Roller Compacted Concrete in South Carolina

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Definition

"Roller-Compacted Concrete (RCC) is a no-slump concrete that is compacted by vibratory rollers."

- Zero slump (consistency of dense graded aggr.)
- No forms
- No reinforcing steel
- No finishing
- Consolidated with vibratory rollers

Concrete pavement placed in a different way!

Benefits of RCC Pavements

- Economical (both initial and life-cycle costs)
- High load carrying ability
- Eliminates rutting
- Excellent overall durability
- Simple, fast construction
- No forms or finishing


CAT
CAT


INGERSOLL-RAND

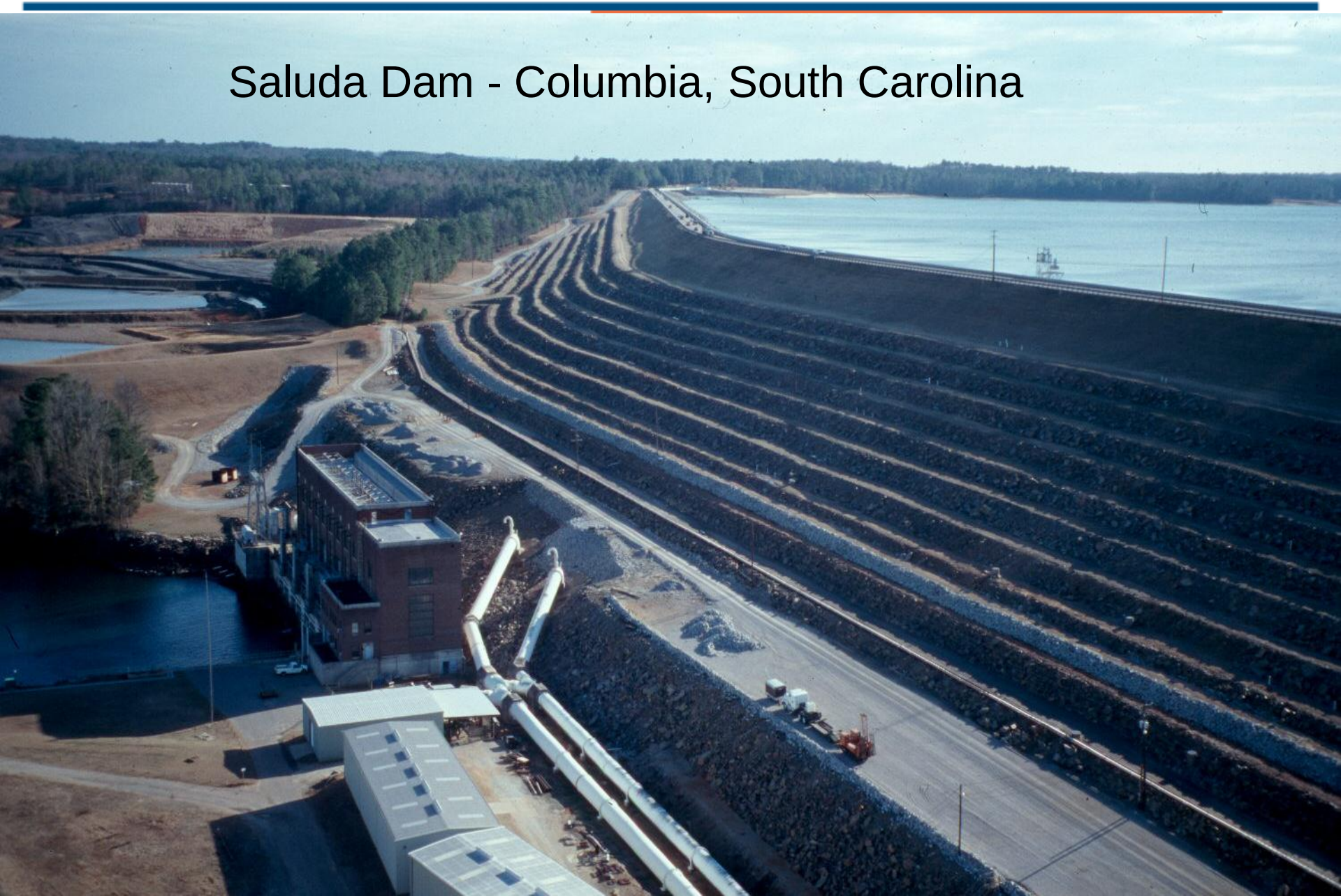
Surface Appearance

- Not as smooth as conventional concrete
- Important to recognize difference
- Similar appearance to asphalt only light grey instead of black

