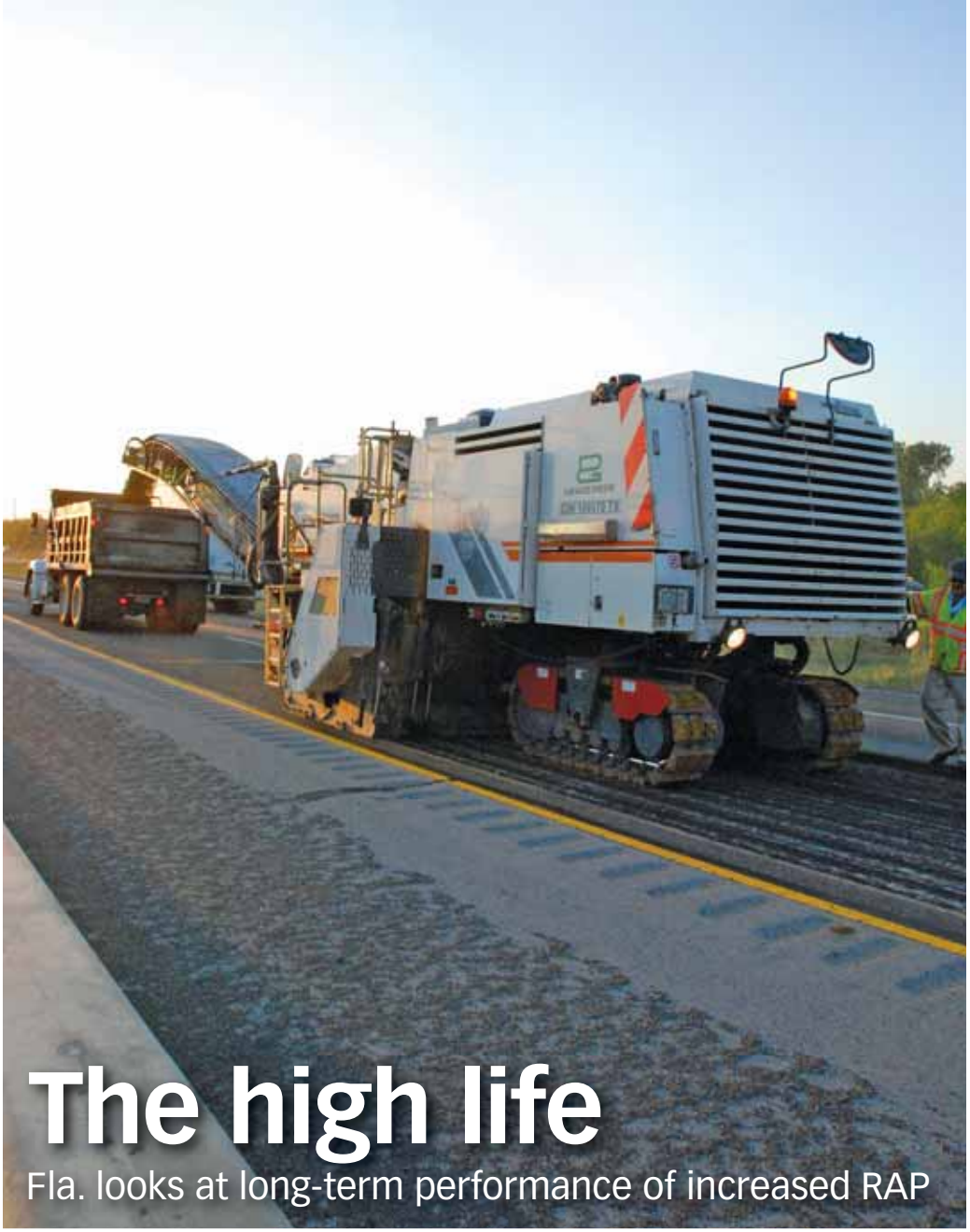

The high life

Fla. looks at long-term performance of increased RAP

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The use of reclaimed asphalt pavement (RAP) has received significant attention nationally in the last few years.

