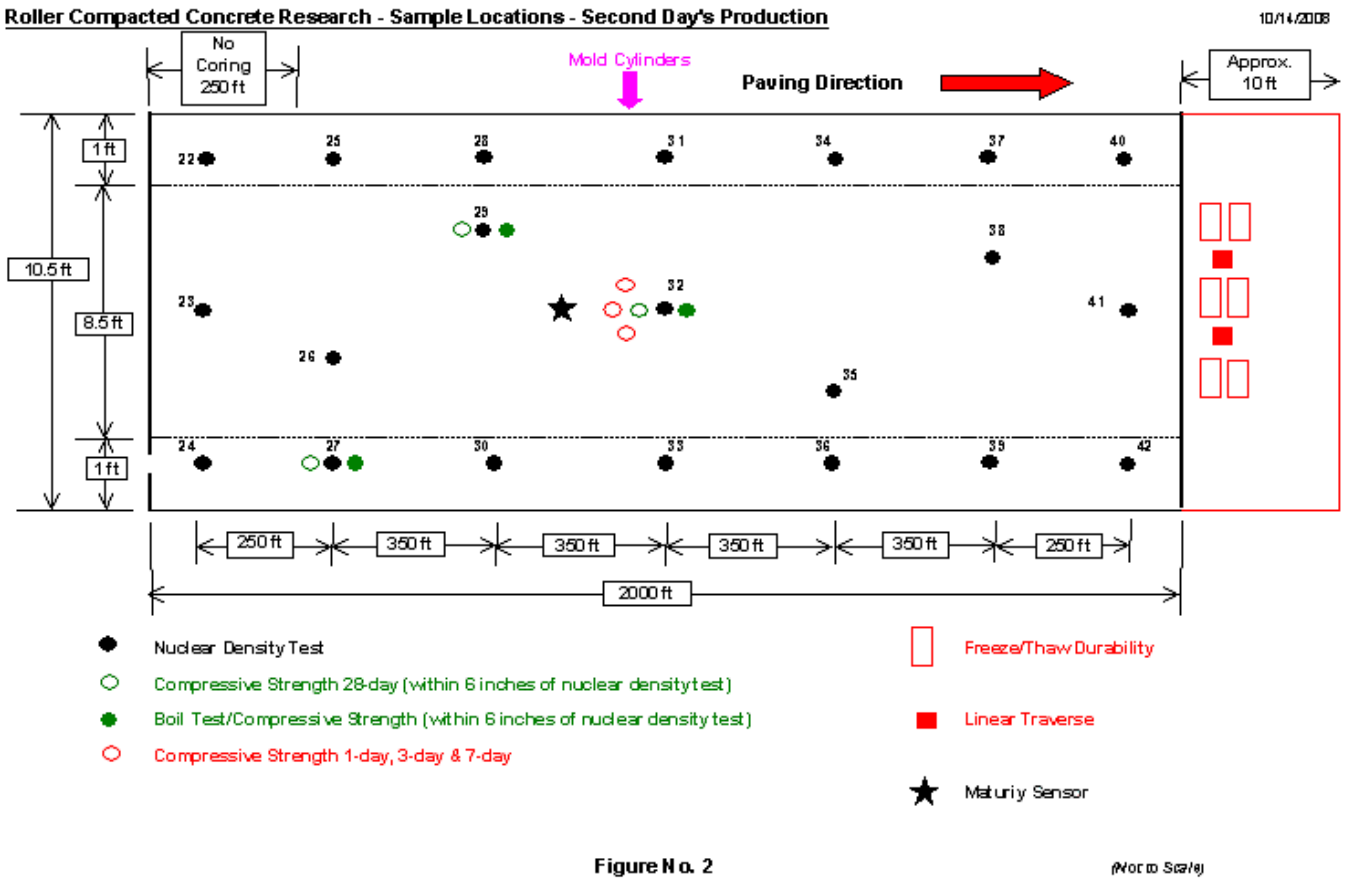

Figure No. 2

(Not to Scale)

Nuclear Density

- Dry Density
- % Compaction
- % Moisture
- AASHTO T 310

Nuclear Density

Percent Compaction	Day 1	Day 2
Uncompacted	91.7	92.9
Compacted	94.1	94.5

Nuclear Density

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Compacted	94.1	94.5

Acceptance for RCC shoulders is 95%

Nuclear Density

	Day 1	Day 2
Uncompacted Density	126.3	128.2
Compacted Density	132.9	130.3
% Moisture	8.0	8.0