Surface Texture

Applications

Saluda Dam - Columbia, South Carolina



Military Facilities

Fort Lewis, WA
1986

Fort Drum, NY
1990

Fort Carson, CO
2008

Intermodal Facilities

Central Station
Detroit, MI

Burlington Northern
Denver, CO

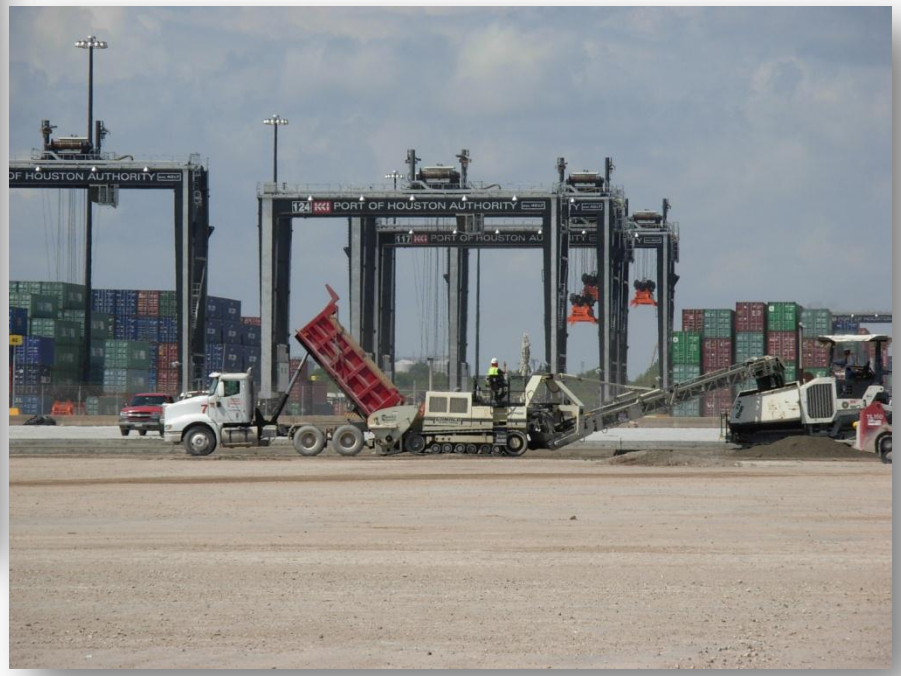
CN Intermodal Yard, Calgary

RCC decreased truck wait time from 8 to 2 hours

Unsurfaced aggregate is difficult to maneuver and presents safety hazard

Port Terminals

Norfolk International Terminal
2006



Port of Houston
2007

Distribution Centers

18 acre distribution center in Austin, TX

10 years after construction

GM Saturn Plant

Spring Hill, Tennessee

Honda Plant

Lincoln, Alabama

Mercedes-Benz Plant

Vance, Alabama

Streets & Interchanges

Residential street
Columbus, OH

Intersection replacement
Calgary, AB

Columbus, Ohio Area

SAVKO
We move the earth.

Highway Shoulders

I-285 Highway
Atlanta, GA

Selected SCDOT Projects

- Powell Pond Rd, Aiken County (Demo. Project)
- SC 5, York County
- US 78, Charleston County
- New State Road, Lexington County
- Greystone Boulevard, Richland County
- South Beltline Boulevard, Richland County
- Richland Street (US78), Aiken County
- SC 9, Horry County
- S-11-171, Cherokee County
- I-385 Shoulders, Laurens County
- I-385 Shoulders, Greenville County
- J A Cochran BP, Chester County
- SC 9 and SC 151 Intersection, Chester County
- SC 21 , Albright Rd, York County

Why are we using RCC?

(Andy Johnson, SCDOT State Pavement Engineer)

- Most or all of pavement structure can be placed in one lift.
- Does not require the curing time or adjacent lane encroachment of traditional PCC.
- Can handle heavy loads and high traffic volumes.
- Should be able to bridge poor subgrades effectively, if you can get it installed.
- Overall structure cost is very competitive with other pavement types.

SC Route 5, Rock Hill, Chester County

- 10” RCC:
  - Bid quantity 25,650 sy - $33/sy
    ($117.86 cy or $63.26/ton)
  - Placed Quantity 22,160 sy

US Route 78, Charleston County

- 5-lane section
- Original pavement built 1920's, widened in 1980's.
- ADT is 41,700 with 10% trucks.
- Asphalt Pavement condition was very poor.

