Advances in Roller Compacted Concrete Pavements

Wayne Adaska, P.E., Director, Pavements and Geotechnical Markets

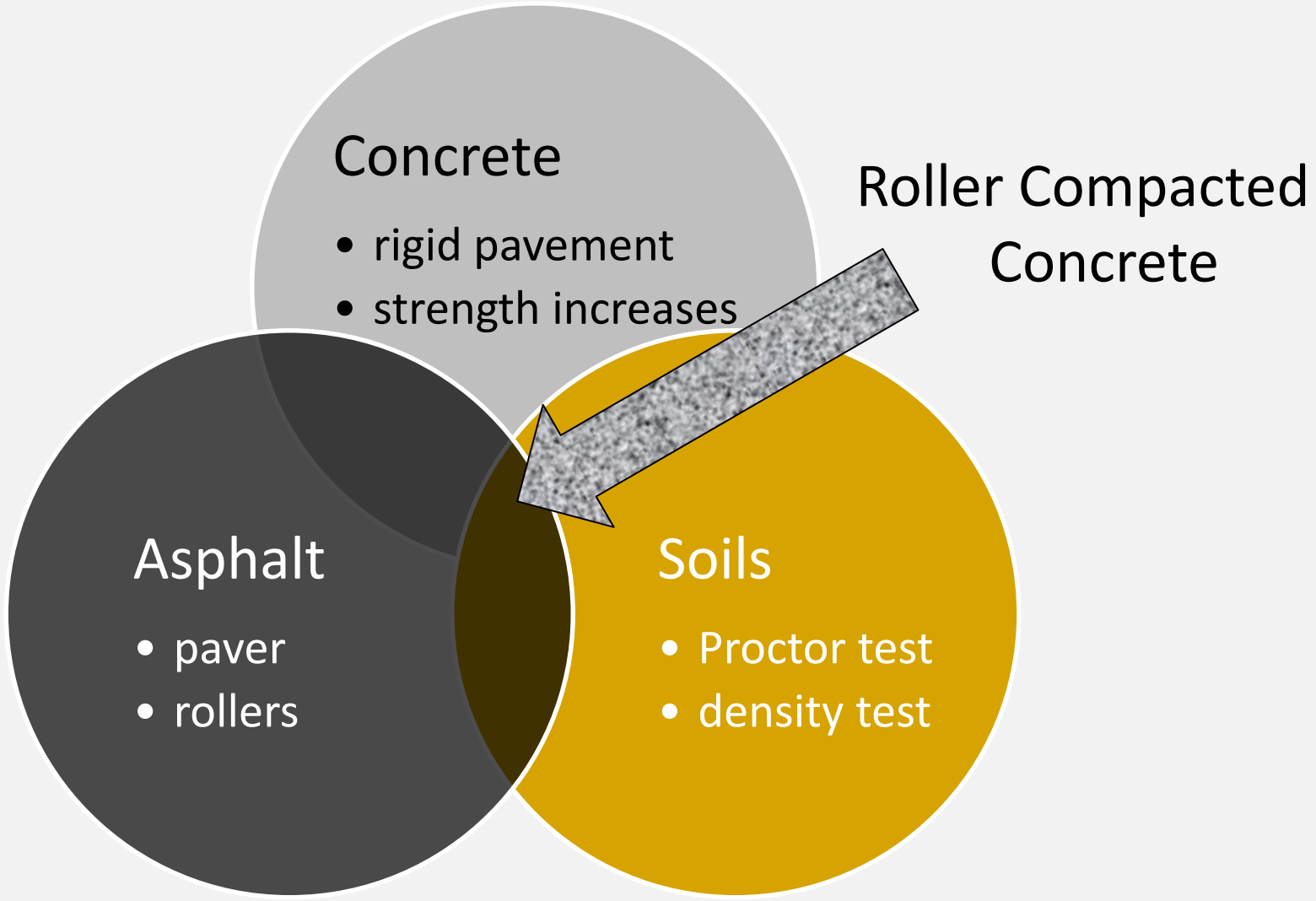
Roller Compacted Concrete

"Roller Compacted Concrete (RCC) is a no-slump concrete placed with asphalt type paver and compacted by vibratory rollers."

- Zero slump (consistency of dense, damp gravel)
- No forms or finishing
- No reinforcing steel
- High production
- Placed with asphalt type pavers
- Consolidated with vibratory rollers

