Construction Considerations in Concrete Pavement Recycling

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• Webinar Outline
  ✓ RCA basics
  ✓ Equipment
  ✓ Materials
  ✓ Process
  ✓ Constraints
  ✓ Design considerations
  ✓ Example project scenarios
Recycling Basics

- Commercial recycle yard
- Mobilization of a crusher to a project
  - ✔ Haul materials to a crusher site
  - ✔ On-grade processing

Commercial Recycle Yard

- Mixture of source materials
  - ✔ Concrete
  - ✔ Masonry
  - ✔ Asphalt

- RCA specifications (gradation and deleterious materials) impact the potential use of this type of material
On-Site Crusher

- Crushing, screening and stockpiling at a central location
  ✓ Interchange ramps within the R.O.W. or similar areas are ideal
- Broken concrete is hauled to the crusher site
- RCA is hauled back to the grade

Typical RCA Site
On-Grade Crusher

- Mobile crusher processes the broken concrete on the grade
- No haul-off or haul back of RCA

Typical On-Grade Crushing
RCA Equipment

• Jaw crusher can be used as a primary crusher
  ✓ Allows feeding of larger sized pieces of broken concrete (24”)
  ✓ Helps to separate steel from the broken concrete

RCA Equipment

• Impact crusher is the most common for RCA applications
• Most steel (dowels, crcp and mesh) should be removed prior to crushing
• Smaller feed size (approx. 12” minus)
RCA Process

• In almost all cases, a screen is used to properly size the material
  ✓ Allows for increased production by returning oversized material to the crusher
  ✓ Can be used to split material on a mid-sized sieve (e.g. 3/8””) when specifications require

RCA Process

• Equipment used to produce RCA is identical to that used in a quarry producing virgin aggregates
  ✓ Similar QC results for gradation
RCA Process

• What about existing sealant?
• What about existing bituminous patch materials?
  ✓ Unnecessary to remove prior to crushing
    ➢ Volume of these materials is negligible when compared to the volume of concrete being recycled

✓ … except when RCA is used as a coarse aggregate for the new concrete pavement

RCA Process

• Breaking pavement
**RCA Process**

- Removing Steel
  - CRCP, dowels and mesh
  - Tie-bars can be left in the broken concrete
  - Steel is usually hauled to a salvage facility

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**RCA Process**

- Loading and hauling
RCA Process
• Crushing and sizing

RCA Process
• Hydraulic hammer breaking over-size rubble
RCA Process

• Excavator feeding crusher
RCA Process

- Magnet

RCA Process

- Sizing screens
  - Oversized returns to crusher
  - Finished product transferred by conveyor
RCA Process

- Oversize return

RCA Process

- Stockpiling – use proper techniques to minimize segregation
On-Grade Recycling

• Same equipment
• No hauling required
  ✓ Significant cost savings
  ✓ Reduced exposure to traffic
RCA Summary

- A controlled process
  - ✓ Breaking
  - ✓ Crushing
  - ✓ Sizing
  - ✓ Stockpiling
  - ✓ Return to project as quality aggregate for subbase, base, concrete, etc.

RCA Design/Construction Considerations

- Material applications
  - ✓ Unbound granular base
  - ✓ Bound granular base (cement treated)(plant mixed)
  - ✓ Granular shoulder/backfill
  - ✓ Concrete aggregate
  - ✓ Other
RCA Design/Construction Considerations

• Construction processes for RCA
  ✓ Shaping and compacting of unbound base is the same as for virgin material
  ✓ However, absorption is higher so even more water will be necessary to attain optimum

Stockpiles must be kept moist (above SSD) to avoid absorption during the batching process

Specific gravity of RCA is lower than virgin materials, therefore it will take less mass per CY of batched materials as compared to virgin aggregates
RCA Design/Construction Considerations

- Fines in RCA
  - Approx. 1% to 2% passing the #200 from crushing clean concrete pavement
  - Additional fines come from excavating underlying soils when loading the broken concrete
  - Gradation specifications should consider:
    - Underlying material – subgrade vs. treated base
    - Modify specification as needed (reduce the low end of % passing the #200)

RCA Design/Construction Considerations

- Fines content comes predominantly from the underlying materials
RCA Design/Construction Considerations