US Route 78, Charleston County

- Alternate pavement design:
  - 200 psy HMA Surface
  - 10 inches RCC


EXIT


BRUCE
TAKEUCHI

US Route 78, Charleston County

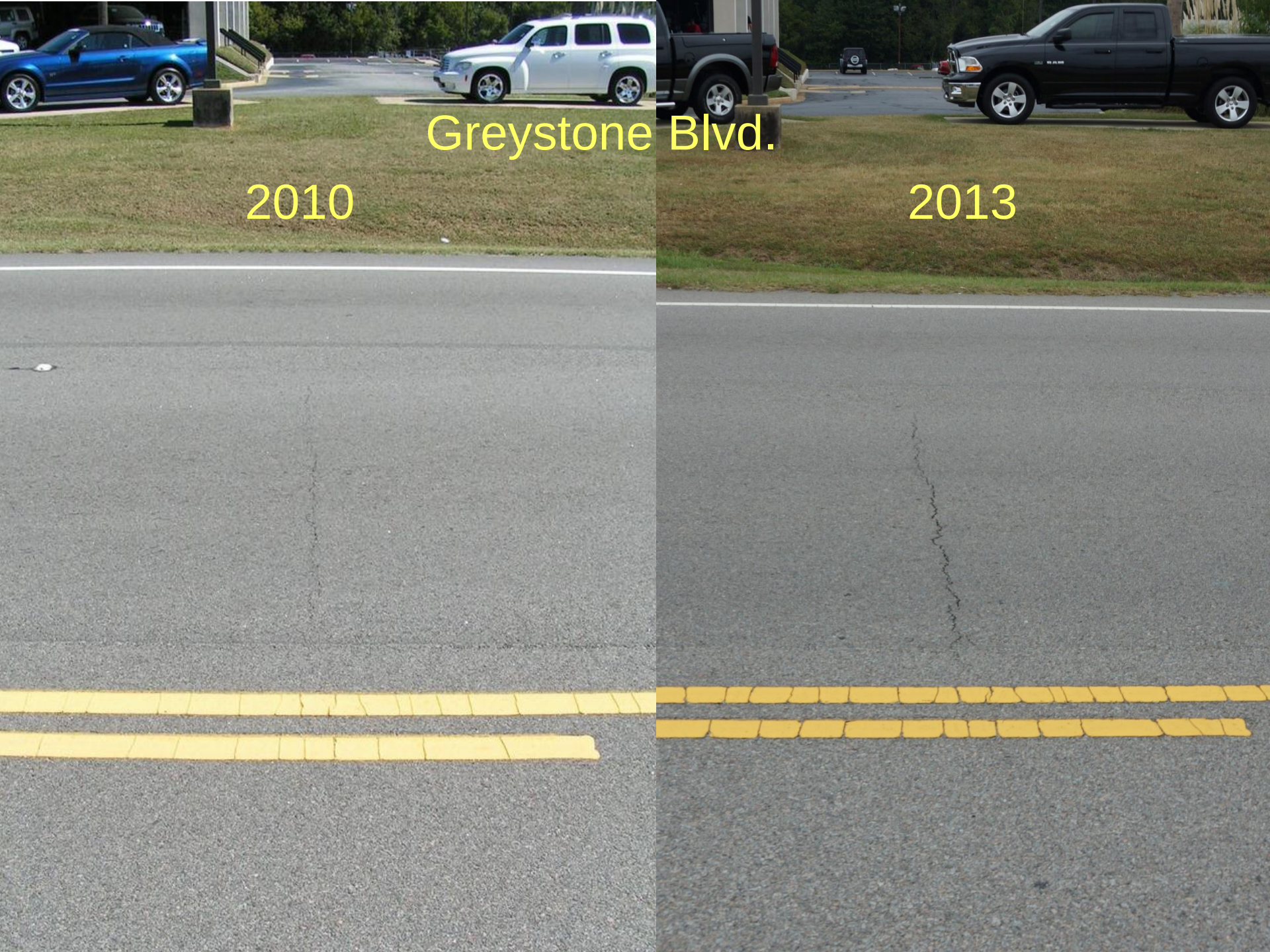
Greystone Blvd. - 2009


Greystone Blvd. - 2009

Greystone Blvd - 2009.

Greystone Blvd. - 2010


Greystone Blvd. - 2013
KIA


Greystone Blvd.
2010
2013


Greystone Blvd. -2013

Richland Avenue (US 78), Aiken, SC


www.morgan-corp.com
morgan corp.
7820
ABG
COMACO


South Carolina!
FIREWORKS


SPEED
LIMIT
45

Richland Ave. - 2013


I-385 RCC Shoulder

PCA
Portland Cement Association

think harder. concrete

SC Route 72 BP, Chester SC

PCA
Portland Cement Association

think harder. concrete

SC Route 72 BP, Chester SC

PCA
Portland Cement Association

think harder. concrete®

SC Route 72 BP, Chester SC

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Portland Cement Association

think harder. concrete

SC Route 151 and 9 Intersection, Chesterfield County

SC Route 151 and 9 Intersection, Chesterfield County

Mixture Design

Engineering Properties

- Compressive strength (f'_c)
  - 4,000 to 10,000 psi
- Flexural strength (MR)
  - 500 to 1,000 psi
  - $MR = C(f'_c)^{1/2}$ where C = 9 (up to 11)
- Modulus of elasticity
  - 3,000,000 to 5,500,000 psi
  - $E = C_E(f'_c)^{1/2}$ where C_E = 57,000 (up to 67,000)

Mixture Design

- Dry enough to support vibratory roller
- Wet enough to permit adequate distribution of paste

Aggregate Selection

- Aggregate selection very important
- Responsible for mix workability, segregation, ease of consolidation
- Pre-blended or stored separately