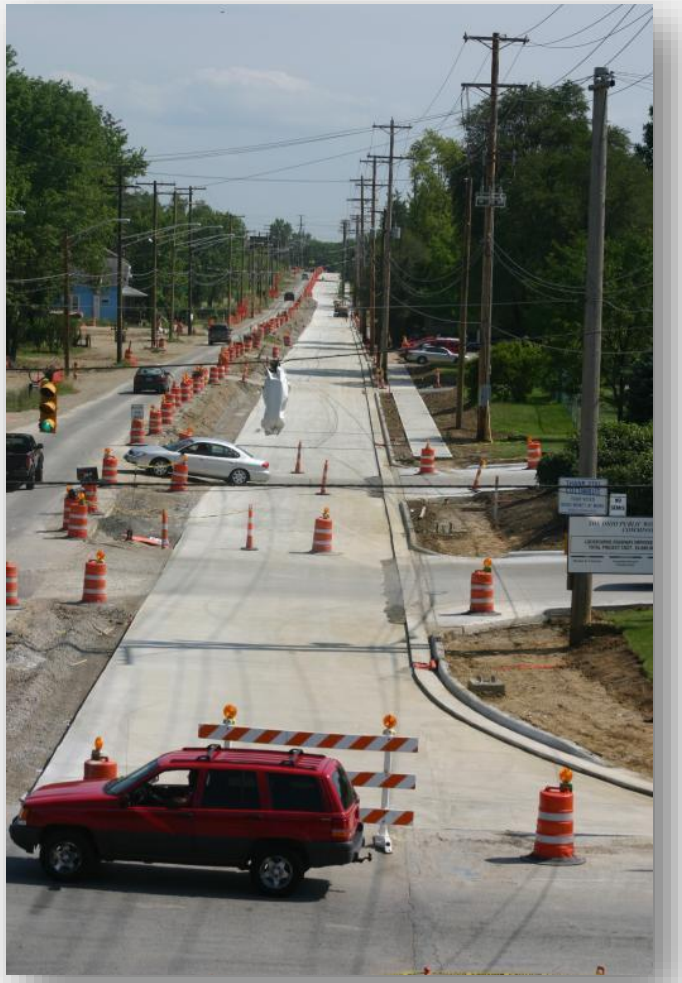
Concrete placed in a different way!

Multiple Characteristics



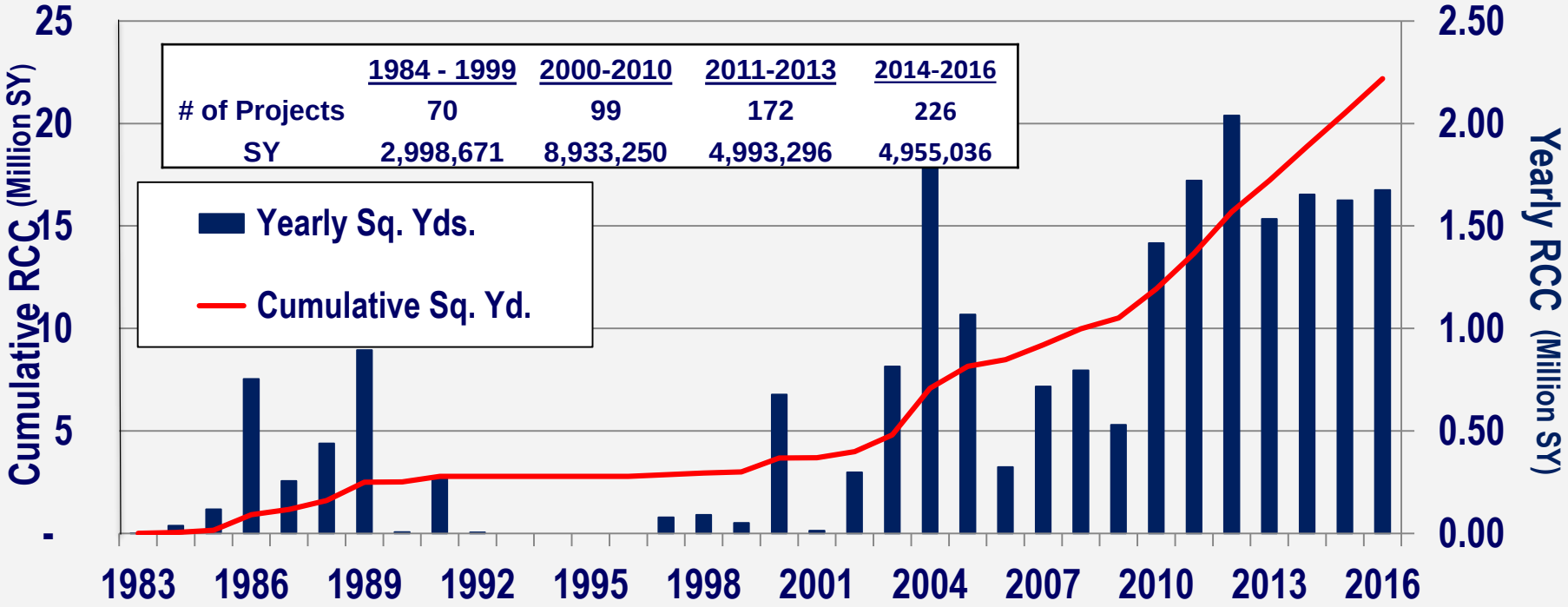
Benefits of RCC Pavements

- ***Fast construction***
- ***Economical***
- ***Early load carrying capacity***
- Supports heavy loads
- Low maintenance
- Durable
- Light surface reduces lighting requirements & Urban Heat Island effects