With the increase in raw material prices and for environmental reasons, there is a demand to use more recycled materials. The use of more RAP in asphalt pavements is a potential cost savings and an environmentally friendly technique to address these issues.

In the past, the use of RAP has demonstrated a performance quality comparable to that of a non-RAP, or virgin, asphalt mixture. The Strategic Highway Research Program performed a 20-year study (Long Term Pavement Performance [LTPP] program) that monitored in-service performance data for 18 pavements in the U.S. and Canada. Several researchers have accessed this data to study different aspects of RAP performance. Ranging from 15% to 25% RAP, all reports have shown the RAP mixtures' performance to be equal to or not statistically different from the non-RAP asphalt mixtures.

A Florida favorite

In 2007, the Federal Highway Administration (FHWA) reported the national average for RAP content being used in asphalt pavements was 12%, increasing only to about 15% by 2010.

However, despite the success rate of these mixtures, the perception that mixtures containing these recycled materials have inferior performance still persists. Today, only 11 states

report actually using more than 25% RAP consistently even though more than 40 states allow greater than 30% RAP use in their asphalt mixtures.

The Florida Department of Transportation (FDOT) had its first RAP project in 1977, where it was used to construct an asphalt base with 25% RAP. Following this, two more test projects were constructed using a 30% RAP leveling course mixture and a 65% RAP structural mixture. With promising performance of these test sections, industry's continued interest and national improvement of the process, FDOT started using RAP routinely in 1980, allowing up to 60% RAP in their hot-mix asphalt (HMA).

Initially, RAP was used in the pavement base and underlying structural layers. Unfortunately, long-term performance is typically based on the pavement surface condition (cracking, ride and rutting) and visual observation of the then-virgin friction courses. Today, nearly all of FDOT's structural and dense-graded friction course mixtures contain RAP. The only mixtures where RAP is currently not permissible are open-graded friction course mixtures.

In 2010, FDOT placed 4.3 million tons of HMA, of which 3.4 million tons contained RAP material. For those mixtures containing RAP the average RAP content was 20%. In Florida, the Marshall Mixture design method was used to design asphalt mixtures until the late 1990s, when FDOT switched to the Superpave mixture design method. Due to the limited long-term performance data of the Superpave mixtures, this study focused on Marshall-designed mixtures constructed from 1991 to 1999. Projects constructed prior to 1991 were excluded from this analysis due to the poor quality of available construction data. A follow-up study will be conducted on Superpave-designed mixtures.

The purpose of this study is to examine the long-term performance and life span of high-RAP (> 30%) mixture designs used on higher tonnage (>5,000 tons) projects. Smaller percentages of RAP have been assumed not to affect pavement performance significantly. Pavement performance will be compared between mixtures containing high RAP percentages and virgin mixtures from the same time period (1991-1999). The virgin mixtures served as the baseline for pavement performance for which the high RAP mixtures will be compared.

Checking the database

Multiple FDOT databases were referenced in order to compile the construction and performance data for each mixture design and project. The mixture design database provided general information about the material used, such as the source of the aggregate or RAP material, the blend percentages for each component, specific gravities of each material and the type and amount of asphalt binder.

Various construction databases were referenced to confirm the use of HMA and a RAP mixture design for each project. During the time frame of these projects, FDOT limited the use of RAP to the structural course. Even though the friction courses, both dense-graded and open-graded, did not contain RAP, they also were identified from the construction reports for later reference.

Once each project was identified, the Financial Project Management database provided the basic information, such as the location of the project (district, county, state road and milepost limits), the important construction start and end dates, the contractor and the type of work being performed (add lanes, resurfacing). Caution was taken during the selection of the designs to be analyzed to ensure a good distribution of pavements across the state and of asphalt contractors.