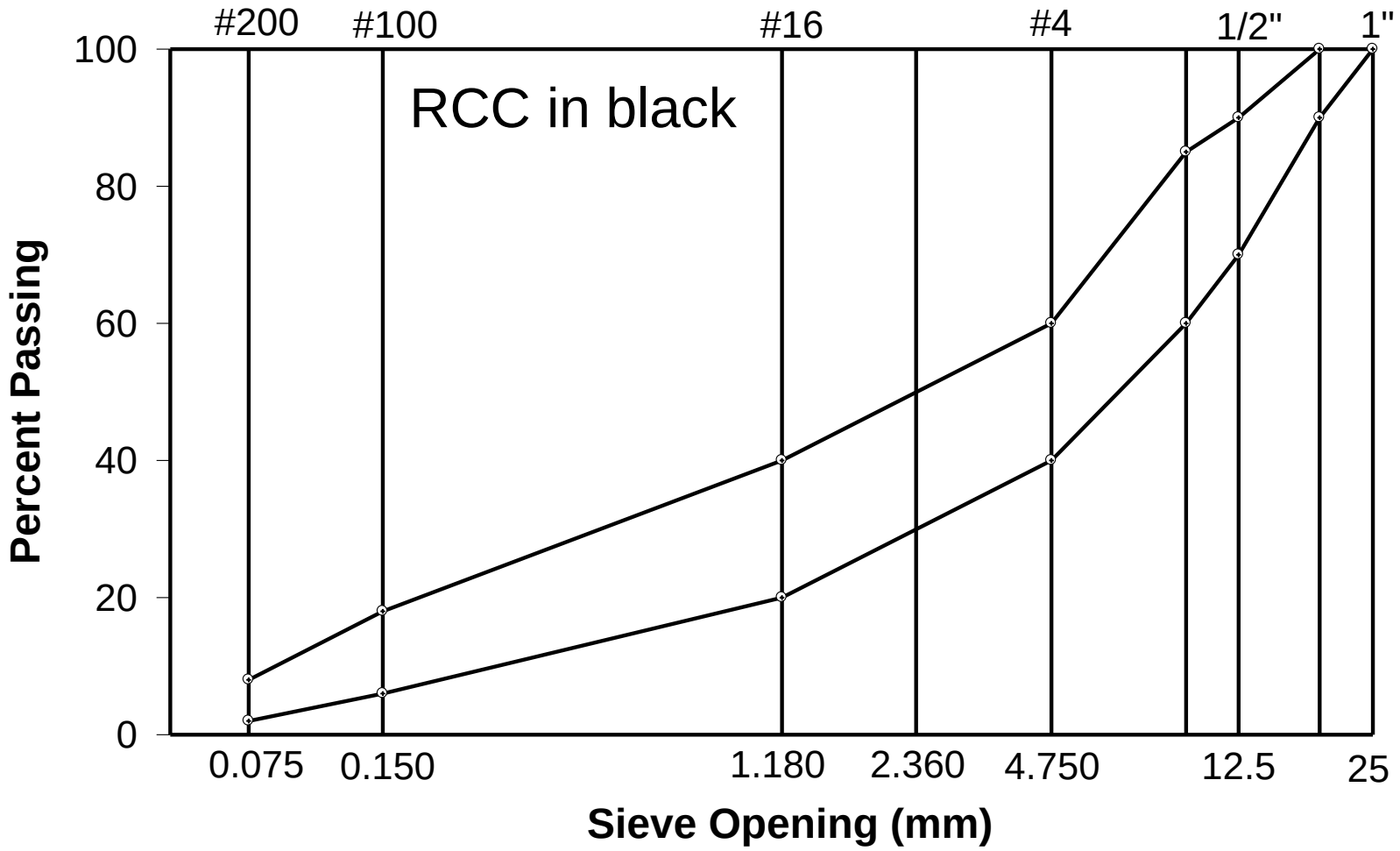
Aggregate Selection

- Highway base course, asphalt or concrete aggregates can be used
- 5/8 in. Nominal Maximum Size
  - Provides smooth surface, reduces segregation
- Higher fine aggregate content than conventional
  - Economic advantage using non-washed and pit-run aggregates including dense graded aggregate base
  - Provide adequate stability under vibratory roller
- 2%-8% passing #200 sieve
  - Supplements paste to fill voids and maintain tight surface