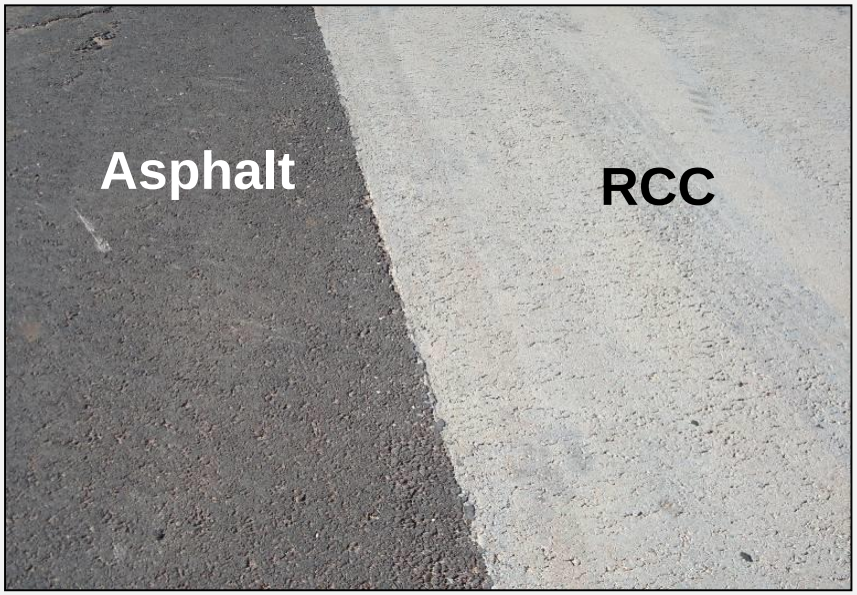
RCC – Experiencing a Renewal

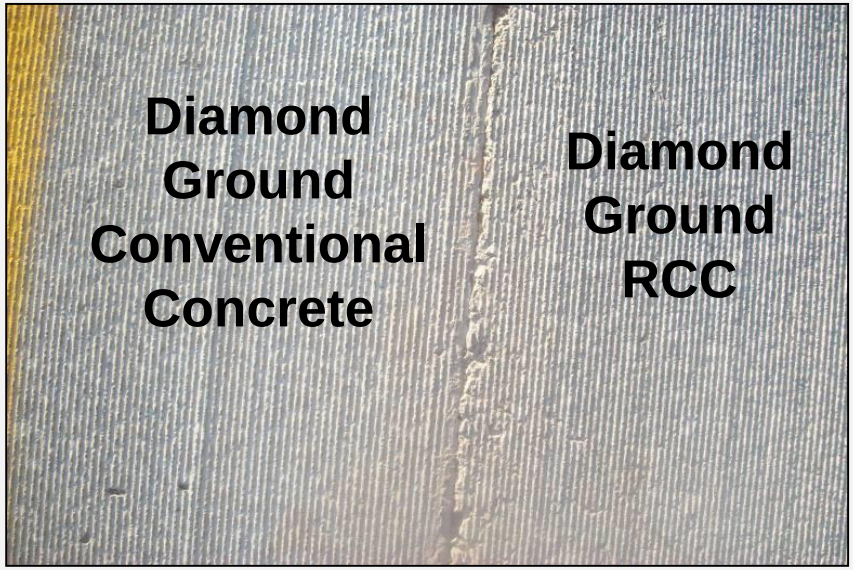
- Originally used for heavy-duty pavements
- Growth has accelerated in last 15 years
- Increase in private & public road use
- Emergence of asphalt contractors



RCC Makes for Strange Bedfellows

Surface Appearance





Technologies to Improve Surface Appearance

Admixtures

- Surface applied liquid reacts with cement to increase paste
- Another is fully incorporated within mixture providing air and improving durability

RCC Mixture Design

Modifications needed in typical no-slump concrete mixture procedures (ACI 211.3R) because RCC is:

- Dryer than zero slump
- Not air-entrained
- Lower cementitious content
- Higher fines content
- Nominal max. size aggregate 1/2 to 3/4 in.

Conventional Concrete vs RCC

Percent by Volume

Conventional Air-Entrained PCC

144 pcf

12	16	6	22	44
C.M.	Water	Air	Fine Agg.	Coarse Agg.