FDOT's Pavement Management Office maintains the state's Pavement Condition Survey (PCS) data. The PCS data was queried within the original limits of each project to determine the life span of the pavement. Since cracking is the No. 1 distress for department-maintained asphalt pavements, the first year of a deficient crack rating was the criterion used to determine the life span of the constructed pavement. The majority of the pavements used in this analysis have already been resurfaced, providing an extra challenge since the resurfacing limits for each project change from resurfacing to resurfacing due to the variable performance of each section of the pavement.

Additional information from the PCS database included estimated future work, the date and type of work of previous construction, percent trucks and average annual daily traffic (AADT) of each roadway selection.

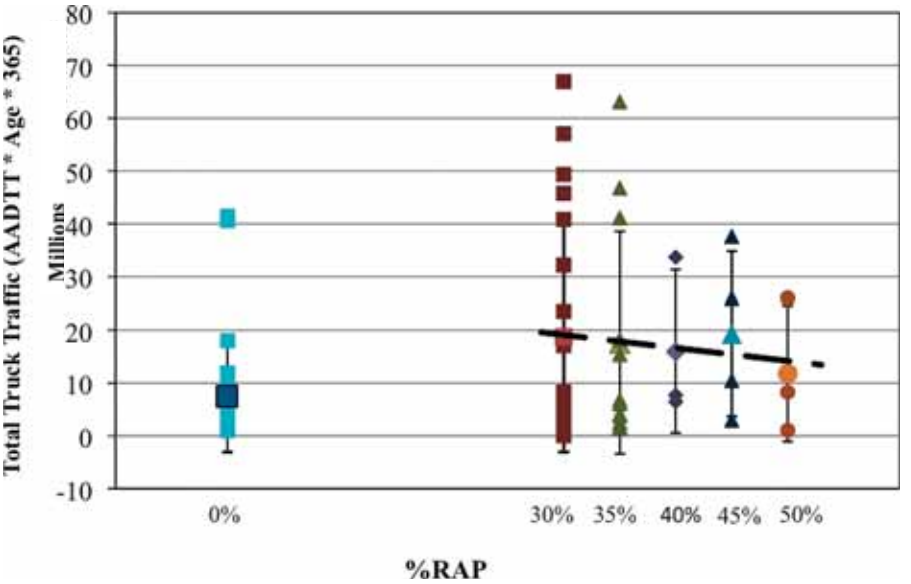
Launching searches

Two methodologies were used to analyze the data: (1) mix design search and (2) tonnage search.

Mix design search methodology

This approach was basic in nature. A list of high RAP Marshall Mixture

Figure 1. Total truck traffic vs. percent RAP.



designs and their corresponding projects were identified. From this list, the district, dates of construction and performance data were collected.

Tonnage search methodology

The initial data search identified the importance of many items missing in the original data set. Therefore, the data-collection methodology was revised to include a (1) minimum tonnage to help ensure a representative performance rating, (2) virgin mixtures designs for a baseline performance comparison, (3) each structural design's associated virgin friction course and (4) total truck traffic (AADT × percent trucks) for each pavement. Friction course data on each project was analyzed to determine if there was a correlation between the performance of the underlying RAP mixture and its corresponding friction course type (open graded or dense graded).

Further analysis

All of the pavements analyzed contained a lower RAP structural layer and a virgin friction course upper layer. Virgin structural mixes with overlying virgin friction courses were added to the second data set. The PCS crack rating is based on visual inspection of the surface layer. The depths of the cracks are unknown, as is the origination (top-down or bottom-up) and nature (fatigue, longitudinal, transverse, etc.) of the cracks. Therefore, it is not possible to isolate the performance of the underlying RAP structural layer from the available information. As a result, performance of the structural layer containing RAP is inferred based on the performance of the entire pavement structure.

Data collected in the mix design search methodology showed a trend of decreased age to deficiency with the increase of percent RAP. However, this data did not account for the volume of traffic each pavement was exposed to.

To ascertain the affects of truck traffic, the age was normalized by truck traffic (AADTT × age [yrs] × 365 [days/yr]) and plotted against the percent RAP.