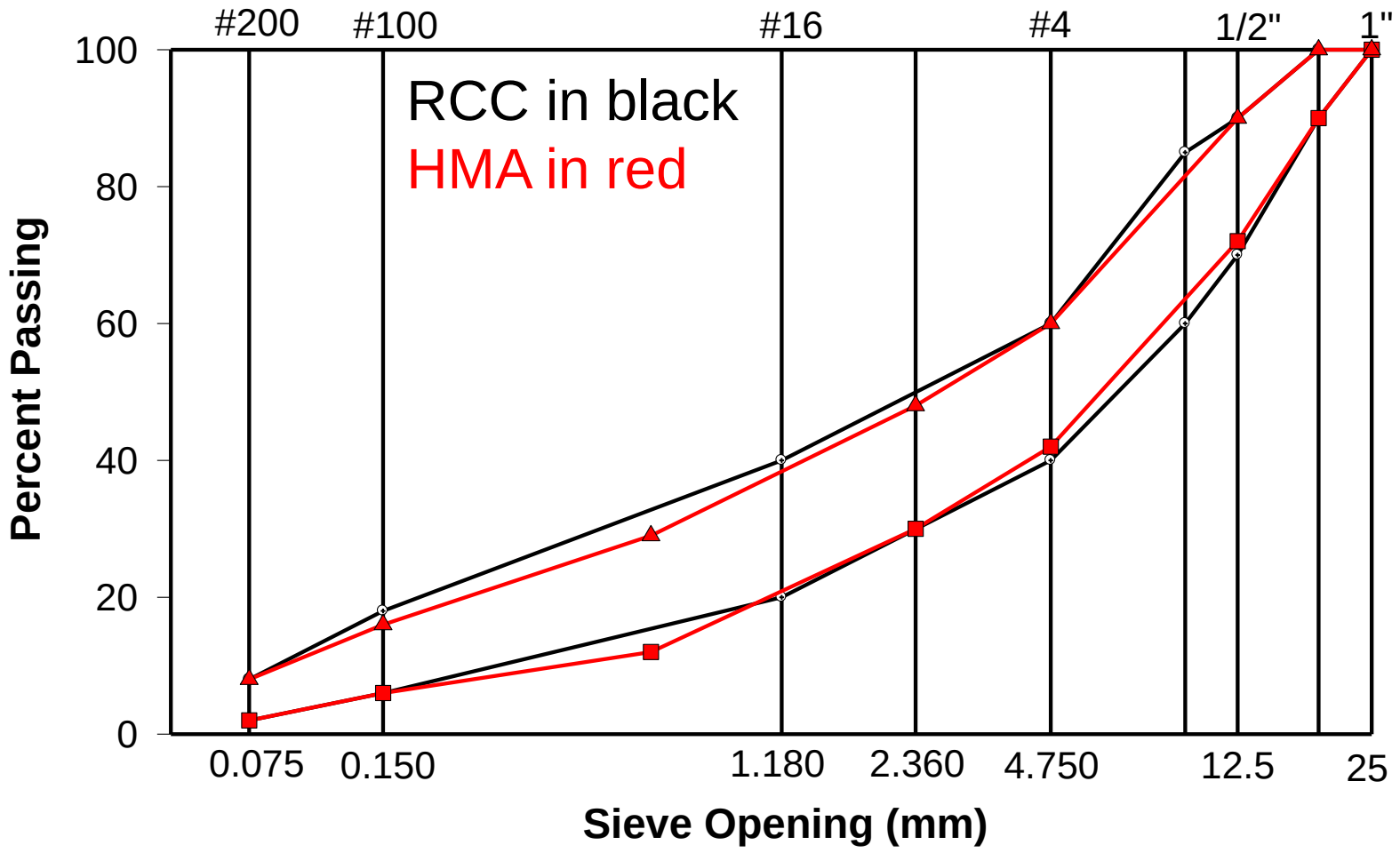
SCDOT GRADATION SPECIFICATION

Sieve Size	Percent Passing by Weight
1 inch	100
¾ inch	90-100
½ inch	70-100
3/8 inch	60-85
#4	40-60
#16	20-40
#100	6-18
#200	2-8