- Residual mortar particles in RCA used as concrete aggregate
  - #4 and larger particles composed of mortar
  - Potential for higher absorption
    - Some projects have shown more distress
    - Further crushing can break these particles down, but leads to inefficiencies (production and by-product)

RCA Design/Construction Considerations

- Should RCA be mandated/specifed, or should the market determine the most efficient means of constructing the project?
- Where should RCA be used?
  - What are the objectives?
    - Cost
    - Sustainability
    - Quality
    - Other
  - It depends …
RCA Design/Construction Considerations - Constraints

- RCA use and applications is impacted by:
  - Availability of space for recycling
  - Environmental permitting restrictions
  - Cost of virgin materials

RCA Design/Construction Considerations - Constraints

- RCA use and applications is impacted by:
  - Volume of RCA available from the project
  - Timing of that availability (phasing)
  - Material specifications
**RCA Design/Construction Considerations**

- Existing divided highway (5 mile project)
  - 8” JPCP
  - HMA shoulders
  - 6” granular base

**RCA Design/Construction Considerations**

- Phase I
  - Temporary HMA widening of NB
  - Place traffic on widened NB
  - 0 CY of RCA available
  - 5,642 CY of virgin granular base required for widening
RCA Design/Construction Considerations

• Phase II
  ✓ Reconstruct SB
    ➢ 12” JPCP on 6” RCA granular base
      – RCA available = 46,933 CY
      – RCA required = 52,800 CY
      – Virgin required = 5,867 CY (≈ 11%)
    ➢ 8” JPCP shoulders on salvaged granular base
      – Salvaged available = 60,133 CY
      – Salvaged required = 69,412 CY
      – Virgin required = 9,279 CY (≈ 13%)
RCA Design/Construction Considerations

- Phase III
  - Reconstruct NB
    - 12" JPCP on 6" RCA granular base
      - RCA available = 46,933 CY
      - RCA required = 52,800 CY
      - Virgin required = 5,867 CY (≈ 11%)
    - 8" JPCP shoulders on salvaged granular base
      - Salvaged available = 69,207 CY
      - Salvaged required = 28,101 CY
      - Excess salvaged granular base = 41,106 CY
RCA Design/Construction Considerations

• What about other RCA applications for the same hypothetical project?
  ✓ 4” cement treated granular base
  ✓ 4” cement treated drainable base
  ✓ Incorporated as coarse aggregate in the JPCP

RCA Design/Construction Considerations

• Specified gradation impacts the amount of RCA recovered
  ✓ Drainable base specifications have fewer fines than a granular base
  ✓ Coarse aggregate for concrete has fewer fines than drainable bases
RCA Design/Construction Considerations

- Specified gradation impacts the amount of RCA recovered

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<th>Concrete Stone Percent Passing</th>
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RCA Design/Construction Considerations

- RCA as granular base
  - 93,866 CY available
  - 93,866 CY used
RCA Design/Construction Considerations

- RCA as cement treated drainable base
  - 93,866 CY available
  - 79,786 CY used
  - 14,080 CY screened and stockpiled

- Where can this material be incorporated in the project?

RCA Design/Construction Considerations

- RCA as coarse aggregate for concrete
  - 93,866 CY available
  - 65,706 CY used
  - 28,160 CY screened and stockpiled

- Where can this material be incorporated in the project?
RCA Design/Construction Considerations

• Back to the hypothetical project
  ✓ Phase III had approx. 41,000 CY of excess salvaged granular base
    ➢ Use as granular base under the 12” JPCP?
    ➢ This leaves ±35,000 CY of RCA that could be used for coarse aggregate in the JPCP
    ➢ Approx. 20,000 CY needed for the JPCP
    ➢ This leaves ±10,000 CY of excess fines and ± 5,000 CY of excess RCA

RCA Design/Construction Considerations

• Verify that the contractor is complying with:
  ✓ Environmental regulations (dust and runoff)
  ✓ Safety regulations
RCA Design/Construction Considerations (summary)

• There are many options for the use of RCA
  ✓ Specifications should allow RCA wherever possible
    ➢ Modify durability requirements (LA Abrasion, sodium sulfate, C 666, etc) to allow RCA
    ➢ Reduce the spec. for the low end of the material passing the #200
    ➢ Gradation QC should be performed at the same frequency as for virgin aggregates

• Let the market determine how/where to incorporate RCA cost effectively