Roller Compacted Concrete

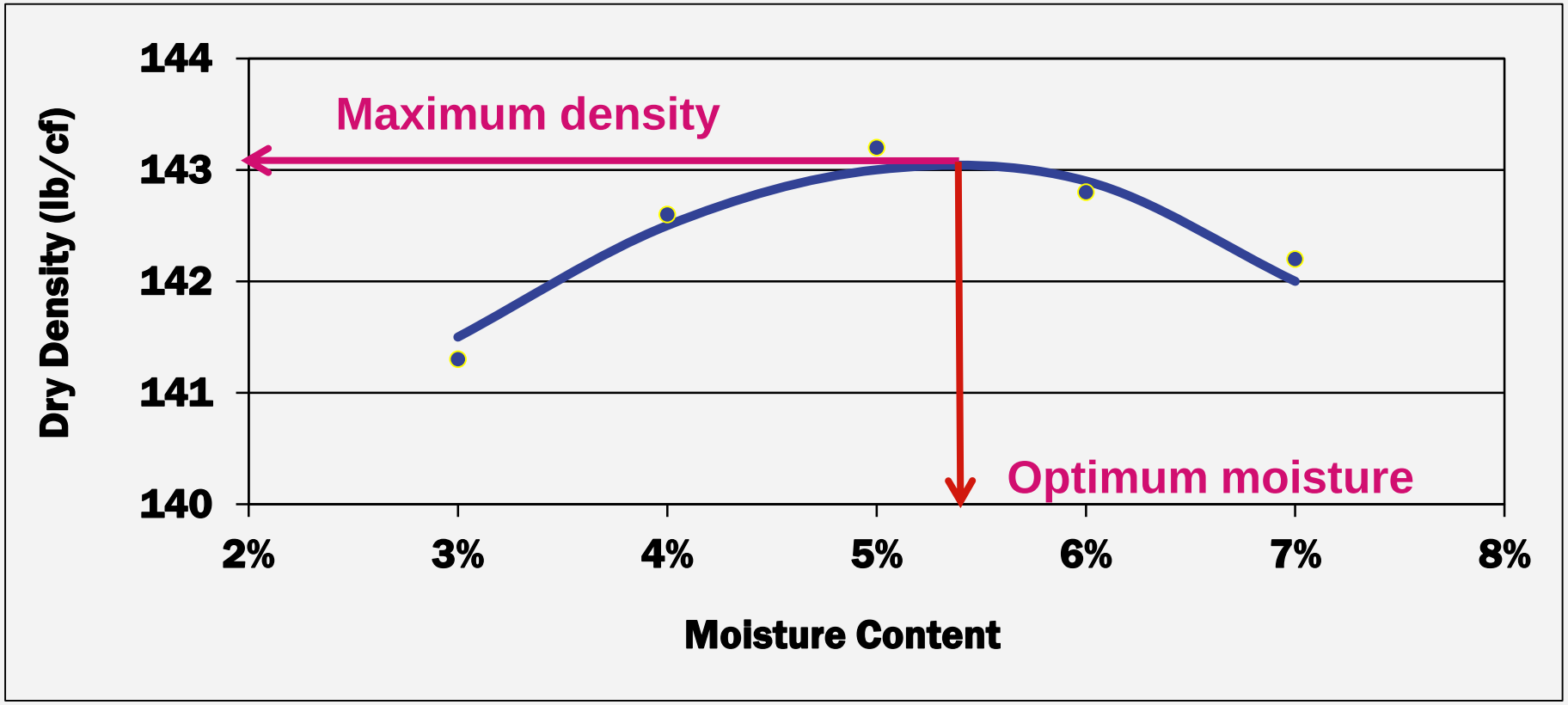
153 pcf

10	14	1.5	36	38.5
C.M.	Water	Air	Fine Agg.	Coarse Agg.