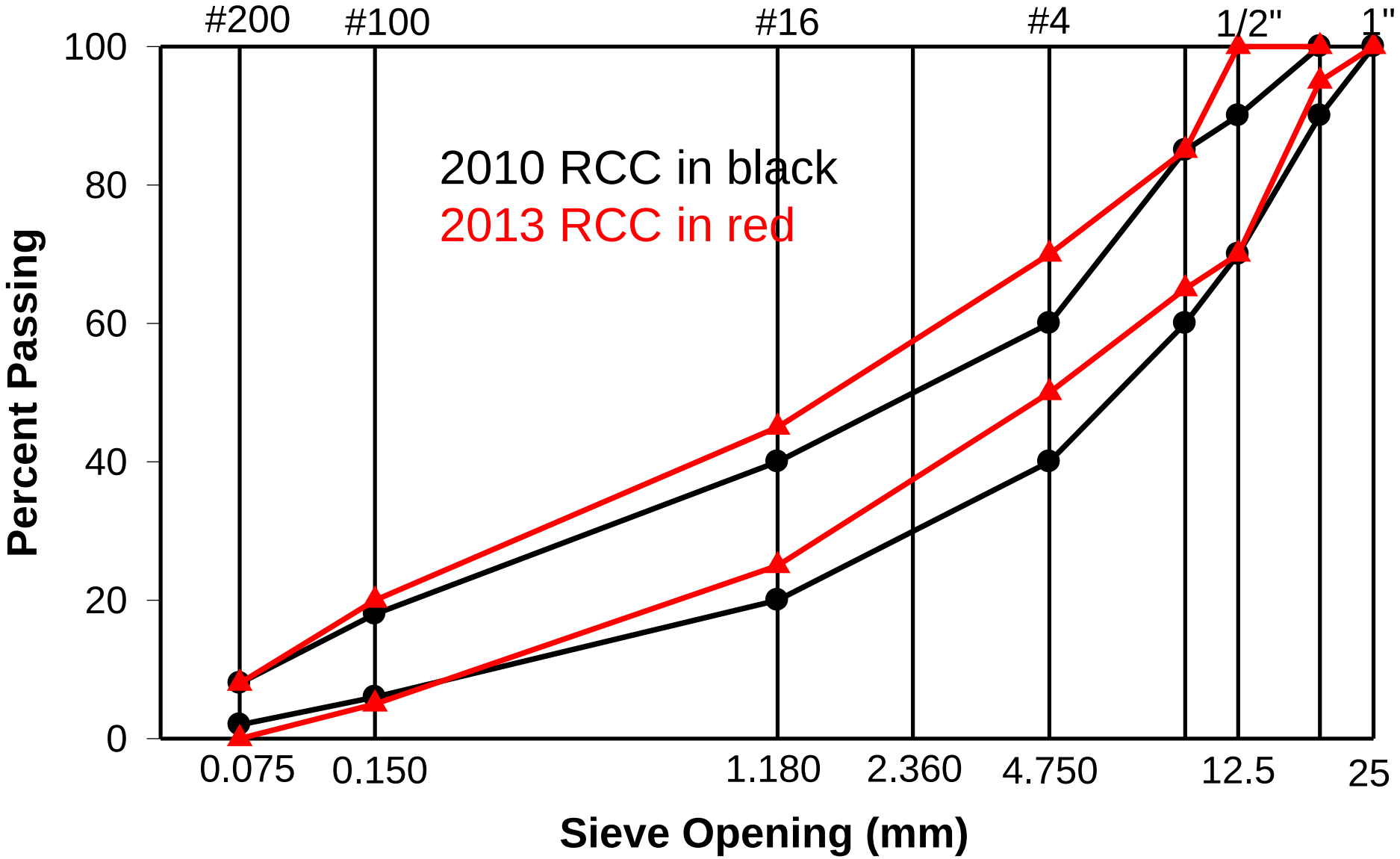
RCC vs. HMA Intermediate Course



RCC vs. HMA Intermediate Course



Evolving Gradation Specs



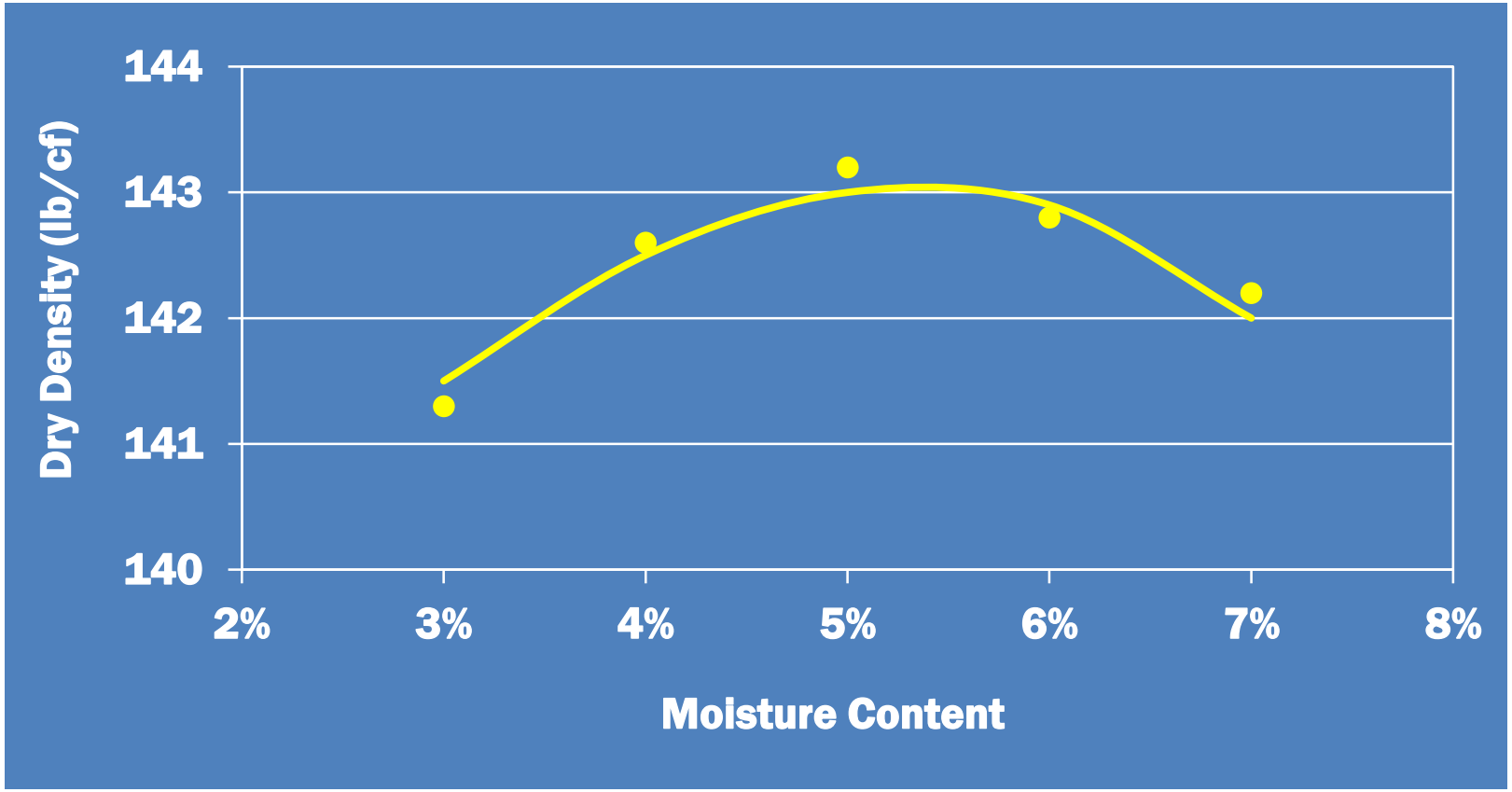
Proportioning Methods

- Several methods available:
  - Concrete consistency tests
  - Soil compaction methods
  - Optimal paste volume method
  - Solid suspensions model
- Always allow time and money for field trial

Soil Compaction Method

- Determine moisture content
  - Construct moisture/density curve
  - Modified Proctor ASTM D1557
  - Assume a median cement content (e.g. 500 pcy)

