ROLLER COMPACTED CONCRETE

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Roller Compacted Concrete Pavements (RCC)

Topics of discussion:

- Definition
- Applications
- Design
- Construction
- Performance

Definition

The largest difference between RCC mixtures and conventional concrete mixtures is that RCC has a higher percentage of fine aggregates, which allows for tight packing and consolidation.

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

Definition

- Zero slump (consistency of damp gravel)
- No forms
- No reinforcing steel
- No finishing
- Consolidated with vibratory rollers

Concrete pavement placed in a different way!

Construction Sequence

- Produced in a pug mill or central batch plant
- Transported by dump trucks
- Placed with an asphalt paver
- Compacted by vibratory and pneumatic-tired rollers
- Cured with water or curing compound

Applications: Why Use RCC?

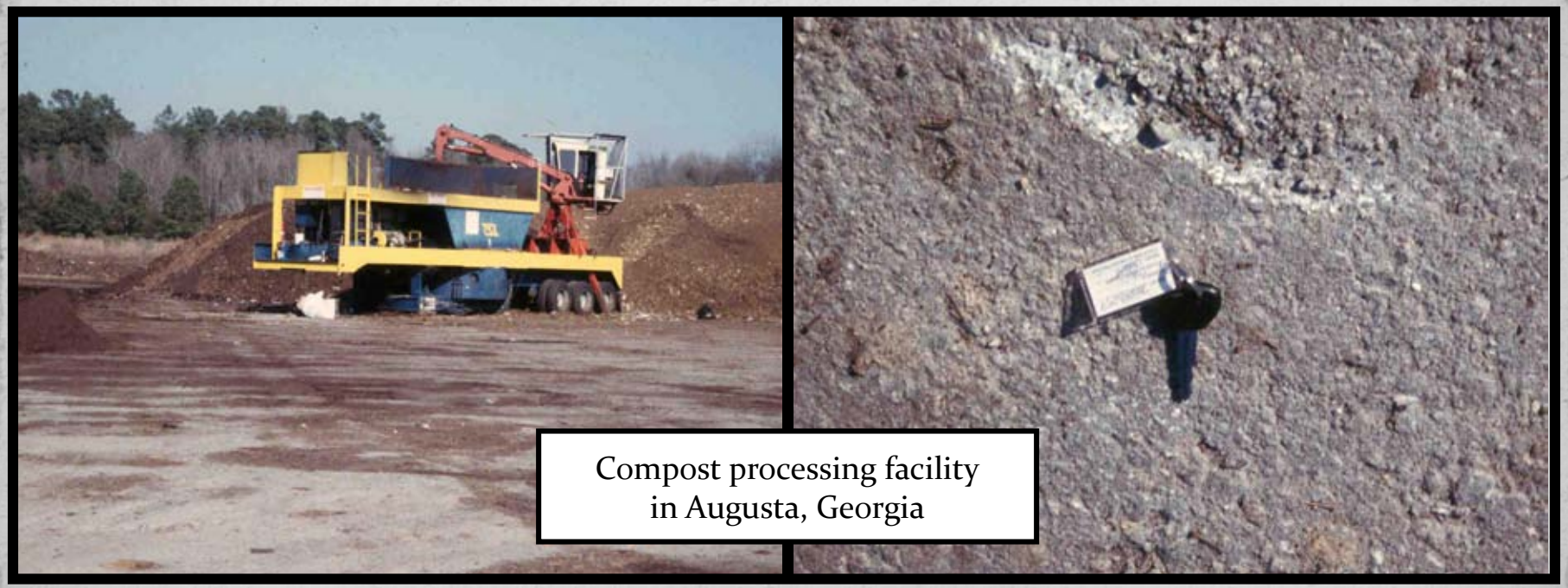
- Low cost
- Easy preparation
- High-volume production
- Minimal labor
- High strength and durability
- Proven performance

Benefits of RCC

- Economical
- High load carrying ability
- Eliminates rutting and spans weak subgrades
- Excellent freeze-thaw durability
- Simple, fast construction
- No forms or finishing
- Light surface reduces lighting requirements