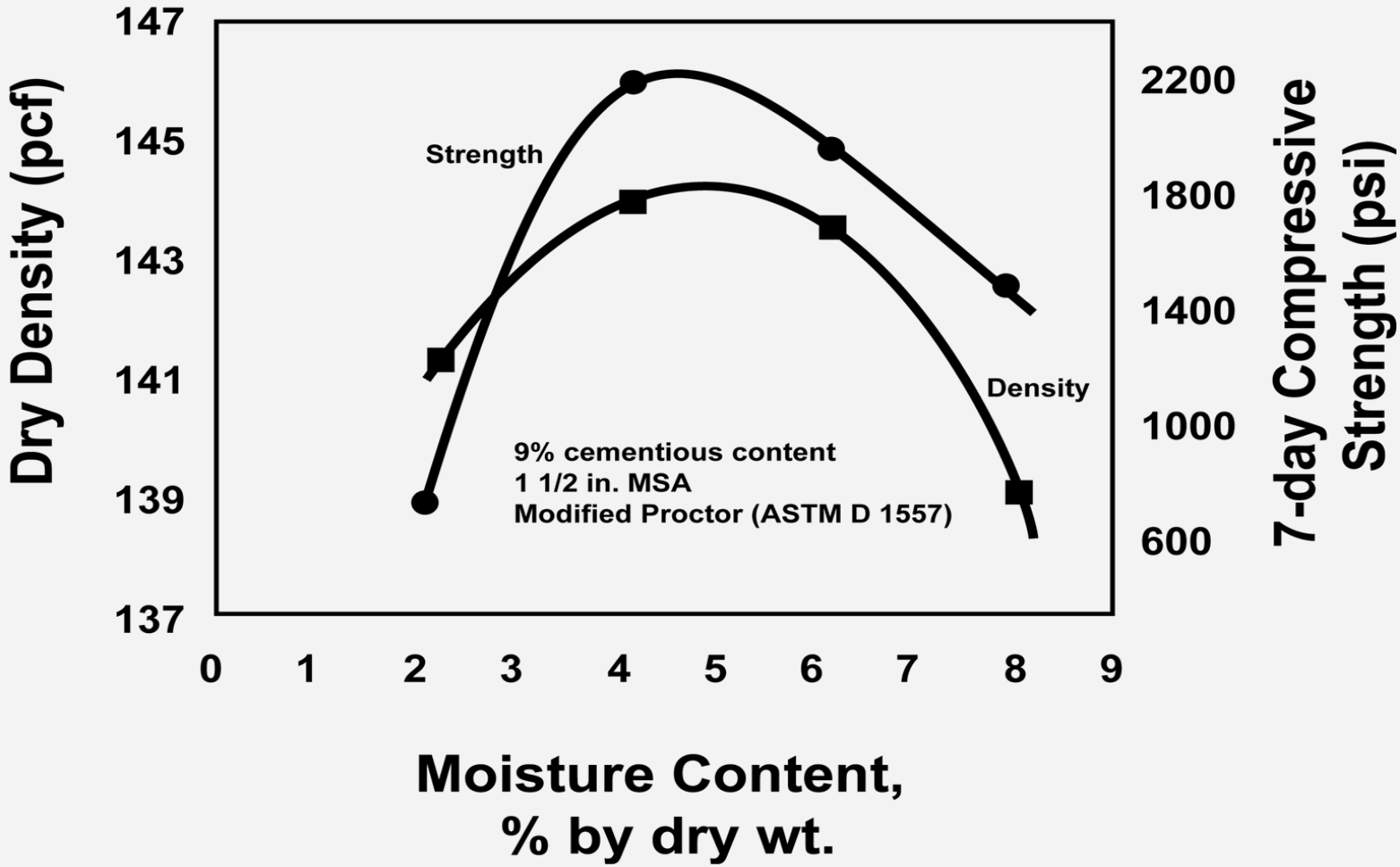
Selection of Aggregate Blend

- ***Aggregate selection very important***
- 75% - 85% of mix by volume
- Responsible for mix workability, segregation & ease of consolidation
- Nominal MSA 1/2” to 3/4”
  - Most projects: 5/8” to 3/4”
  - As small as 1/2” for tighter surface and reduced segregation
  - 1” for non-wearing courses or where surface appearance is not critical
- Aggregate quality meets ASTM C33

Moisture – Density Relationship



Relationship Between Density and Strength



Construction

Construction Requirements

- Test section
- Subgrade preparation
- Mixing process
- Placing
- Compacting
- Curing

Test Section

- Train contractor and testing personnel
- Demonstrate workability and appearance of mix
- Demonstrate equipment capabilities
- Demonstrate construction details
  - Joints, bonding, compaction, etc.
- Develop rolling requirements/pattern
- Test RCC and develop correlation factors for density and f’c vs. MR
- Consider location of test section

Subgrade Preparation

- Stiff enough to provide resistance to compaction equipment (95% compaction)
- Ensure subgrade contractor meets compaction requirements
- Non-pumping subgrade
- Replace unsuitable materials
- Consider stabilized base
- Shape to proper lines and grades

Production

- Types of batching & mixing equipment
  - Drum & horizontal shaft mixers
  - Dry batch plants
  - Pugmills
- Must be mixed vigorously
- Uniform distribution of paste is critical for proper performance
- Maintaining proper water content critical

Moisture Sensitive

- ***Moisture control imperative***
- 0.5 gallon = 0.1% moisture
- Measure moisture in stockpile & mixture continuously
- Maintain stockpile moisture content consistent (sprinkling, covers, etc)
- Loader operator plays important role
- Coarser mixtures very sensitive to moisture increases

Drum & Horizontal Shaft Mixers

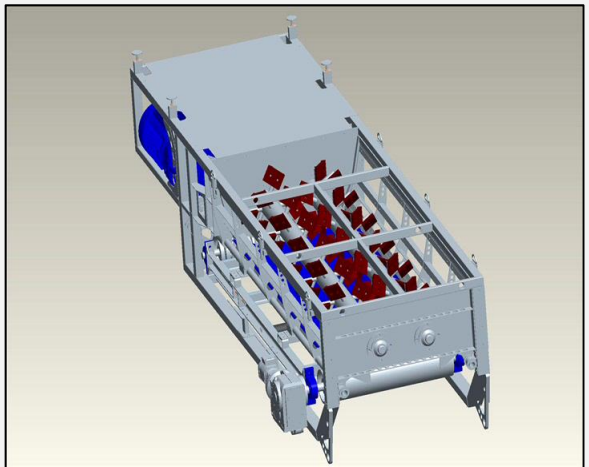
- Highly accurate proportioning
- Local availability
- Smaller output capacity
- Longer mix times than conventional concrete
- More cleaning with drum mixer
- Dedicated production
- Horizontal shaft spiral blade mixer very efficient

Dry Concrete Batch Plant

- Highest local availability
- Very good for small jobs
- 2-step process
  - Feeds transit mixers
  - Discharge into dumps
- Mix 50 -60% capacity
- Low production
- Segregation concern
- Intermittent cleaning required
- Portable pugmill mixers

Pugmills

- Batch or continuous
- High-volume applications
- 125 to 250 + cy/hr
- Excellent mixing efficiency
- Mobile, erected on site



Placing

- Production should match paver capacity
- Uninterrupted forward
- Material transfer device
- Layer Thickness
  - 4” min. thickness
  - 9” to10” max. thickness (single layer)

- Timing Sequence
  - Limited time (generally 60 minutes max.) for placement of adjacent lanes to maintain “fresh joint”
  - Multiple lifts placed within 60 minutes for “fresh joint”