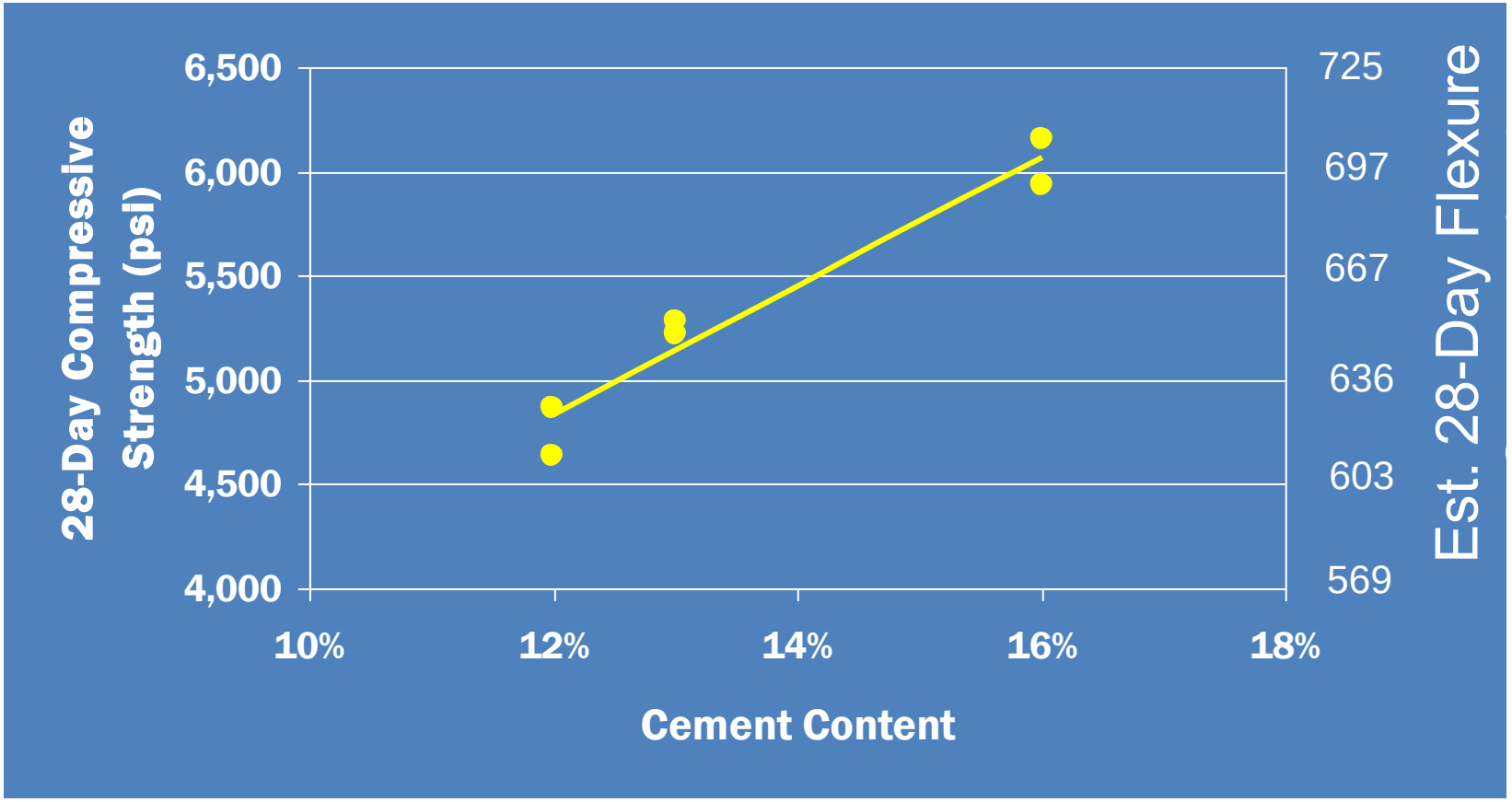
Moisture-Density Relationship



Soil Compaction Method

- Determine cementitious materials content
  - Use optimum moisture content
  - Run cement series
    - e.g., 11%, 13%, 15%, 17%
  - Select cement content which yields appropriate strength.

Strength vs. Cement Content



Aggregates And Cementitious (Cement & Fly Ash) Materials

Casting First Lift Of Cylinder Specimen Using Hilti TE905 for ASTM C 1435

Placement Of Second Lift

Completed Test Cylinders

Sample RCC Mix Designs

	Units	Port of Tacoma Intermodal Yard	CTL Mix	Canada Mix
Coarse Aggregate	lb/cy	1,700	2,106	2,210
Fine Aggregate	lb/cy	1,700	1,378	1,338
MSA	in	5/8	3/4	1/2
% Finer Than #200	%	3 - 7	2	1
Cement	lb/cy	450	504	470
Fly Ash	lb/cy	100	0	36 (silica fume)
Water	lb/cy	257	211	172
Admixture	oz/cwt	none	none	5 (WR)
w/c ratio	-	0.47	0.42	0.34
Unit Weight	lb/cy	154.3	152.0	153.1
Compressive: 3 day	psi	1,810	5,460	-
Compressive: 28 day	psi	6,050	7,900	-
Flexural: 3 day	psi	525	690	1,205
Flexural: 28 day	psi	770	900	1,640

Admixtures

- Fly ash, slag, silica fume have been used
- Retarders can be used to increase working time
- Water reducers used to increase workability
- Air entrainment very difficult in the field, but
  - Experience has shown RCC can be made F/T resistant
- Fibers seldom used
  - Increased difficulty with mixing & compaction


Construction

Subbase/Subgrade Preparation

- Same requirements as conventional concrete.
- Must be stiff to provide full compaction.
- Stable subgrade.
- Non-pumping subbase.
- Moisten subbase prior to RCC placement.

Mixing Plants

Generally three types of available mixing operations:

1. Dry Batch Plant
2. Rotary Drum Mixing Plant
3. Continuous Flow Pugmill

Rotary Drum Mix Plants

- Available at some locations.
- Mobilization issues.
- Capacity reduced due to low water content of mixture.

Continuous Mix Pug Mill

- High-volume applications
- Excellent mixing efficiency for dry materials
- 250 to 900+ tons/hr
- Mobile, erected on site
- Mobilization costs

Transporting and Placement

Placing

- Layer Thickness
  - 4 in. Minimum Thickness.
  - 9 – 10 in. Maximum Thickness in a single lift.
- Timing Sequence
  - Adjacent lanes placed within 60 minutes for “fresh joint”
  - Multiple lifts placed within 60 minutes for “fresh joint”
- Production should match paver capacity
  - Continuous forward motion for best smoothness

