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Review

100% recycled hot mix asphalt: A review and analysis

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ABSTRACT

A holistic evaluation of the feasibility of producing 100% recycled mixtures is presented. Eleven technologies readily available for producing 100% Reclaimed Asphalt Pavement (RAP) hot asphalt mixtures are described in the article and the complementary video (http://youtu.be/coj-e5mhHEQ). The recorded performance of 100% RAP mixtures is analyzed along with identification of typical high RAP distresses. Recommended mix design procedures and the best RAP management strategies are described. A cradle-to-gate analysis of environmental effects indicated 18 kg or 35% CO_2eq savings per t of produced 100% RAP asphalt mixture compared to virgin mix, while cost analysis showed at least 50% savings in material related expenses.

Contents

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1. Introduction

Currently in many construction projects asphalt is recycled in unbound base layers; for road shoulders and rural roads; cold or hot in-place recycling; and adding a relatively small percentage added to new hot mix asphalt. Asphalt recycling is not truly sustainable when it is degraded and used in these lower value applications. 100% hot mix recycling closes the materials cycle by fully utilizing the valuable materials found in reclaimed asphalt in high quality applications.

There are many questions and confusion among researchers and industry regarding the feasibility and necessity for production of total Reclaimed Asphalt Pavement (RAP) recycling. This paper and the complementary video (http://youtu.be/coj-e5mhHEQ) presents a holistic study to evaluate the technology, benefits, constrains, costs, and viability of 100% RAP hot mix asphalt as well as summarizes the recorded performance of such mixes.

1.1. RAP use and availability

In Europe, the data from 19 countries that provided European Asphalt Pavement Association (EAPA) with RAP use statistics shows that 47% of the available RAP was used in hot or warm mix asphalt applications, while 22 million tonnes were used in other applications or stockpiled (EAPA, 2012). In the US, a survey by National Asphalt Pavement Association (NAPA) (Hansen and Copeland, 2013) estimates a total of 71.8 million tonnes of RAP accepted in 2011, 84% of which were used in asphalt applications. Although nationally this is a high re-use rate, in urbanized areas the restrictions on the maximum allowed RAP content in mix design and technical capabilities of asphalt plants have created high surplus of RAP. Estimation by New Jersey Asphalt Pavement Association (data provided by K. Monaco and J. Purcell) for the last six years shows only 41% RAP use in asphalt pavements which has caused excess RAP of 4.1 million tonnes (Table 1).

Table 1
Estimated amount of excess RAP in New Jersey.

Year	RAP milled, t	RAP used	Excess RAP, t
2007	1,593,017	42%	675,853
2008	1,391,622	26%	359,245
2009	1,552,194	41%	636,844
2010	1,687,364	42%	703,976
2011	1,893,295	50%	939,844
2012	1,925,047	43%	833,703
Total	10,042,538	41%	4,149,464

In developed countries, road maintenance overwhelm new construction creating great amounts of readily available material that can potentially be re-used for resurfacing of the same road pavements. These statistics demonstrate that there is enough RAP available for higher RAP use in HMA applications, especially in urbanized areas. Establishing 100% RAP recycling asphalt plants can significantly increase the recycling capacity and help reduce the amount of RAP that is wasted in low value applications.

2. 100% RAP production

The maximum amount of reclaimed asphalt is mainly limited by the available production technology. In a conventional recycling process superheated virgin materials indirectly heat the RAP aggregates thus imposing limitations on the amount of RAP that can be added. Most drum plants can accommodate up to 50% RAP (Bonaquist, 2007) and a typical RAP range of batch plants is 10–20% (Kandhal and Mallick, 1997). Producing mixtures of higher RAP content using conventional plants would require an unrealistically high superheating temperature of virgin aggregates, causing blue smoke from volatilization of RAP binder, and risk dryer fires if RAP feed is interrupted.

There are multiple technologies readily available for production of 100% recycled hot mix asphalt. The authors contacted owners/producers of five of these plants and visited two of plant locations. Basic information about these facilities is summarized in Table 2 and the main principles of each technology are summarized later in this section as well as illustrated in the video (http://youtu.be/coj-e5mhHEQ). All contacted producers pointed out that conventional techniques and equipment can be used for placement and compaction of 100% RAP mixes. None of them revealed any serious issues with mixture workability or performance.

Other technologies that are designed for 100% RAP recycling, but are not described in detail, include:

- "HERA System" is an indirect heating process in which hot gasses heat the outside of satellite tubes in drum, inside which the asphalt is heated and dried while rotating (Volker Wessels, 2013).
- "Bagela" recycler is an ultra-portable (towable) drum with up to 10 t/h production capacity. Flame in a separate combustion chamber heats RAP mainly through the hot wall of mixing drum (Bagela, 2013).
- RSL is another company producing towable recycling units with up to 25t /h capacity. In the process heat is directed into the top of the mixing drum, inside which the asphalt is heated and dried while rotating (RSL, 2014).

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