Field Sampling Plan

- 8 cylinders molded according to ASTM 1176 (Vibrating Table)
- 8 cylinders molded according to ASTM 1435 (Vibrating Hammer)
- Two cylinders tested at 1 day, 3, day, 7 day, and 28 day for each molding technique

Concrete Strength Results

	Day 1 Core	Day 1 Cylinder	Day 2 Core	Day 2 Cylinder
1 day*	3450 (2 day)	2030	2110	2765
3 day*	3910	3500	3080	3940
7 day*	4360	5040	3490	4570
14 day	N/A	5240	N/A	5465
28 day**	3580	5560	2800	5700

* 1 core at 950 feet

** Average of 3 cores at 250, 600, and 950 feet

Core Thickness and Density

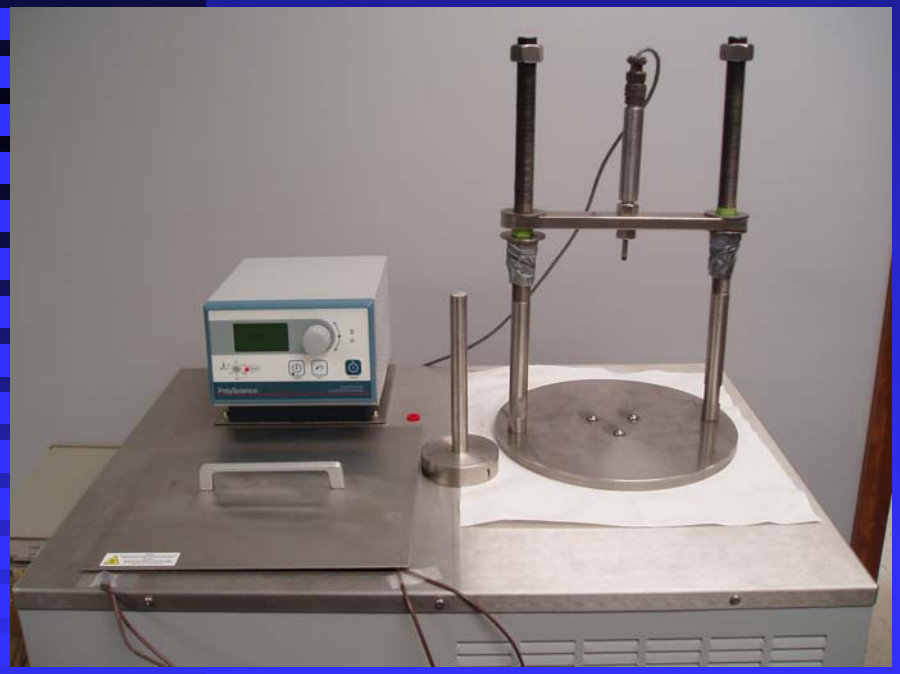
	Day 1	Day 2
Average Thickness	5.65	6.07
Average Density	142.35	139.17