Placing Equipment

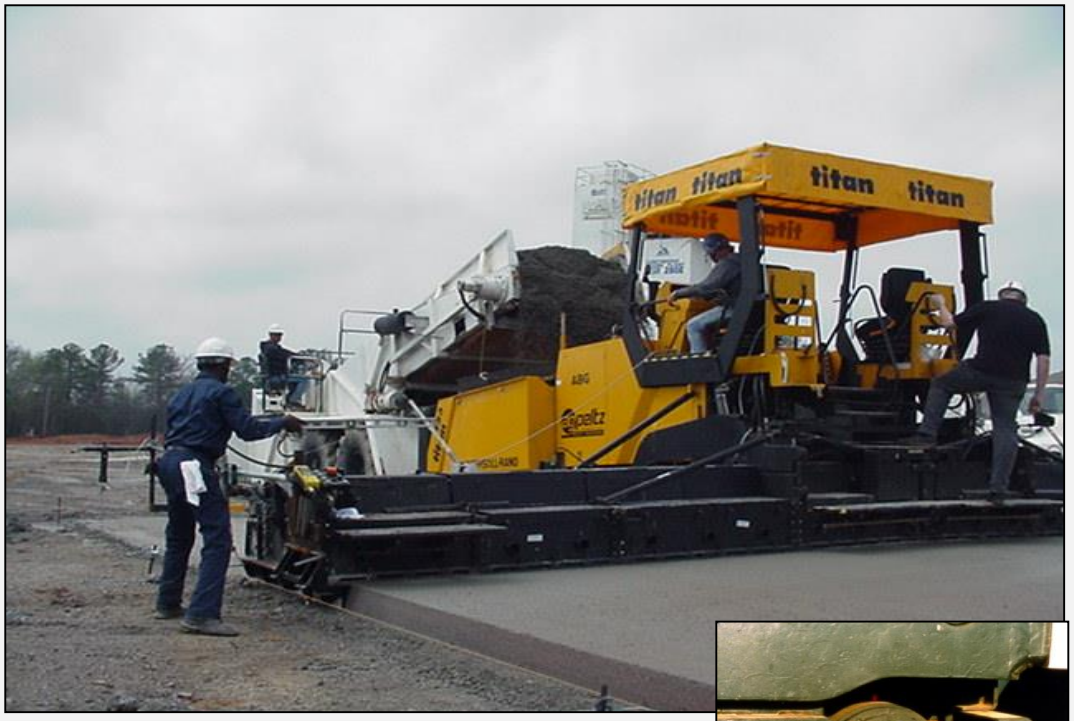
Conventional asphalt pavers

- Available everywhere
- Provide some initial density (80-85%)
- Relatively smooth surface
- Lift thickness range: 4”- 6”
- Increased roll down to achieve density

Placing Equipment

High density pavers

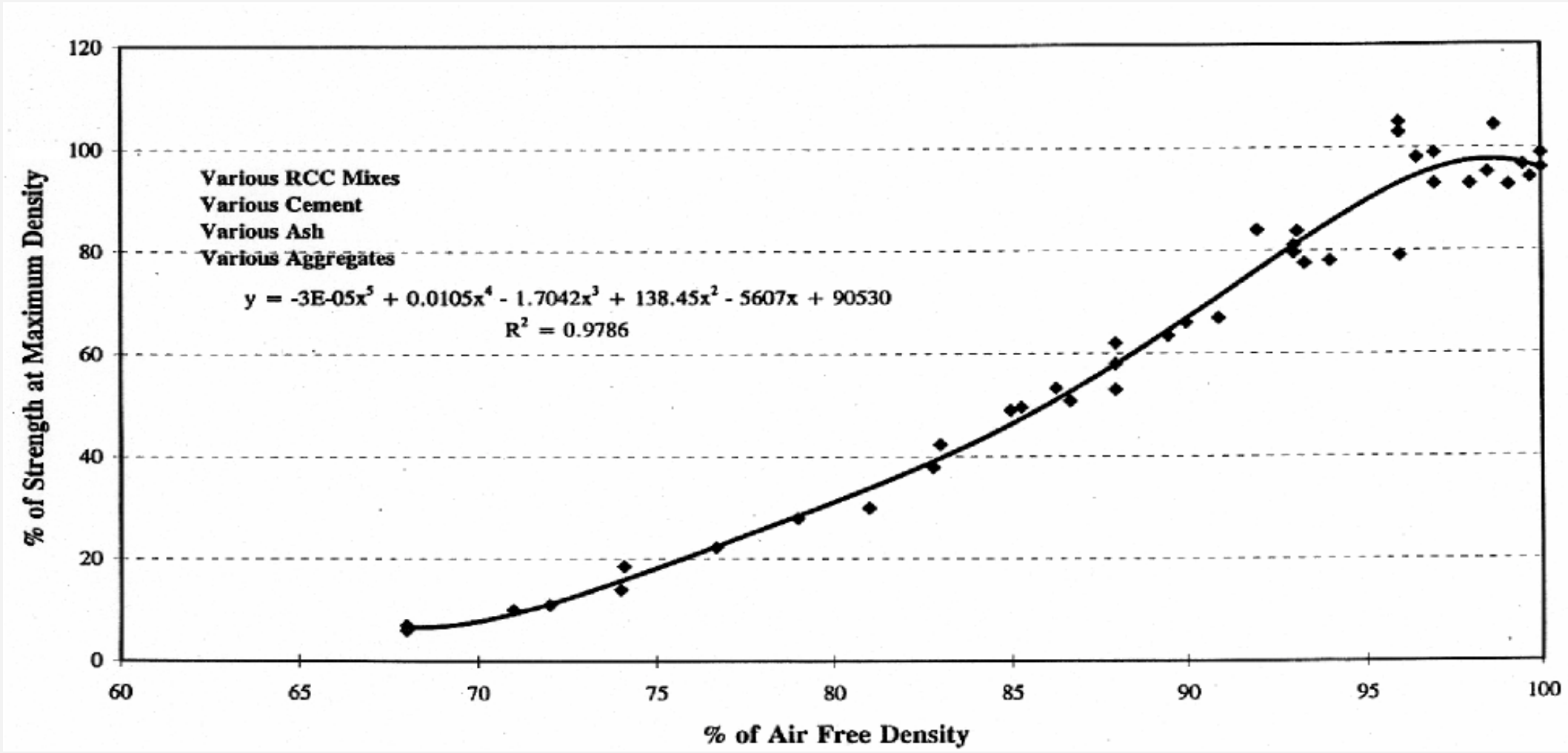
- Vibrating tamping screed
- High initial density (> 90%)
- Lift thickness range: 4”- 10”
- Less roll-down
- High-volume placement (1,000 to 2,000 yd^3 per shift)



