Project Summary Report: 8207-002
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Feasibility of Reclaimed Asphalt Pavement as Aggregate in Portland Cement Concrete Pavements

Phase II: Field Demonstration

http://www.mdt.mt.gov/research/projects/mat/cement.shtml

Introduction

Each year, the US highway industry produces over 100 million tons of reclaimed asphalt pavement (RAP) through standard rehabilitation and construction of the nation's roads. Although this product has been reused in several applications, usually in hot plant mixes, a large portion of this material remains unused. With a sizeable share of RAP wasted in stockpiles and landfills, the exploration of further uses for this construction byproduct is warranted. Using RAP as aggregate in Portland cement concrete pavement (PCCP) is one possible application for this recyclable material. Portions of virgin aggregate used to produce concrete pavement may be replaced with RAP, creating a pavement that is both efficient and environmentally friendly.

What We Did

This research investigated the feasibility of using RAP to replace virgin aggregates in concrete pavements. Specifically, this research considered using minimally processed RAP (i.e., simply fractionating it into fine and coarse components with no washing or crushing) in this capacity for roadways in the state of Montana. This research was conducted in multiple phases.

The first phase of research used a statistical experimental design procedure (response surface methodology – RSM) to investigate mix proportioning in concrete mixtures containing RAP to achieve desired performance criteria. Based on the RSM models, two concretes were ultimately selected for further evaluation: a high RAP mix (HR) and a high strength mix (HS). These mixes were then evaluated through a suite of mechanical/durability tests. The second phase of this research was focused on: (1) evaluating the field application of RAP concretes, and (2) further optimizing RAP mixes in order to reduce the amount of required cement.

Figure 1: Typical RAP Pile in Montana

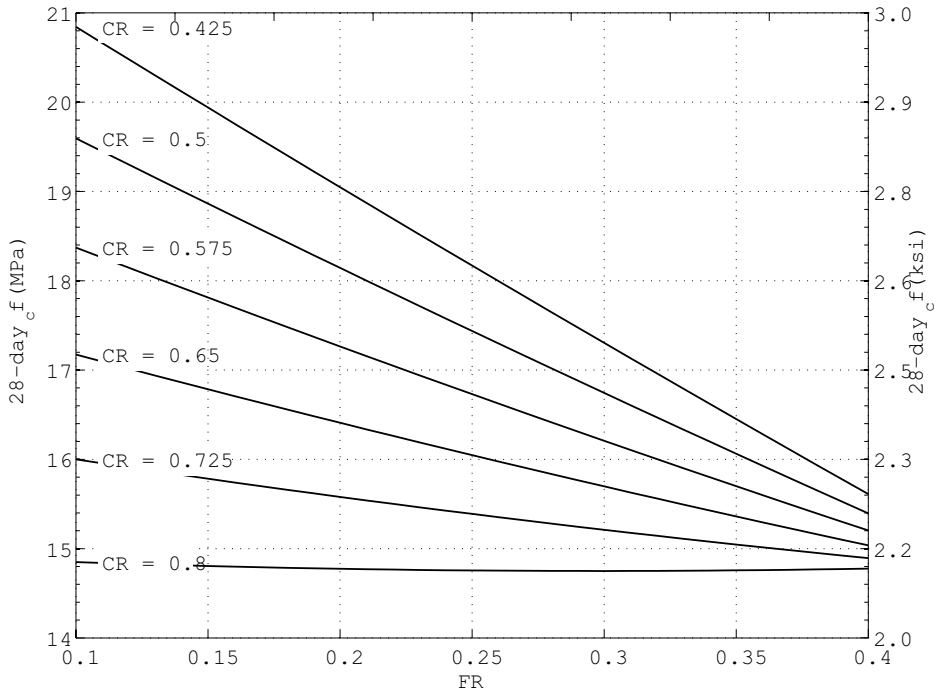

Figure 2: Effect of Fine and Coarse Recement on 28-day Compressive Strength During Phase 1

The field application of RAP concrete was evaluated through a field demonstration project near Lewistown, MT, in which two RAP concrete test slabs (one HR slab and one HS slab) were placed on a roadway at the MSU/WTI Transcend Research Facility. In regards to the optimization, two optimized mixes were developed and evaluated through a series of mechanical and durability tests.