Traditional RCC Projects

- Low-speed vehicles
- Industrial sites
- Large, unrestricted paving areas



Compost processing facility
in Augusta, Georgia

log sorting yards

intermodal facilities

Off-Highway Applications

- Haul roads
- Military applications
  - Tank hardstands
  - Maintenance yards
- Intermodal shipping
- Airfield apron areas
- Parking and storage
- Truck terminals and distribution centers

parking areas

distribution centers

Honda Plant - Alabama 2001

Mercedes

Mercedes

Streets and Highways

- Industrial access roads
- Residential streets
- Highway inlays
- Fast-track, high-volume intersections
- Shoulders and turn lanes

Industrial Drive

Tennessee DOT

secondary roads

subdivision streets

Other Uses for RCC

Engineering Properties

- **Compressive strength**
  - 4,000 to 10,000 psi
- **Flexure strength**
  - 500 to 1,000 psi
  - $f_r = C(f'_c)^{1/2}$
- **Modulus of Elasticity**
  - 3,000,000 to 5,500,000 psi
  - $E = C_E(f'_c)^{1/2}$

Mixture Design

Conventional concrete mixture procedures are not appropriate!

- Not air-entrained
- Lower water content
- Lower paste content
- Larger fine aggregate content
- Maximum aggregate size 3/4" or 1" max

Optimum Moisture Content

- Dry enough to support a 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

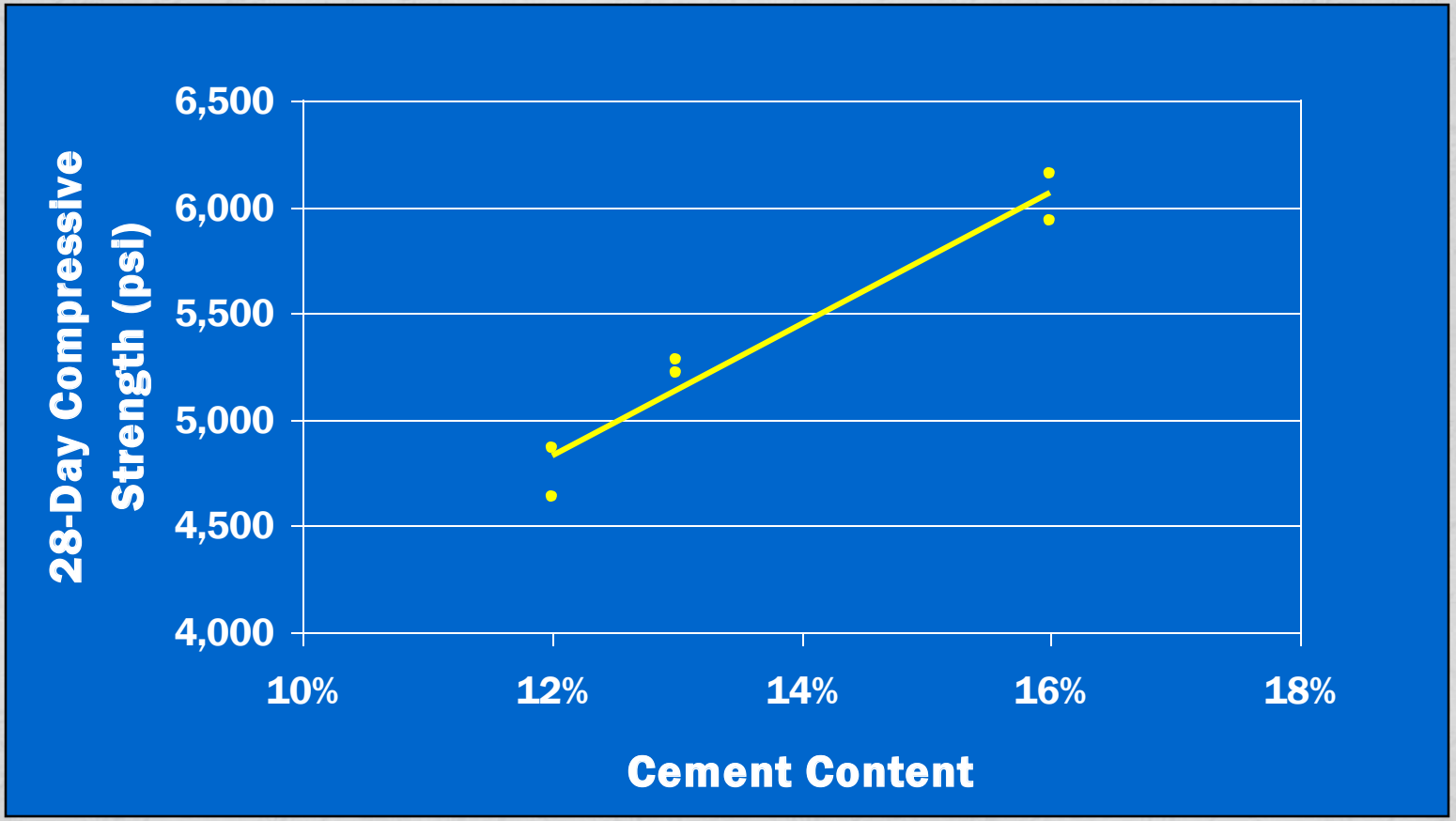
- **Select a sound, well-graded aggregate.**
  - For stability under vibratory roller, aggregate interlock for load transfer, and flexural strength