Compaction

- ***Proper compaction is critical for strength and durability***
- Compact to 98% Modified Proctor (ASTM D1557)
- Vibratory steel dual-drum roller
- Pneumatic tire or rubber coated steel drum to smooth surface
- Finish w/smaller steel roller

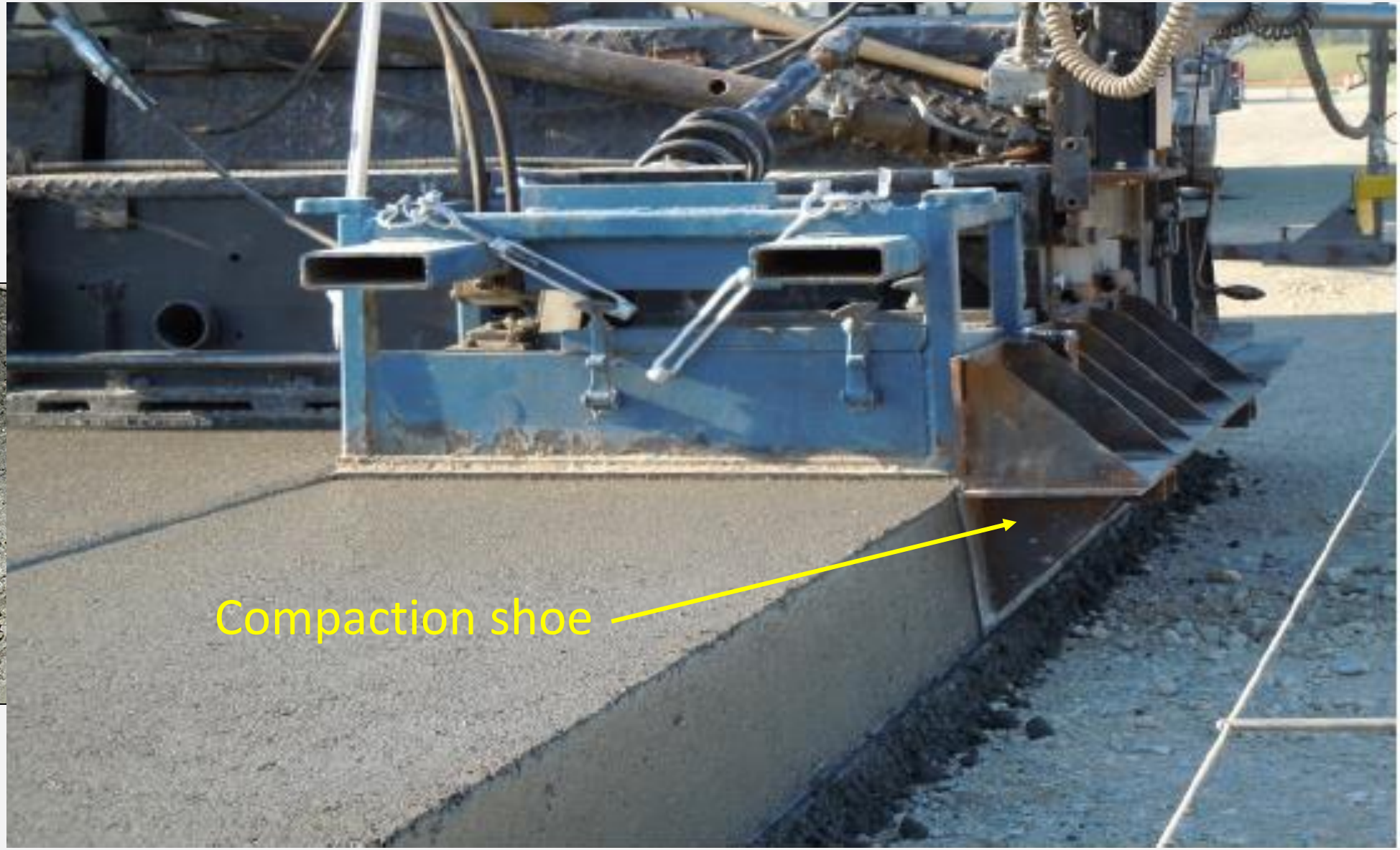
Compaction Very Important



Edges Critical to Performance

- Compaction more difficult
- Segregation more likely
- Minimize number of cold joints
- Care needed to match grade from cold to fresh joint

