PCC Mix Designs Using Recycled Concrete Pavements

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Overview

- Reassessment of recycled concrete aggregate (RCA) use in rigid pavements
- History of RCA use
- Characteristics of RCA concrete
- RCA production
- RCA concrete production
- Guidelines for RCA use
• Recent understanding of how to accommodate RCA in concrete is better
  - water-reducing admixtures/plasticizers
  - wash aggregate
  - no fines if unable to accommodate variable workability
• RCA is a valuable resource because it contains high-quality aggregates
• SHRP 2-R21 composite pavement initiative
History of RCA Use

- Minnesota, Michigan, Iowa, Illinois, and Texas pioneers of using RCA in PCC pavements in the early 1980s, however
  - Texas suspended using RCA in its PCC pavements
  - Minnesota relegated RCA to base layers/pipe trenches in the early 1990s
- European experience from late 1980s
  - Austrian standard practice is to recycle existing rigid pavement into new concrete/concrete composite pavements.
  - Germany & others also beginning to use RCA
- Other European countries, Japan, and Korea have published lab studies of RCA but little mention of field study

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RCA Concrete Characteristics

• Strength of RCA concrete compared to conventional aggregate concrete:
  □ **Compressive** strength of RCA concrete is typically less
  □ **Flexural** strength of RCA concrete is usually greater
  □ **Tensile** strength of RCA concrete is usually similar

• Shrinkage

• Durability
Why Aren’t More States Using RCA?

• Cost is greater to recycle than to mine and haul virgin aggregates
• Lack of quality rigid pavements that are at the end of their useful life
• Aggregate supplies are not in danger of depletion in the near future
• Adequate landfill space
• Recycling concrete is not a familiar practice for engineers or contractors
Why Aren’t More States Using RCA?

Information to help you feel more comfortable designing, specifying, and producing concrete with Coarse RCA

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Multiple sources good for base

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RCA Origin

Single source good for RCA

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RCA Origin

Multiple source

Single source

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Sieve with adjustable screen size

Washing the aggregate to remove fines

RCA Production

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European studies showed that RCA could contain 10-20% bituminous particles without significant loss of concrete strength.
• Specify a maximum and a minimum aggregate size controlled by setting of crushers and screens
• Maximum size should be one sieve-size less than the maximum size in existing concrete
• Sizes in-between can sometimes be controlled with screens
• The smaller the maximum size, the more fines are produced
• Wash coarse RCA for less variability of water demand
AGGREGATE ABSORPTION!

From database of RCA concrete:

- Conventional coarse aggregate absorption ranged from 0.3-2%
- Coarse RCA absorption ranged from 1.5 to 8%
- Recent single source coarse RCA absorption measured by the U of M:
  - 1.5-2.0% (Airport)
  - 0.8-1.5% (I-94)
Saturate aggregate and allow to air dry before putting it into the mix

- Aggregate should not give or take water
- Avoids variability of workability between batches
- Not all ready mix plants and/or contractors are equipped to do this
  - source of water
  - run-off
Wild Card

- From database, fine RCA absorptivity ranged between 5.4% and 15.8%
- Sand and Mortar particles
  - Mortar particles can hydrate
- From others’ research
  - Partial fines replacement successful with the addition of a fly ash or silica fume
- Research underway to understand how to accommodate this absorptivity
Guidelines for RCA Use in New Concrete

- **Golden Rule:** Use a single source for RCA used in new concrete
- **Silver Rule:** The absorption of recycled concrete aggregates requires attention
- Wash fines from coarse aggregate for more consistent workability
- Limit the max size of RCA to one sieve size lower than the max size of aggregate in existing concrete
Thank you
Concrete Over Concrete Composite Pavement

• A part of the Strategic Highway Research Project (SHRP-2) R21 project entails concrete/concrete composite pavement research
• Modeled after EU practice standard since the 1950s
• Want to import technology

Source: Derek Tompkins, 2008 European Roads Tour
Concrete Over Concrete Composite Pavement

- Avenue for in-place concrete recycling
- Quick replacement
- Typical U.S. one-layer pavements not as resource efficient
- Durable
- Accommmodates heavy traffic
- Low maintenance