- **Crushed or uncrushed gravel or crushed stone. Crushed aggregates:**
  - Require more compactive effort
  - Require more water
  - Provide greater stability, less segregation
  - Provide higher flexural strength

Typical Aggregate Gradation

Sieve Size		Percent Passing	
in	mm	Minimum	Maximum
1"	25	100	100
3/4"	19	83	100
1/2"	12.5	72	93
3/8"	9.5	62	82
#4	4.75	51	69
#8	2.36	38	56
#16	1.18	28	46
#30	0.6	18	36
#50	0.3	11	27
#100	0.15	6	18
#200	0.075	2	8

Strength vs. Cement Content



Admixtures

- Retarders or water reducers can be used to increase working time
- Air entrainment not necessary
  - But RCC is freeze/thaw resistant when constructed properly
    - Air void system similar to hot mix pavements, voids are in the matrix
- Fibers seldom used, benefits have not been demonstrated
  - Increased difficulty with compaction reported

Roller Compacted Concrete Pavements (RCC)

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Production - Continuous Pug Mill

- High-volume applications
- Excellent mixing efficiency for dry materials
- 150 to 300+ tons/hr
- Mobile, erected on site
- Higher mobilization costs

Production - Central Mix Batch Plant

- Consistent mix load to load
- Local availability
- Smaller output capacity
  - 60 – 100 c.y./hr
- Longer mix times than conventional concrete
- Dedicated production

Production - Dry Concrete Batch Plant

- Highest local availability
- 2-step process
  - Feed into transit mixers
  - Discharge into dumps
- Very slow production
- Segregation issues from handling multiple times
- Least desirable method

Transporting

- Rear dump trucks normally used
- Minimize transport time
- Covers required
  - Non mesh covers only

Preparation for Placement

- Simple preparation: *no dowels, reinforcing, or forms*
- RCC ideal for wide-open, unimpeded placement runs
- Ensure subbase is smooth and at specified grades
- Set up stringlines or ensure proper grade control through paver automation
- Moisten subbase prior to RCC placement

Placing

- **Layer thickness**
  - 4 inches minimum
  - 8 inches maximum
  - 10 inches with some heavy-duty pavers
- **Timing sequence**
  - Adjacent lanes placed **within 60 minutes** for "fresh joint"
  - Multiple lifts placed **within 60 minutes** for proper bonding
- **Production should match paver capacity**
  - Continuous forward motion for best smoothness

Placing Equipment

- **High density pavers**
  - Vibrating screed
  - Dual tamping bars
  - High initial density (90% to 95%)
  - Reduces subsequent compaction
  - High-volume placement (1000 - 2000 tons/shift)
  - Designed for harsh mixes
  - Smoothest RCC surface

Placing Equipment

- **Conventional Asphalt Pavers**
  - Provides some initial density (80%-85%)
  - Relatively smooth surface

So how do you know when the mix is "right" for placement???

So how do you know when the mix is “right” for placement???

