Recycled Concrete Aggregate in Transportation Projects
Background

- Aggregates in transportation construction
  - $\approx 2.241$ billion metric tons of crushed stone (2006)
  - Transportation infrastructure $\approx 95\%$ of production
  - Need for transportation projects is expected to increase to $2.5$ billion tons by 2020 (FHWA, 2004)

- Conventional aggregate resources are becoming limited

- Alternative sources such as recycled concrete aggregate (RCA) must be investigated
RCA: State of the Art

- 130 to 140 million tons of concrete is crushed for recycling purposes annually (CMRA, 2004)
- 50 million tons of RCA is recycled from airports, and municipal and state roadways (Saeed 2004)
- The most common pavement application for recycled concrete aggregate (RCA) is base/subbase construction
- 41 states report using RCA (2004 FHWA survey)
  - 39 states allow RCA in PCC pavements
  - 38 states allow RCA in base layers
  - 8 states allow RCA in HMA pavements
  - 17 states allow RCA for other construction purposes
RCA Uses

- RCA uses (USGS 2007 statistics):
  - Road Base
  - HMA Mixes
  - Low-Value Products
  - New Concrete Mixes
  - High-Value Rip-Rap
  - Other

- 68% Other
- 7% Road Base
- 7% HMA Mixes
- 7% Low-Value Products
- 6% New Concrete Mixes
- 3% High-Value Rip-Rap
- 9% Other
State Experiences (FHWA 2004)

- Texas
  - Limits RCA fines to 20% in concrete applications
  - Have obtained excellent performance as a base
  - Does not use RCA in structural concrete due to creep and shrinkage
  - Private industry and municipalities consume over 60% of the RCA

- Virginia
  - Established an income tax credit for the purchase of recycling machinery
  - Commercial applications are the prime use of RCA
State Experiences

- **Michigan**
  - ✓ Coarse RCA permitted to be used for HMA and many concrete applications
  - ✓ RCA is also allowed for base courses, surface courses, shoulders, approaches, and patching

- **Minnesota**
  - ✓ Uses almost 100% of removed concrete pavement as dense graded aggregate base

- **California**
  - ✓ Most of the removed concrete pavement is used as aggregate base
RCA as a Sustainable Solution

- RCA has contributed to several reported economic and environmental benefits

<table>
<thead>
<tr>
<th>Resource Conservation</th>
<th>Economic Benefits</th>
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<tbody>
<tr>
<td>Reduces landfill requirements</td>
<td>Haul distances can be limited</td>
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<tr>
<td>Conserves virgin aggregate</td>
<td>Reduces disposal costs</td>
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<tr>
<td>Metal can be recovered</td>
<td>Reduces construction traffic/delays</td>
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Barriers to Using RCA

- High initial investment
  - Concrete crushers
  - Additional equipment for metal removal
- Maintenance costs of concrete crushers
- Possible contaminants
- Excess amount of fine RCA
  - Fine RCA includes a significant amount of mortar particles, not durable aggregate
Needed Research

- Are virgin aggregate specifications and test procedures applicable to RCA? Are additional specifications required?
  - RCA will typically have higher absorption and lower specific gravity than natural aggregate
  - RCA usually produces concrete with slightly higher drying shrinkage and creep, which become greater with increasing amounts of recycled fine aggregates
  - It is difficult to control particle size distribution during crushing - the RCA may fail to meet grading requirements of ASTM C33 – “Standard Specification for Concrete Aggregates”
**Needed Research**

- Will pavement layers constructed with RCA contribute to leeching of chlorides or other contaminants that could lead to corrosion of reinforcement?
  - The chloride content of RCA is of concern if used in reinforced concrete, particularly if the RCA is from pavements where road salt is routinely used.

- Can RCA from ASR distressed PCC be used for transportation applications?
  - ASR prone PCC may become even more susceptible as RCA
  - Are conventional mitigation techniques such as the use of low alkali cements, fly ash, etc reasonable solutions?
**Needed Research**

- Is there an optimal amount of RCA for concrete mixes?
- Can crushing operations be modified to generate more coarse aggregate and minimize fine aggregate?
- Recycling of fresh concrete
  - Can techniques be optimized to reclaim aggregate and washed paste
- RCA as aggregate source for HMA
  - Does high absorption rate, and therefore need for more asphalt, make this unattractive on a large-scale basis?