Reclaimed Asphalt Pavement

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Introduction

Reclaimed Asphalt Pavement, more commonly referred to as RAP, is removed and or reprocessed pavement materials that contain both asphalt and aggregate. More simply, Reclaimed Asphalt Pavements are those pavements that are produced from the materials of old, recycled asphalt pavements. According to the Federal Highway Association, these materials are most often produced from the reconstruction of asphalt pavements, the resurfacing of asphalt pavements, or accessing subsurface utilities below asphalt pavements ("Federal Highway," 2008). The usage of these materials in new asphalt pavements has been going on for well over a century throughout the United States. However, their usage did not become commonplace until the 1970s. According to a paper written for the National Center for Asphalt Technology, in order to combat the Arab oil embargo of the early 1970s, asphalt material engineers created recycling methods to lower the use of asphalt binder and therefore the cost of asphalt mixtures (West, 2010). Thus, asphalt mixtures that contained RAP began to become popular.

Usage and Applications of RAP

The usage of RAP in asphalt mixtures varies widely depending on location and application. In terms of location, states have progressed at different rates of RAP usage. States have different requirements and limitations on how much RAP content can be used in asphalt mixtures. Figure 1 displays the findings of a survey conducted by the Federal Highway Administration on the state of practice for RAP usage (Copeland, 2011). States highlighted in yellow saw no increase in RAP usage from 2007 to

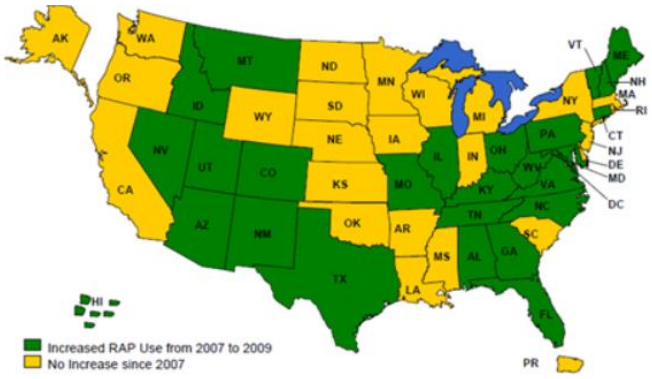

Figure 1. States Increasing Their RAP Usage 2007-2009

2009. States highlighted in green saw an increase in RAP usage from 2007 to 2009. Overall, there is a general trend of increasing RAP usage throughout the United States; although, states are progressing at different rates.

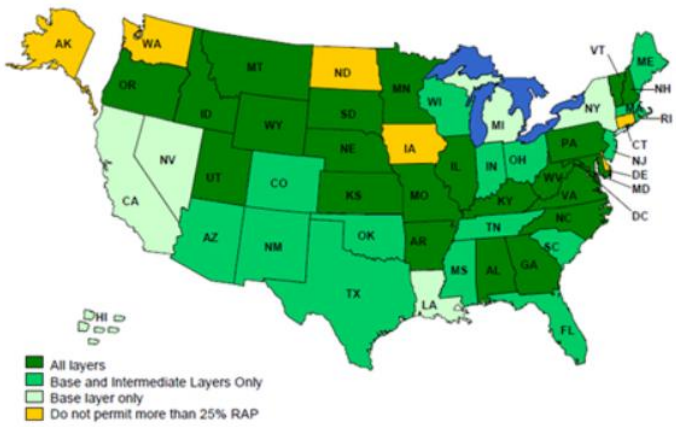

Figure 2. States Permitting >25% RAP in HMA Layers

The average RAP content in new asphalt mixtures is approximately 12% ("FHWA Recycled," n.d.). Additionally, the National Asphalt Pavement Association has been pushing for an increase in average RAP content to 25% (West, 2010). The survey conducted by the Federal Highway Administration also discovered that discrepancies exist within states based on the allowable RAP content in asphalt mixtures and what is actually used in certain pavement layers. Figure 2 displays which states allow for greater than 25% RAP content, also known as a high RAP mixture, depending on pavement layer (Copeland, 2011). Figure 3 displays which states have actually used more than 20% RAP mixtures in certain pavement layers (Copeland, 2011). For example, although Illinois has permitted the usage of more than 25% in all layers of HMA paving, Illinois has not been using more than 20% in all layers of HMA paving.

