Texas A&M Transportation Institute

PROJECT SUMMARY

Texas Department of Transportation

0-6855: Validation of RAP and/or RAS in Hydraulic Cement Concrete

Background

Reclaimed or recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS) have been widely used in hot-mix asphalt (HMA) in Texas. However, a high volume of RAP is still available in stockpiles along the Texas Department of Transportation's (TxDOT's) highways or at HMA concrete producers' plants, in spite of their use by the asphalt industries. Ground RAS from manufacturers and post-consumer uses are also available. The possible use of RAP and RAS in portland cement concrete (PCC) would not only help dispose of excess RAP and RAS, but also provide a cost reduction for aggregates in hydraulic cement concrete.

What the Researchers Did

In this project, the previous findings on the mechanical properties and durability of PCC containing RAP (RAP-PCC) reported from literature were validated and further explored through a comprehensive experimental program. Researchers investigated the microstructures and crack propagation in the RAP-PCC system by using several advanced techniques such as optical microscope, x-ray computed tomography, and scanning electron microscopy. Researchers also evaluated PCC pavement containing RAP-PCC slab through both pavement performance software and the life cycle assessment model. Finally, researchers developed guidelines and an implementation plan to facilitate the use of PCC containing RAP in the field.

What They Found

Researchers examined the feasibility of the use of RAP in PCC as virgin aggregate replacement from different aspects. Testing RAP-PCC mechanical properties and durability yielded the following findings:

- Replacing virgin coarse aggregate by RAP has caused reduction in compressive strength (CS), modulus of elasticity (MOE), modulus of rupture (MOR), and split tensile strength (STS). The percent reduction in MOR turned out to be the lowest.
- The coarse RAP with suitable gradation containing sufficient intermediate size particles can help make dense-graded concrete. The dense-graded RAP-PCC showed better workability and mechanical properties compared to the other gap-graded RAP-PCC.
- The American Concrete Institute (ACI) has developed equations applicable for conventional PCC to predict other mechanical properties (e.g., MOE, MOR, and STS) from measured compressive strength. The ACI equations underestimate the prediction of MOR, MOE, and STS for RAP-PCC. The ACI equations were modified in this study to represent RAP-PCC systems.
- Regression relationships were developed to describe RAP-PCC mechanical properties

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with varying asphalt content. Both CS and MOR have strong linear relationships with global asphalt binder volumetric fraction.
- From the relationship equations, approaches to determine the optimum RAP replacement were proposed for both Class P and low-strength classes of concrete.

The studies on the microstructure and crack propagation in RAP-PCC indicated:

- The presence of RAP clump is a common feature. The agglomerated RAP particles appeared to be a single particle to the naked eye, but their agglomerated nature was clearly visible under the microscope.
- The major weak point of the RAP-PCC system is the asphalt. Asphalt cohesive failure (i.e., cracks easily propagating through the asphalt layer around the RAP particles) is the major failure mechanism.
- The presence of RAP has caused higher amounts of air voids in the studied RAP-PCC mixtures compared to the reference PCC sample.

After a comprehensive pavement performance analysis and life-cycle assessments, researchers concluded:

- At higher replacement level (>20 percent), the pavement containing RAP-PCC needs slightly higher slab thickness. A slight increase in thickness is largely caused by the increase in the coefficient of thermal expansion and Poisson's ratio, and the reduction in MOR when RAP is added into concrete.
- Compared with the material production for plain PCC pavement, the production of materials for constructing RAP-PCC pavements (either full depth or two lift) yielded lower economic activity (more economical) and consumed less energy. It released fewer air pollutants, greenhouse gases, and toxic materials. It also led to fewer amounts of land use and water withdrawals.
- The idea of using RAP-PCC as bottom lift in a two-lift PCC pavement can maximize the RAP usage without compromising the pavement performance or with a compromise within the permissible limits. The cost and environmental benefits were obvious for the two RAP-PCC pavement types.
- Other than the benefits from the material production process, the use of RAP in PCC can reduce the size of the RAP stockpile significantly, which leads to cost savings and protecting the environment and public safety.

What This Means

The RAP-PCC mechanical properties and durability data generated in this project can serve as a valuable database for identifying future research and field implementation of RAP-PCC. The identification of asphalt cohesive failure as the major failure mechanism in the RAP-PCC system provided supports behind the observation and could help find methods to improve RAP-PCC performance. The results from life-cycle assessment suggest that the proper use of RAP to make PCC can not only make RAP-PCC cost-effective but also environmentally friendly. The guidelines and implementation plans developed in this project will be good resources for TxDOT to decide further gap-filling research and implementation, which promotes technology transfer and sustainable construction practices.

For More Information

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