What We Found

Phase I Findings:
Two concrete mixtures containing RAP were found to meet MDT pavement specifications: a high RAP mix (HR) and a higher strength mix (HS). These mixes were identical to each other sans the RAP replacement rates; the HR mix had a relatively large amount of RAP with 50 percent of the fine and 100 percent of the coarse aggregate replaced with RAP. The HS mix was designed to have a higher strength by using half of the RAP (25 percent of the fine aggregate was replaced and 50 percent of the coarse). This research demonstrated that both the HR and HS mixes had adequate mechanical properties and durability to be used in concrete pavements in the state of Montana. That being said, the inclusion of RAP was generally found to have a negative impact on the mechanical properties and durability of the concrete, with the HS mix generally outperforming the HR mix. The negative impact of including RAP was postulated to be due to: (1) the decreased bond between the asphalt coating on the RAP and the hardened paste, and (2) the conglomerations of asphalt and smaller particles found within the coarse fraction of RAP. Furthermore, the nature of the RAP aggregates significantly affected the accuracy of traditional techniques for accounting for aggregate moisture content.

Phase II Findings:
RAP can be processed in the field, and RAP concrete slabs can be batched/placed/finished with conventional concrete equipment, with no major issues. Further, the RAP concrete slabs did not see significant damage/shrinkage/curling throughout the first few years of use. Suitable concrete mix designs containing a significant amount of RAP while maintaining conventional cement contents were obtained with the use of commercially available water-reducing admixtures. The two mixes developed in this research contained approximately 6.5 sacks of cement per cubic yard, and had adequate mechanical properties and durability (sans chloride permeability and compressive strength for one of the mixes) to be used in concrete pavements

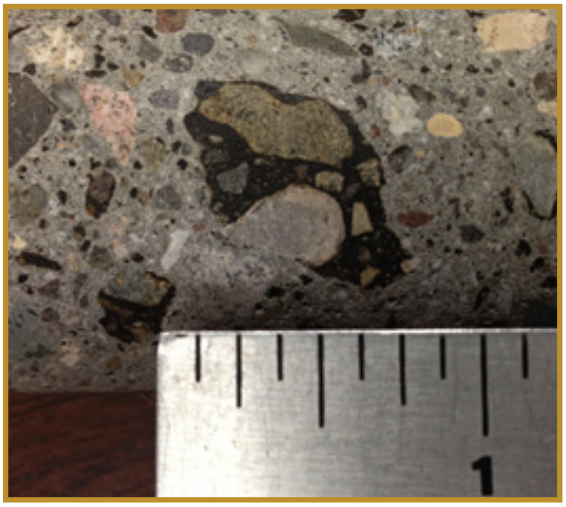

Figure 3: Coarse RAP in Concrete from Phase 1

Figure 4: Casting Field Demonstration Slabs During Phase 2

in the state of Montana. That being said, these mixes required the use of a water-reducing admixture to achieve the desired workability, and were difficult to consolidate. Further, the process for batching these mixes involved slump adjusting the mixes with the admixture, as the nature of the RAP aggregates made it difficult to adjust mixes for variations in moisture content. These issues may hinder the use of these RAP mixtures in real-world applications.

What the Researchers Recommend

While this research demonstrated the feasibility of using RAP as a replacement to virgin aggregates in concrete pavements, the inclusion of RAP was generally found to have negative impacts on the mechanical properties and durability of concrete. To overcome the negative effects of including RAP, fairly rich mixes containing a significant portion of portland cement (15-25% more than a conventional mix) were required to meet performance specifications. Further, the use of RAP in this application does not recover/exploit its asphalt cement potential. That being said, there may be circumstances where RAP aggregate concrete may be a suitable alternative to conventional concrete or asphalt pavement. For instance, in remote areas where natural aggregates are scarce and a durable concrete pavement is desired, old asphalt roadways could be milled, and the resulting RAP could then be processed on-site and used in a concrete pavement or white topping. In such circumstances, the researchers recommend using the HS mix developed in this research, which has coarse and fine RAP replacement rates of 50 and 25 percent, respectively. This mix contains a significant portion of RAP, and was shown to perform better than the other mixes developed/evaluated in this research.

For More Details . . .

The research is documented in Report FHWA/MT-15-002/8207-003 located at: http://www.mdt.mt.gov/research/projects/mat/cement.shtml .

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MDT Implementation Status: October 2015

Results of this research project will be used in discussions regarding appropriate use of recycled asphalt pavement by MDT staff.