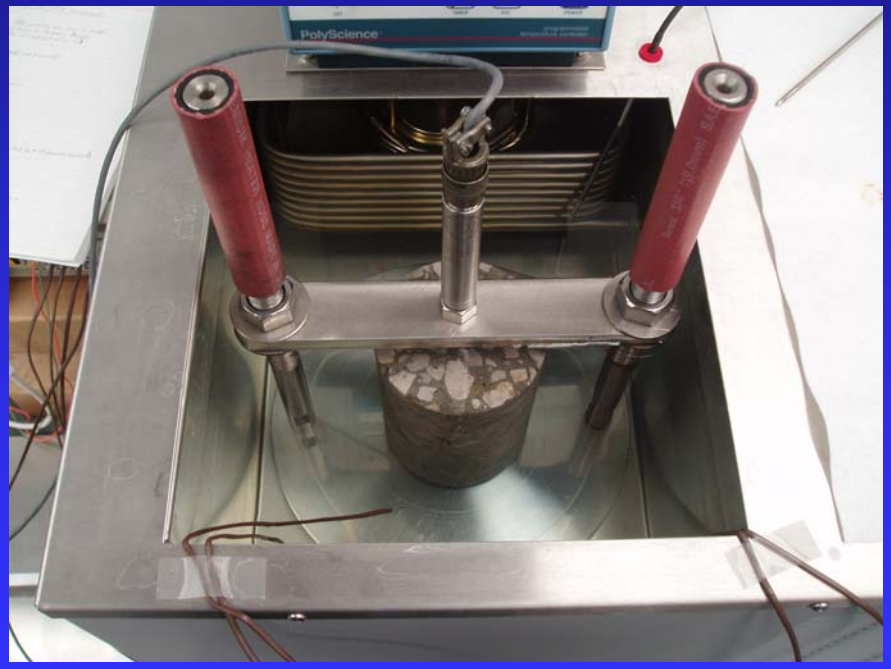
Coefficient of Thermal Expansion

-AASHTO TP 60

-Tested at 28 days

-Tests length change due to temperature change in micro-strains



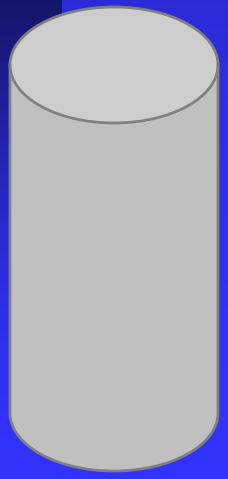


Boil Test

- **Density, Absorption and Voids in Harden Concrete**
  - Determine permeable voids of concrete
  - ASTM C 642
  - Mold 1 – 6” x 12” cylinder
  - Tested at 28 days

Boil Test

- Test Procedure – Permeable Voids:



top

middle

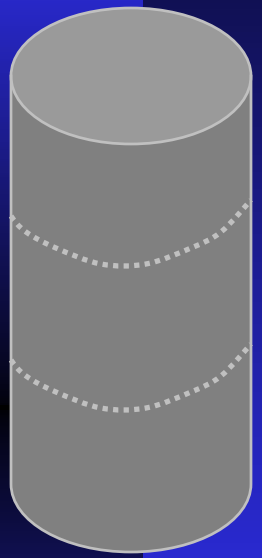
bottom -
not tested

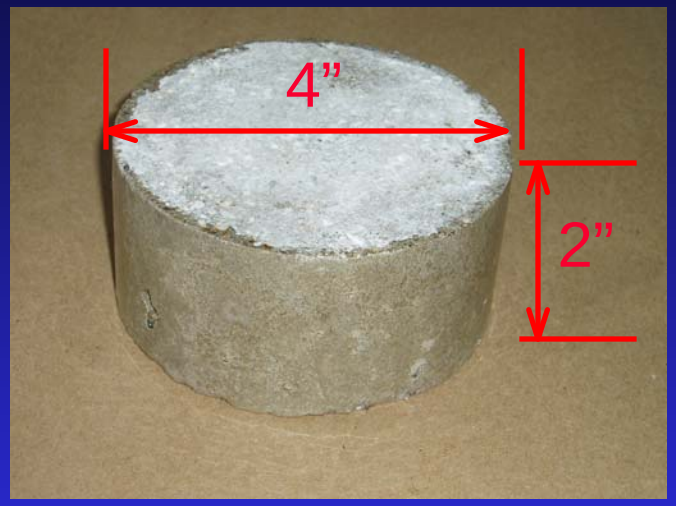
Rapid Chloride Permeability

- **Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration:**
  - Determine permeability of concrete
  - AASHTO T 277
  - Mold 1 - 4" x 8" cylinder
  - Test at 28-days

Rapid Chloride Permeability

- Test Procedures – Chloride Penetration





Chloride Ion Penetrability Base on Charge Passed

Charge Passed (Coulombs)	Chloride Ion Penetrability
>4000	High
>2000-4000	Moderate
>1000-2000	Low
100-1000	Very Low
<100	Negligible

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Charge passed through the RCC…..

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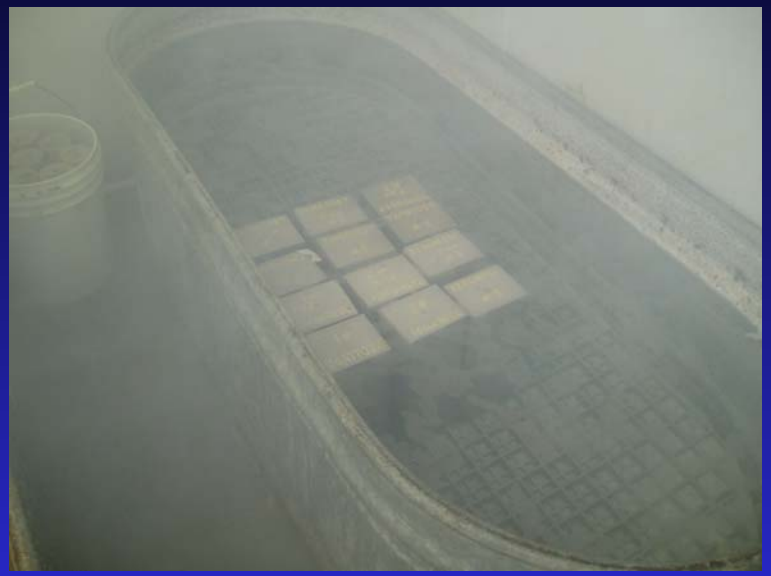
Charge passed through the RCC….. >10,000