Edge Compaction



Fresh Longitudinal Joint

- Adjacent lane should be placed within 60-minutes
- Must keep edges moist until adjacent lane placed

Cold Joint Construction

- Cut joints back to fully compacted RCC
- Cut edge should be vertical and clean
- Place fresh RCC slightly higher to allow for reasonable “roll down”

Running Longitudinal Cold Joint

Curing

- ***EXTREMELY IMPORTANT***
- Water, sheeting or concrete curing compound
- Application rate depends on surface texture

Quality Control Testing

Moisture & Density

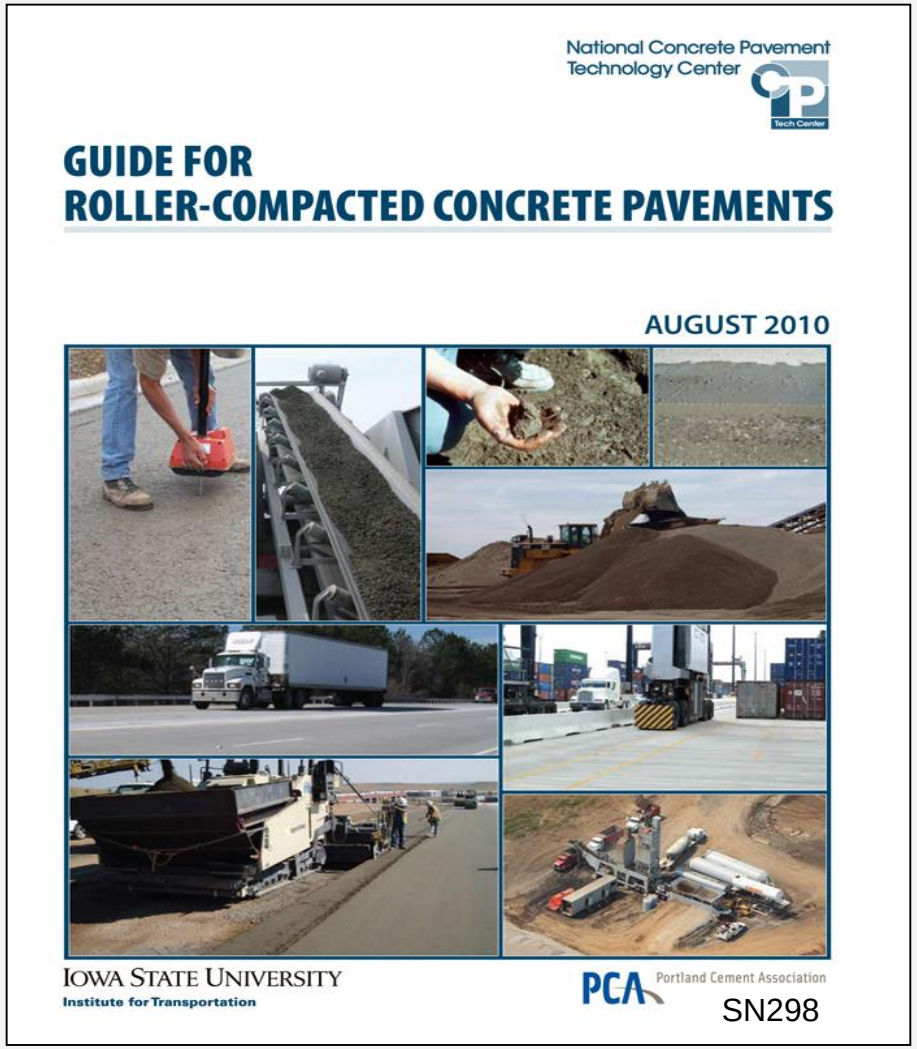
- Tested with nuclear gage in direct mode
- Test density behind paver & after roller to establish rolling patterns to achieve specified density
- Achieve 98% of modified proctor wet density
- Nuclear gage gives general moisture fluctuation indication - Calibrate with oven dried moisture
- Oven dried is most accurate

Compressive Strength

- Cylinders prepared with vibratory hammer according to ASTM C1435
  - 4 lifts for 6” X 12” cylinders
  - 3 to 4 cylinders per set
  - Strength timing often depends on traffic opening (1, 3, 7, 28 days)
- Cores can be obtained where density is not being achieved

Resource Materials

- Introduction
- Applications
- Properties
- Mixture Proportioning
- Structural Design
- Production
- Construction
- Troubleshooting



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Summary Comments

- Use of RCC in the United States is growing
- Emergence of asphalt contractors
- Major benefits include cost, speed of construction and early trafficking
- Surface textures can vary (manage expectations)
- Mix designs for RCC pavements typically use the soil compaction method
- Compaction/Density…important for strength & durability
- Special attention paid to fresh and cold joints
- Moisture ranges are tight +/- 0.5 percent of optimum
- Curing essential for durable surface