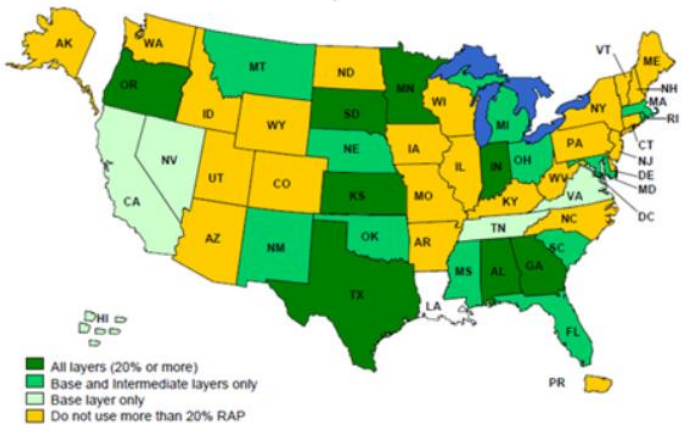

Figure 3. States Actually Using >20% RAP in HMA Layers

Many applications exist for RAP in terms of highway construction. According to the Federal Highway Association, RAP, whether milled or crushed, can be used for asphalt concrete

aggregate, Hot Mix Asphalt, Cold Mix Asphalt, granular base aggregate, stabilized base aggregate, and embankment or fill ("Federal Highway," 2008). Each application of RAP has its own benefits and drawbacks. Undoubtably, the most common usage of RAP is in Hot Mix or Warm Mix Asphalt, as displayed in Figure 4 ("National Asphalt," 2014). The usage of RAP in aggregate, Cold Mix Asphalt, and other applications does not compare to the usage in Warm Mix Asphalt. Over time, less and less RAP has been used in aggregate. Most importantly, the amount of RAP being landfilled has been consistently negligible.

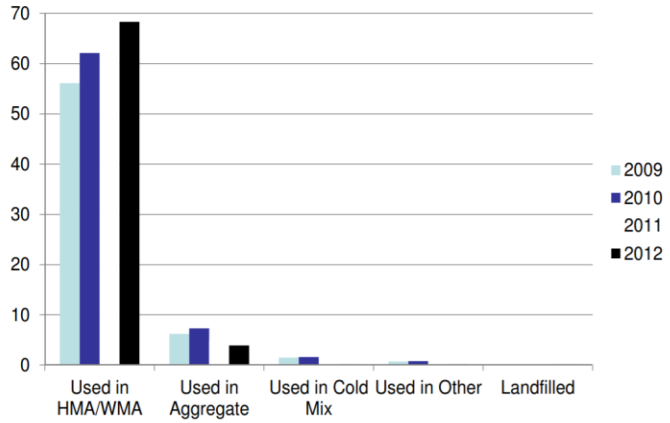

Figure 4. Common Applications of RAP

For Hot Mix Asphalt paving applications, mixtures with RAP can be processed at a central processing facility or on site for in-place recycling ("Federal Highway," 2008). Most commonly, asphalt mixtures that utilize RAP are produced at a central processing facility. At the facility, the required gradation of RAP is produced from a series of screens, conveyors, crushers, and stackers ("Federal Highway," 2008). The RAP product is then used in Hot Mix Asphalt paving as a replacement for aggregate ("Federal Highway," 2008). For in-place recycling, which is less common, no processing is actually performed. Instead, this process is a "single or multiple pass operation using specialized heating, scarifying, rejuvenating, laydown, and compaction equipment" ("Federal Highway," 2008). The applications for RAP for roadway construction are endless. While most RAP is used in Hot Mix Asphalt paving, each application provides economic, environmental, and performance benefits.

Benefits of RAP

In terms of the benefits, the use of Reclaimed Asphalt Pavements promotes environmental sustainability, lowers construction costs, and provides equivalent or better performance than asphalt pavements that do not contain reclaimed asphalt materials.

Many environmental benefits, such as reduced landfill waste and less production and transportation energy usage, are created due to the usage of RAP. By reusing old asphalt pavement instead of virgin materials in the production of new asphalt mixtures, a significant amount of landfill space is left empty. One survey had estimated that the reclaiming of RAP during the construction year of 2017 saved approximately 49 million cubic yards of landfill space (Williams, Copeland, & Ross, 2018). According to the Environmental Protection Agency, asphalt pavement has become the most recycled product throughout the United States ("Environmental Protection," 1993). Additionally, when choosing RAP over virgin asphalt, energy isn't used in creating and transporting virgin asphalt to the job site. Therefore, less greenhouse gasses will be released into the atmosphere. Figure 5 displays the environmental costs of creating one ton of virgin asphalt (Marbach, n.d.).