Freeze / Thaw Testing

- **Resistance of Concrete to Rapid Freezing and Thawing**
  - AASHTO T 161, Procedure B
  - Test started after 35 days of curing
  - Beams cured in lime water



Required Beam Size

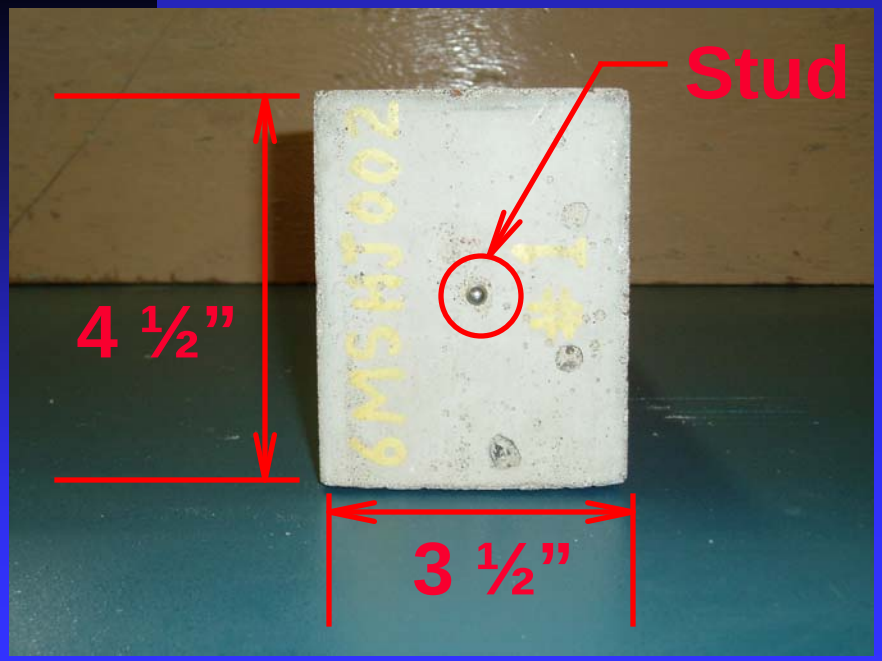
- **Width, depth or diameter**

- Range from 3” to 5”

- **Length**

- Range from 11” to 16”

