Recycled Concrete Aggregate in Transportation Projects

Background

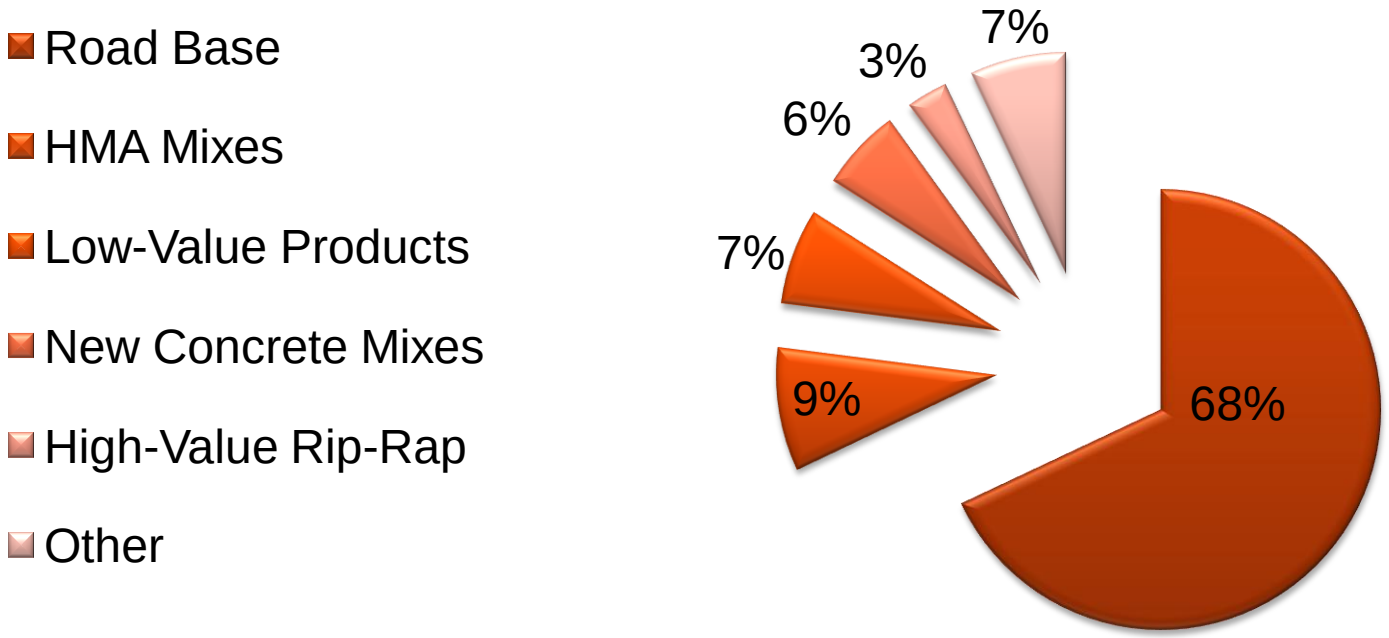
- Aggregates in transportation construction
  - ✓ ≈ 2.241 billion metric tons of crushed stone (2006)
  - ✓ Transportation infrastructure ≈ 95% of production
  - ✓ Need for transportation projects is expected to increase to 2.5 billion tons by 2020 (FHWA, 2004)
- Conventional aggregate resources are 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):



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

Resource Conservation	Economic Benefits
Reduces landfill requirements	Haul distances can be limited
Conserves virgin aggregate	Reduces disposal costs
Metal can be recovered	Reduces construction traffic/delays

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?