Mine or quarry the rock or aggregate	**1870 lbs of rock**
Add asphalt oil	**16 gallons**
Power the hot plant generators	**75 lbs of greenhouse gas emissions**

Figure 5. Requirements of One Ton of Virgin Asphalt

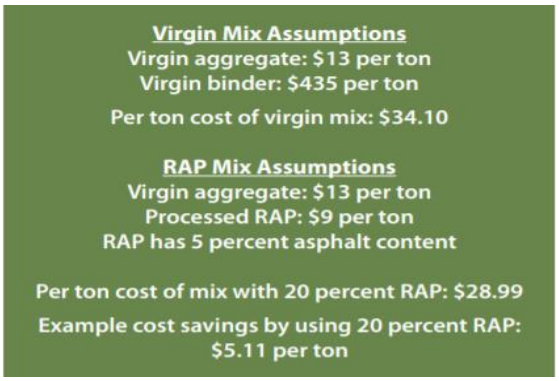

Figure 6. Virgin Mix vs. 20% RAP Mix with 5% Asphalt Content

The economic benefits of the usage of RAP are also important to consider when deciding between virgin and recycled materials for asphalt mixtures. In general, using RAP will significantly reduce costs when compared to virgin materials. The cost savings of a 20% RAP mixture with a 5% asphalt content is displayed in Figure 6 ("FHWA Recycled," n.d.). The

figure shows that the example costs savings is approximately $5.11 per ton for such a RAP mixture. In 2017 alone, over 76.2 million tons of RAP were put to use in new asphalt pavements throughout the United States, saving taxpayers over $2.2 billion (Williams, Copeland, & Ross, 2018). Overall, the most cost-effective usage for RAP is for asphalt paving. The usage of RAP as base or for building up the shoulder is not as effective in saving construction costs ("FHWA Recycled," n.d.).

One of the most important factors in deciding what type of mixture to use for a particular application is the mixture's performance. The assumption that a mixture without RAP will outperform a mixture with RAP has been proven untrue in several comprehensive studies. One study, performed by the National Center for Asphalt Technology, compared the long-term pavement performance of sections of pavement constructed with RAP and virgin materials. The mixture with recycled materials had a RAP content greater than 30%. The study concluded that almost all sections containing RAP performed the same as, or better than, sections containing virgin materials ("FHWA Recycled," n.d.). A similar study, which was performed by the Florida Department of Transportation, found similar long-term performance results. In their study, FDOT examined the effect of overlay thickness, virgin mixtures versus mixtures with 30% RAP, and the effect of milling the existing pavement prior to overlay (West & Willis, 2014). All of the 500-foot test sections were in service almost 20 years later (West & Willis, 2014). The sections that contained RAP had a higher International Roughness Index after 15 years than sections that contained only virgin materials, regardless of thickness and whether there was milling prior to overlay (West & Willis, 2014). Another study, which was performed at the University of California Berkeley, concluded that the addition of RAP to an asphalt mixture improved the rutting performance (Alavi, Jones, He, Chavez, & Liang, 2016). Ultimately, the performance and longevity of pavements is one of the most important factors to consider. The performance of RAP,

both short term and long term, has shown that RAP is a viable alternative to pavements constructed with traditional, virgin materials.

Drawbacks of RAP

Although RAP has its benefits, there are several drawbacks that must be considered. One of the major issues with RAP is the lack of support from both contractors and State transportation departments (Copeland, 2011). This could be due to several factors. While some of the previously discussed studies have shown that the performance of RAP is promising, there has not been enough information or testing available on the long-term performance of high RAP mixtures (Copeland, 2011). Additionally, the cost savings that are generated from RAP usage and the amount of RAP being put into use have not been properly documented (Copeland, 2011). According to a report written for the Federal Highway Administration for the state of the practice of Reclaimed Asphalt Pavements, there are several challenges that are currently limiting the increased usage of RAP. These challenges include State department specification limits, the variability of RAP materials, RAP availability, and previous experiences using RAP due to contractor inconsistency (Copeland, 2011). In order to continue the usage and promotion of RAP, further studies, both short and long-term, must be performed.

Conclusion

The construction of pavements throughout the world and the United States continues to progress today. With advances in technology, recycled materials have become viable alternatives to virgin materials in pavement construction. Reclaimed Asphalt Pavements have become quite popular due to their increased economic savings, their improved environmental impact, and their bettered performance compared to traditional asphalt pavements. While drawbacks exist, the benefits of Reclaimed Asphalt Pavements are worth consideration when constructing roadways.

Additional testing of RAP mixtures will allow for private and public entities to better understand and quantify the benefits of RAP.

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Figure Sources

Fig 1:https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/11021/11021.pdf

Fig 2:https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/11021/11021.pdf

Fig 3:https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/11021/11021.pdf

Fig 4: http://www.apa-mi.org/docs/2014_APAMconference_RAP.pdf

Fig 5: http://reclaimasphalt.com/wp-content/uploads/2014/12/budget_control.pdf

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