Two points of interest: (1) There is a trend showing decreasing performance with increasing amounts of RAP and (2) in the range analyzed (30-50% RAP) all mixtures containing RAP performed better than the mixtures containing no RAP.

Relationship between friction course type and percent RAP in structural course

An open-graded FC-2 with ground tire rubber (GTR) and a dense-graded FC-3 with GTR were the two friction course types analyzed. Other friction course types not analyzed due to lack of data points included FC-1, FC-2 with latex additive and FC-3 with latex additive.

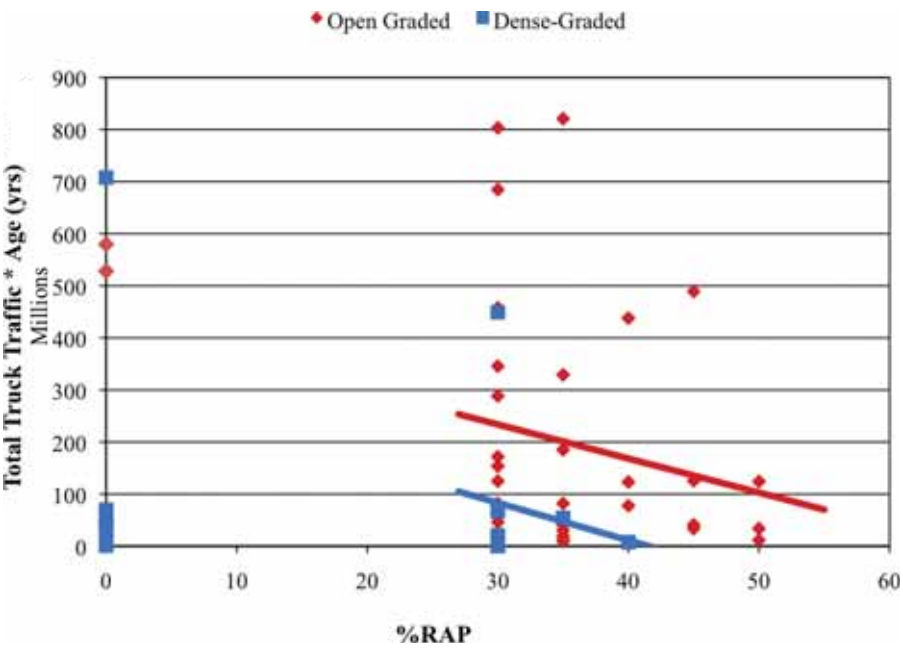
The age of pavement vs. percent RAP for pavement with open-graded friction courses was plotted.

Data indicated RAP mixtures overlaid with virgin open-graded friction course mixtures decrease in performance with increasing percentages of RAP at the same rate as RAP mixtures overlaid with virgin dense-graded friction course mixtures. Additionally, the data indicates that RAP mixtures overlaid with virgin open-graded friction course mixtures have a longer loading capacity than RAP mixtures overlaid with virgin dense-graded friction course mixtures.

The average age in which the open-graded friction courses become deficient is 11.2 years. This is in close agreement with the Pavement Management Office's reported performance of Florida's open-graded friction courses in general. However, for dense-graded friction courses, the average age to deficiency was 10.7 years. This does not agree with reported performance, which typically averages 14 years before becoming deficient. The trend of the decreased performance with increased amounts of RAP may be correct, but due to the lack of sufficient data points for the dense-graded friction course mixtures, the relationship between the open-graded and dense-graded friction course performance may not be correctly reflected in this data set.

Based on the results of this analysis, it is recommended that a similar study using mixtures designed with the Superpave mix design system be conducted. This study should involve RAP mixtures in the surface course to more directly determine the relationship between percent RAP and pavement performance. Finally, a more detailed long-term study of pavement performance in addition to the annual performance survey should be conducted. R&B

Figure 2. Total truck traffic * age (yrs) vs. percent RAP filtered by their corresponding friction course.



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For more information about this topic, check out the Asphalt Channel at www.roadsbridges.com.