OKLAHOMA Transportation RESEARCH

PROJECT TITLE
RECYCLING AND REUSE OF MATERIALS IN TRANSPORTATION PROJECTS - CURRENT STATUS AND POTENTIAL OPPORTUNITIES INCLUDING EVALUATION OF RCA CONCRETE PAVEMENTS ALONG AN OKLAHOMA INTERSTATE HIGHWAY

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INVESTIGATORS
Anol Mukhopadhyay, Ph.D., P.G.
Xijun Shi, Ph.D.
Dan Zollinger, Ph.D., P.E.
Materials and Pavement Division
Texas A&M Transportation Institute (TTI)
The Texas A&M University System

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Office of Research & Implementation

Oklahoma Department of Transportation
200 NE 21st Street,
Oklahoma City, OK
73105-3204

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HIGHLIGHTER

RECYCLING AND REUSE OF MATERIALS IN TRANSPORTATION PROJECTS - CURRENT STATUS AND POTENTIAL OPPORTUNITIES INCLUDING EVALUATION OF RCA CONCRETE PAVEMENTS ALONG AN OKLAHOMA INTERSTATE HIGHWAY

November 2023

OVERVIEW The Oklahoma Department of Transportation (ODOT) is committed to protect and enhance the human and natural environment while developing a safe, economical, and effective transportation system. The state has great interests in using recycled and reusable waste materials, such as Recycled Concrete Aggregate (RCA), Reclaimed Asphalt Pavement (RAP), recycled tires, crushed glass, and recycled carpets, in infrastructure constructions. With the increasing demand of using sustainable materials coupled with reduction in funding for maintenance and repair of our nation's infrastructure, the use of recycled materials in construction offers an effective way to both reduce cost and decrease the carbon footprint without compromising performance and service life. This study was focused on addressing two main objectives related to the use of recycled materials for construction of transportation infrastructure in Oklahoma. The first objective was to evaluate the availability of the recycled materials and develop strategies for increasing use of recycled materials in ODOT transportation construction projects. The second objective was to evaluate the long-term performance of existing Portland Cement Concrete Pavement (PCCP) made with RCA in Oklahoma. A jointed plain concrete pavement (JPCP) and a continuously reinforced concrete pavement (CRCP) section were selected and evaluated through various tests.

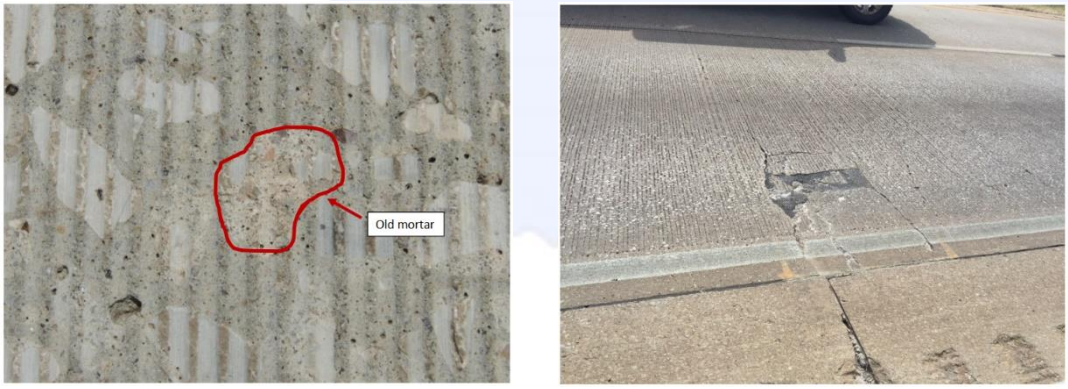
RESULTS To address the first objective, an extensive literature search was conducted to acquire information pertaining to properties, current practice, and available field investigations of the commonly used recycled materials. Based on the survey sent to the representative from ODOT to inquire general interest of using different recycled materials and potential challenges of using these materials, use of recycled concrete aggregate in concrete paving mixtures was identified as the primary interest for Oklahoma infrastructure projects. Subsequently, a review of the key findings pertaining to RCA material properties and effects of RCA on PCCP performance was performed. Based on the collected survey results from the nationally recognized RCA researchers together with the findings from existing literature, the following recommendations were summarized for reducing the detrimental effects of RCA on PCCP performance.

- Keeping RCA stockpiles at saturated status was found important due to RCA's high-water demand.
- Short joint spacings were recommended to compensate the negative effects caused by the higher coefficient of thermal expansion of the RCA-PCC (Portland Cement Concrete with Recycled Concrete Aggregate).

- Building a strong base and subgrade support was highly recommended for RCA-PCCP to avoid slab faulting and base erosion.
- RCA-PCC may not be placed in hot summer due to the higher shrinkage potential of the PCC slab.
- Dowel bars were recommended for pavement with RCA to compensate the lower aggregate interlock.
- Use of RCA in PCC may cause steel to corrode faster than normal. Therefore, RCA might need to be washed before mixing. Use of corrosion resistant steels can be helpful.

Additionally, a comparative life cycle assessment between RCA in PCCP and plain PCCP concluded that the use of RCA in PCCP could offer benefits covering all three aspects of sustainability such as cost savings, energy savings, conservation of good quality virgin aggregates, reduction in consumption of landfill space, reduction in greenhouse emissions, etc. These benefits are expected to be magnified in the future with a growing demand of environmental awareness and gradual reduction of good quality local virgin aggregate sources

The second objective of the study was to evaluate the long-term performance of two existing PCCP sections made of RCA-PCC in ODOT covering visual survey, determination of mechanical properties, petrographic examination, and evaluation of the existing subbase through Falling Weight Deflectometer (FWD). The first section represented a JPCP portion made of RCA on I-40 in Oklahoma County between mileposts 165 and 173, which was constructed in 1984. The second section represented a CRCP section on I-35 (southbound) in Logan County between mileposts 147 and 152, which was constructed in 1989. The northbound CRCP section made of virgin limestone coarse aggregate between the same mileposts on I-35 has served as a control section. It was found that the modulus of elasticity and split tensile strength of the RCA sections were invariably lower than their corresponding control sections for both JPCP and CRCP pavements. Although, the JPCP sections with RCA-PCC showed a slightly higher average compressive strength compared to the control section, the CRCP sections with RCA-PCC showed lower compressive strength compared to the control section. The surface condition survey data and the FWD results indicated that the JPCP section with RCA-PCC exhibited relatively lower degree of performances compared to the control JPCP section, but such trend is not valid for the CRCP sections.



(a) (b)

Figure 1 (a) Identification of RCA with old mortar from the field survey in I-40 EB Segment 3, and (b) Picture of a Typical Punchout from I-35 SB

Based on the findings, it is verified that good base support, strong load transfer, and shorter joint spacing are essential design considerations for JPCP made of RCA-PCC. CRCP might be more suitable for implementing RCA-PCC as it could better protect the base from erosion caused by higher differential energy and help restrain high drying and thermal volume change of RCA-PCC.

POTENTIAL BENEFITS The findings from this study clearly revealed that there are widespread benefits of using recycled and reused waste materials in construction in Oklahoma. In particular, use of RCA for concrete pavement applications not only was found to be a technically sound concept, but also can lead to significant sustainability benefits. The good long-term performance of the two studied sections should strengthen the idea of using RCA in PCC. As local aggregate source is being further diminished, use of recycled aggregates (e.g., RCA, RAP) would provide a cost-effective solution for concrete paving projects.