Strive for SSD + a little…

Placement of RCC

Construction Joints

- Most critical area of project
- Must be constructed properly for durability
- Ensures bond/interlock, so slab acts monolithically
- Four types of construction joints:
  - "Fresh joints"
  - "Cold joints"
  - "Horizontal joints"
  - "Construction joints"

Compaction

- Proper compaction is critical for strength and durability
- Compact to 98% of Modified Proctor
- Vibratory roller
- Non-vibratory steel wheel roller
- Rubber-tire roller

Curing

- Extremely important; ensures surface durability
- Low moisture in RCC
- No "bleeding" or excess moisture rising to the surface so must stop evaporation
- Cure for minimum 3-4 days for cars, 7 days for trucks
- Three methods:
  - Moist cure
    - *Similar to DOT bridge decks, constant wetting required…*
  - Concrete curing compound
  - Asphalt emulsion


Night paving for humidity & temp

Natural Cracks

- Most economical
- 30 to 80 ft spacing
- Often first cracks appear within 24 hours
- Narrow crack widths
- Seal if > 1/8 inch
- Best load transfer
- Minimal raveling

Saw-Cut Joints

- More aesthetically pleasing
- Soft-Cut very effective, shortly following placement
- Need to saw within 12 hours to avoid uncontrolled cracking
- $\frac{3}{4}$-inch deep

Joint Spacing

- Transverse joint spacing
  - 10 – 20’ depending on thickness of slab
  - ¼ depth of the slab
  - Should be cut the following day
- Longitudinal joints
  - Same spacing interval
  - Typically in line with construction joints
    - Intermediate cuts may be necessary

Joint Spacing

- Simple rule of thumb
  - Cut more joints!

- A crack that occurs in a saw cut is a good crack…..

Surfacing

- Paver-placed RCC needs no surface for durability
- Adequate for low-speed traffic
- High-density pavers can provide smoothness for medium-speed traffic
- Thin asphalt surface (1-1/2 to 3 inches)
  - Improves surface for high-speed traffic
  - Placed immediately or any time thereafter