Placing Equipment

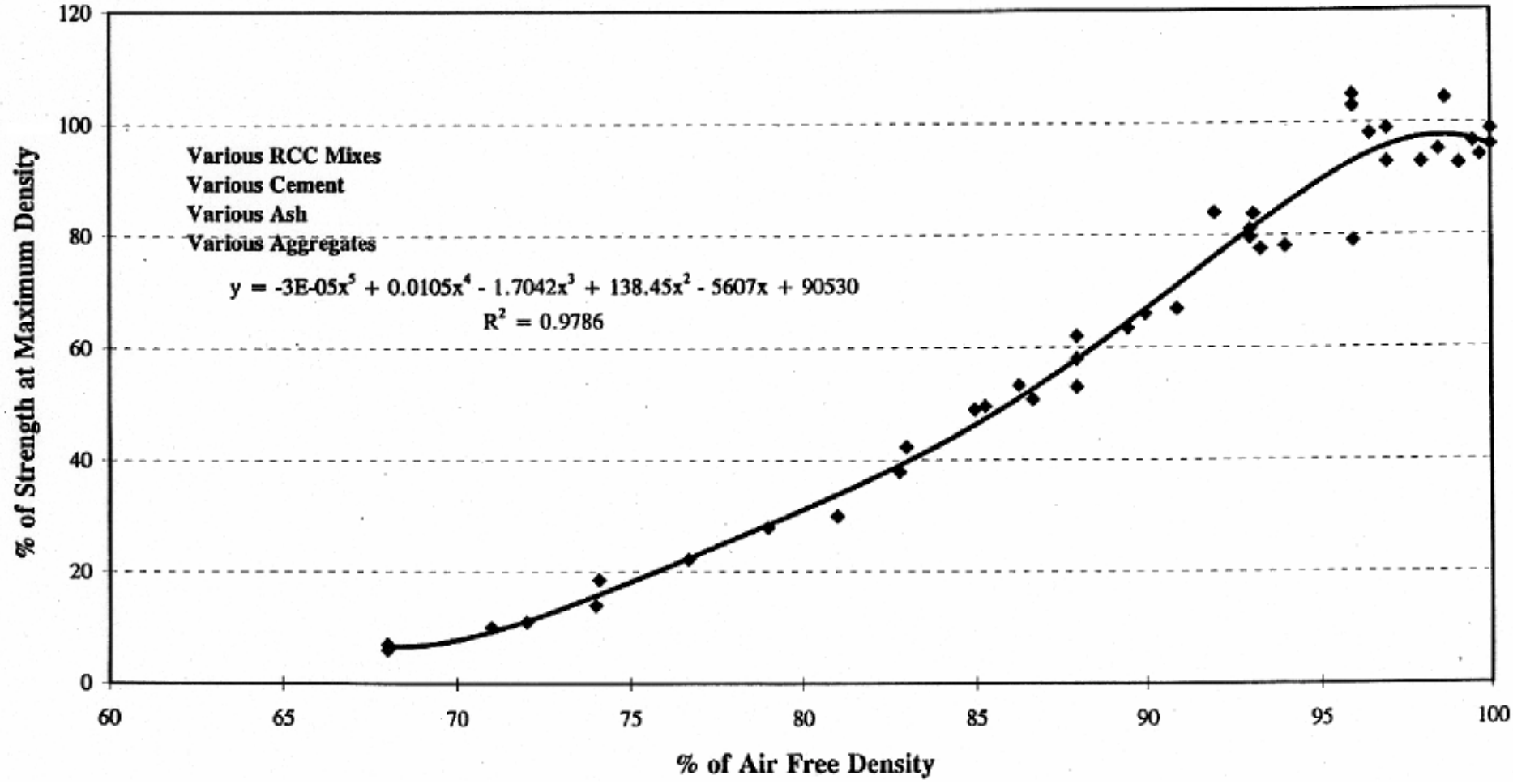
- High density pavers
  - Vibrating screed
  - Dual tamping bars and or pressure bars
  - High initial density, 90-95%
  - Reduces subsequent compaction
  - High-volume placement (1,000 to 2,000 cubic yards per shift)
  - Designed for harsh mixes
  - Smoothest RCC surface

Roller Compaction
(rubber-coated drum)

Compaction-Final Density

- Final density is critical for strength and durability
- Compacted to 98% modified Proctor (typical)
- Dual steel drum roller
- Combination roller
- Rubber coated steel drum roller

Compaction is critical



Transverse Joints


Early entry saw


Depth D/4 to D/3

Curing

- Extremely important; Ensures surface durability
- Low moisture content in RCC dictates moisture retention.
- Three methods:
  - Moist Cure
  - Concrete Curing Compound
  - Asphalt Emulsion

Concrete Curing Compound

- White-pigmented concrete curing compounds
- Apply 1 to 1.5 times the normal application rate

Bituminous Curing Compound

- Excellent moisture barrier
- Common compounds:
  SS-1, RC-250, MC-250
- Clean surface if needed
- Moisten surface
- Apply at 0.15 to 0.30 gal/sy
- Good for asphalt cap


HILTI TE 805
TEST SPECIMEN - DO NOT DISTURB


HILTI TE 805

OPENING TO TRAFFIC

Access to apartment complex had to be maintained

Access was provided directly behind the high-density paver, even prior to roller compaction

SCDOT Specifications

Traffic:

Protect the RCC from vehicular traffic during the curing period. Completed portions of the RCC pavement may be opened to automotive and light truck traffic as soon as the strength is sufficient to prevent damage to the RCC. The pavement may be opened to unrestricted traffic after 4 days.

Roller Compacted Concrete

Questions ???

- Dams
- Intermodal Facilities
- Military Bases
- Port Terminals
- Interstate Shoulders
- Auto Industry Plants
- Streets and Local Rds
- State Highway System
- Nuclear Power Plants
- Logging Yards