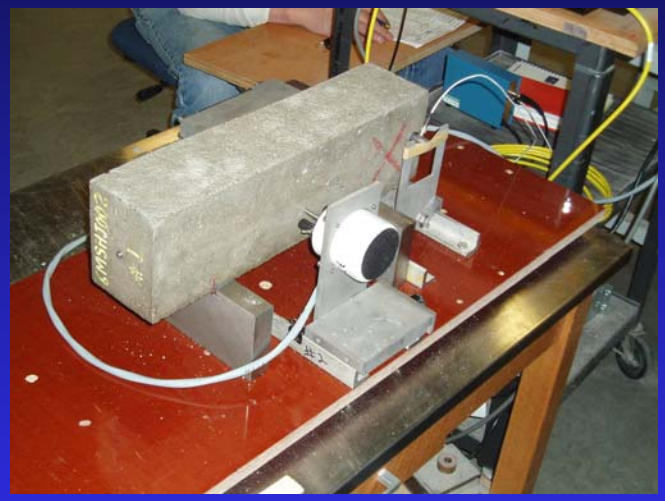
- **MoDOT Beams**

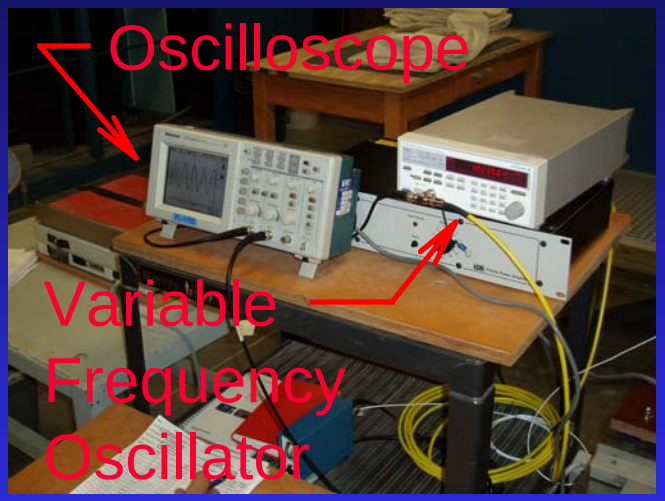


Harden Concrete Testing

- **Determining durability factor**

- Fundamental transverse frequency





Macro-texture Depth

- ASTM C 965

Macro-texture Depth

- Random Cross-Section of the project
- Ranged from 0.7 mm to 1.0 mm
- Average 0.86 mm
- Current minimum is 0.7 mm
- Extra Test performed on noticeably smooth section was 0.4 mm.

Macro-texture Depth

Linear Traverse

- Test performed on concrete sawed from the pavement for freeze-thaw durability testing
- ASTM 457
- Microscopical determination of air content of hardened concrete and of the specific surface, void frequency, spacing factor, and paste-air ratio of the air-void system in hardened concrete.

Profilograph

- In accordance with Section 502
- Initial results
  - Day 1 ~ 69 in/mile
  - Day 2 ~ 85 in / mile
- Current acceptance level is 45 in / mile for speed limit 45mph or less

Lessons Learned (so far)

- Delivery

Lessons Learned (so far)

- Delivery Trucks should remain covered

Lessons Learned (so far)

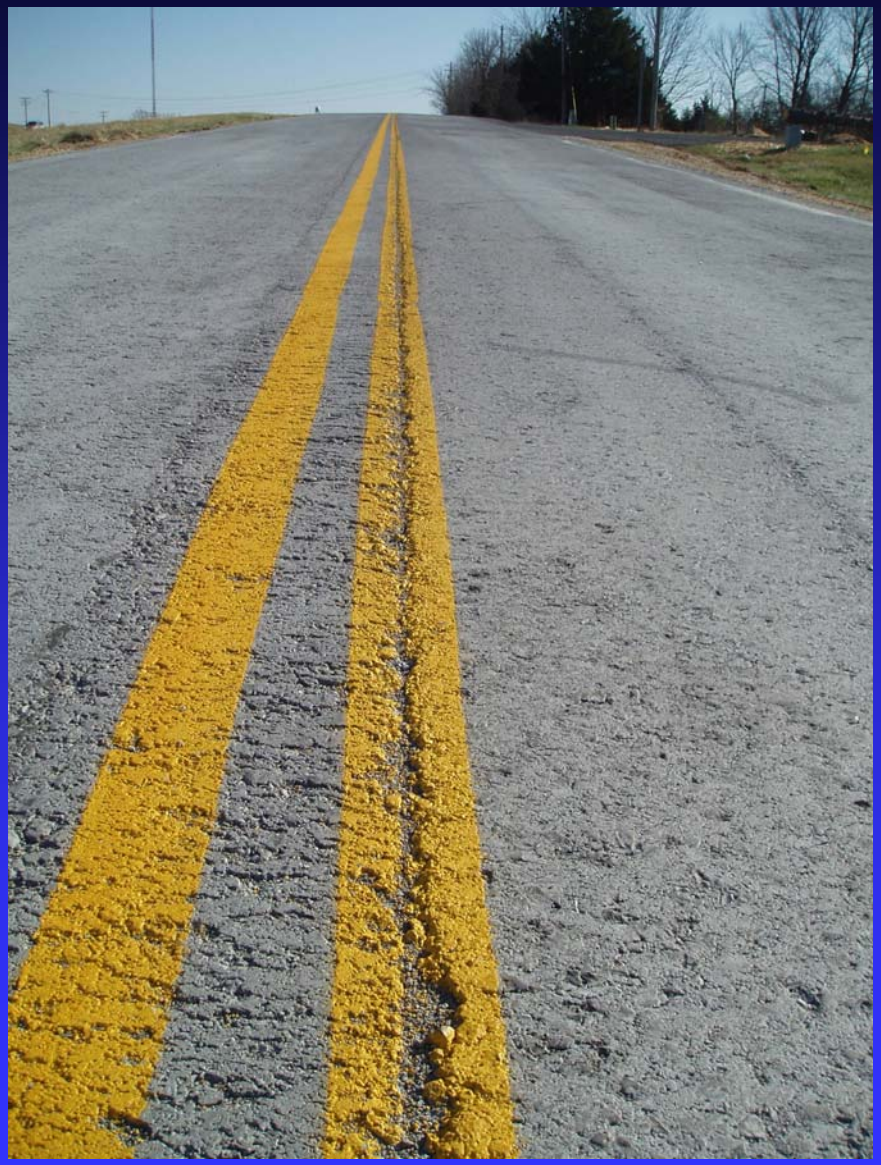
- Cold Joints

Lessons Learned (so far)