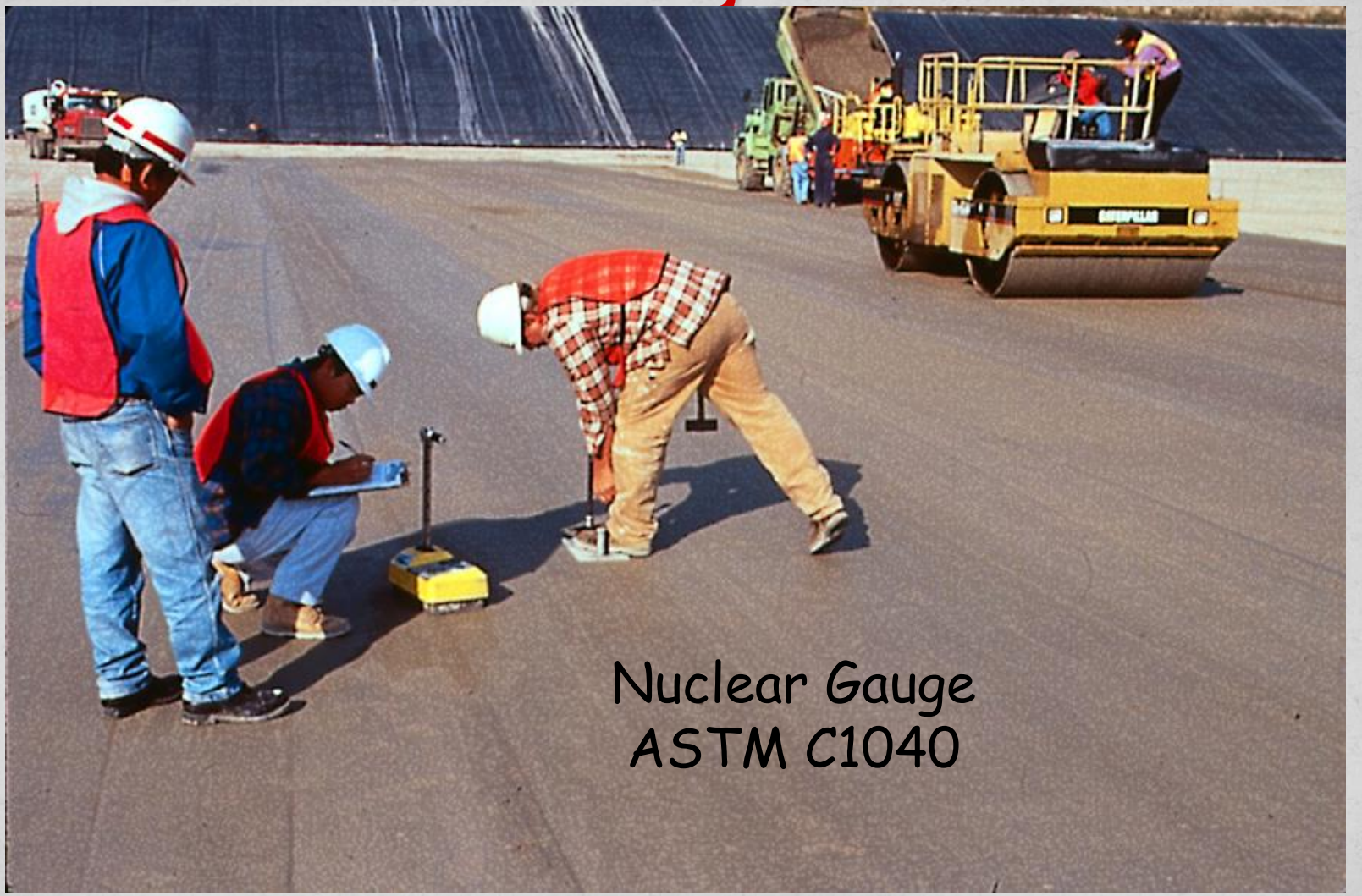

SOUTHERN TIER CATHOLIC SCHOOL


DURA-PAC

Strength Testing

Fabricating Cylinders
With Vibrating Hammer
ASTM C1435

Moisture / Density



Surface Texture and Condition after Industrial Wear and Tear

- Thin layer of surface fines may wear away in first 2-3 years
- Stabilizes thereafter
- Coarse aggregate exposed, but embedded
- Provides traction

Surface Smoothness

- Unsurfaced RCC can be built for low to medium speed traffic
- High density paver achieves good ride quality
- Joints/cracks do not affect ride quality appreciably

RCC Performs!

- Actual RCC performance relatively unknown in 1970's and 1980's
- Gained confidence in 1990's that RCC will perform for 20+ years
- PCA R&D project commissioned
  - *Roller Compacted Concrete Pavements: A Study of Long Term Performance*
  - Confirmed anecdotal evidence of performance

Review time….

1. What is the big difference between RCC and conventional Concrete?
   A. You can add color to conventional concrete.
   B. The slump of RCC is typically 6” – 8” which is higher than conventional concrete.
   C. RCC is a proprietary mix so therefore it is not readily available.
   D. RCC has a higher percentage of fine aggregates, which allows for tight packing and consolidation.

Review time….

1. What is the big difference between RCC and conventional Concrete?

D. RCC has a higher percentage of fine aggregates, which allows for tight packing and consolidation.

Review time….

2. Cast in place concrete walls are a terrific application for RCC.
   A. True
   B. False

Review time….

2. Cast in place concrete walls are a terrific application for RCC.

   A.

   B. **False**

Review time….

3. Which of the following are typical means of placing RCC?

A. Placing with an HD hot mix style paver and compacting.
B. Utilizing a truss screed for strike off, bull floating, and finishing.
C. Placing with a standard hot mix paver and compacting
D. Both A. and C.

Review time….

- Which of the following are typical means of placing RCC?
  A. Placing with an HD hot mix style paver and compacting.
  B. .
  C. Placing with a standard hot mix paver and compacting
  D. **Both A. and C**.

Review time….

4. Which pieces of equipment should be employed for QC/QA testing of RCC?

A. Slump cone and Roll-A-Meter.

B. Slump cone, thermometer, and pressure meter.

C. Marshall hammer and ASTM approved sieves.

D. Proctor hammer and molds with a nuclear density gauge to monitor compaction.

Review time….

4. Which pieces of equipment should be employed for QC/QA testing of RCC?

- D. Proctor hammer and molds with a nuclear density gauge to monitor compaction.

Review time….

- 5. What outputs are ***not*** provided by NRMCA's Design Assistance Program (DAP)
  - A. Structural design
  - B. Project specification developed for project
  - C. Foundation design for the building
  - D. Joint layout pattern

Review time….

- 5. What outputs are ***not*** provided by NRMCA's Design Assistance Program (DAP)
  - C. Foundation design for the building

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Questions???

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