- Cold Joints Should be thoroughly cleaned or sawed prior to adjacent concrete placement

Lessons Learned (so far)

- Cold Joints

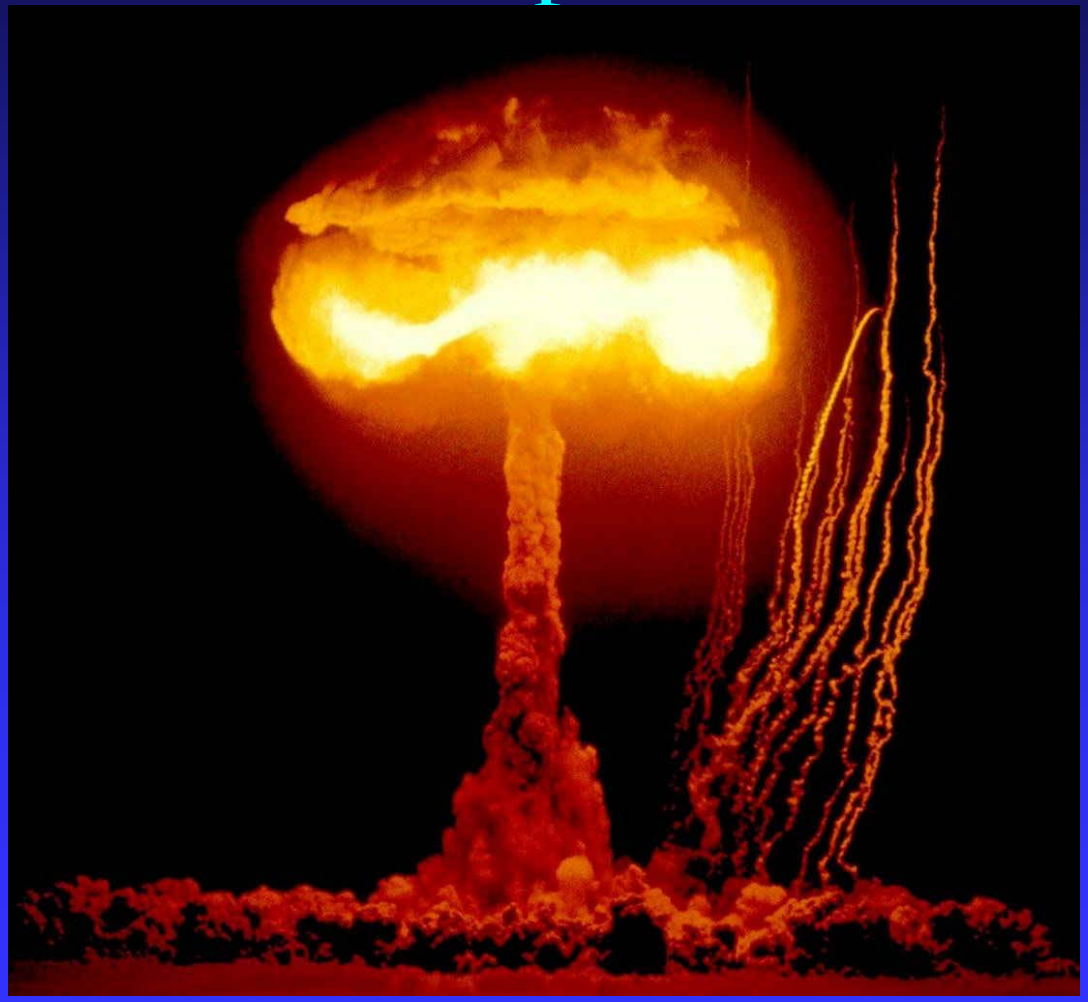


Lessons Learned (so far)

- Density is essential for strength and durability

Specifications

- Curing Compound application rate and expedience
- Covering loads
- Test section/Trial Batch 30 days in advance
- Minimum Density Requirements

Asphalt / Concrete Industry Utopia!

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