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How to reduce reclaimed asphalt variability: A full-scale study

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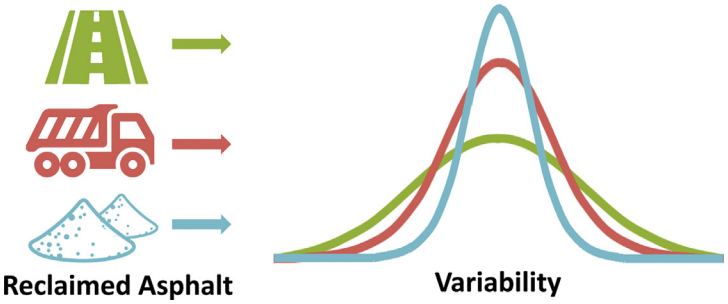
HIGHLIGHTS

- Milling and mixing of asphalt stockpile reduced RAP variability by similar amount.
- Reduced variability allowed to increase RAP content in mix design from 20 to 40%.
- Milling of asphalt generated 4.8% additional dust in RAP.
- Variability of RAP aggregates was similar to virgin aggregates.

GRAPHICAL ABSTRACT



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ABSTRACT

A 270 m long highly variable pavement section was isolated for this research (video https://youtu.be/JmkjavMwhao) to evaluate quantitative changes in variability of reclaimed asphalt pavement (RAP) as a result of milling and stockpile homogenisation operations. The results demonstrated that variability of binder properties and binder content reduced by a similar magnitude during milling and mixing, with each operation allowing to increase the maximum RAP content in new mixtures by 10%. Statistical analysis confirmed that filler content increased by 4.8% during milling while average values of other test results were not significantly changed.

1. Introduction

Due to high binder cost and environmental concerns, use of Reclaimed Asphalt Pavement (RAP) in hot mix asphalt is gaining popularity. Unfortunately RAP is often inhomogeneous which is one of the main hindrances for the use of this material and a cause for imposing limitations on the maximum RAP content in hot asphalt mixes [1–3]. Inhomogeneity is caused by variability of the milled pavement, blending together RAP from various sources, various pavement ages, damage states, milling of multiple layers, etc. A study by Solaimanian and Tahmoressi [4], based on evaluation of four construction sites, concluded that RAP exhibits significantly higher variability than virgin materials. This in turn increases the variability of high RAP mixtures, in particular with respect to bitumen content and gradation. Similarly, high

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variability of RAP leading to mixture inhomogeneity has been reported by Kallas [5] and Valdes et al. [3].

Other studies have demonstrated that RAP may not be as variable as traditionally perceived. Estakhri et al. in a comprehensive study [6] analysed aggregate stockpiles from 13 asphalt plant locations and found that RAP was less variable that virgin aggregates and that increasing RAP content in the mix did not increase the variability of the produced mixtures. Similarly, National Asphalt Pavement Association (NAPA) [7] indicates in its guide that RAP millings from a single project are typically consistent in composition. National Center for Asphalt Technology (NCAT) [2,8] goes a step further and demonstrates that even when multiple-source RAP is used, processing of the material allows to ensure higher RAP consistency than that of virgin materials.

It is not surprising that different research results come to various conclusions in respect to RAP variability. RAP variability is a function of the asphalt pavement history at specific location as well as the general policies of road network management. High density of pothole repairs or pavement reconstruction and maintenance actions in short road sections will later lead to high variability when pavement is milled. The variability will change from one site to another and in a broader sense – from one country to another. For these reasons it is important to ensure a reliable method to evaluate the variability of reclaimed asphalt and the necessary actions to reduce it. The reports referenced above mostly provide bulk statistical results over large quantities of RAP. The RAP management guides [2,7,9] include suggestions to reduce RAP variability, for example screening, crushing, creating composite stockpiles. While highly valuable, these guidelines lack quantitative details on how does the RAP consistency change during homogenisation operations. This research, therefore, attempts to isolate a single case and follows the quantitative changes in the variability of pavement, starting from cores and through milling and mixing operations of reclaimed material in a stockpile.

It can be highly valuable to come to a decision on how milling and processing of RAP will affect its homogeneity. From a road designer point of view it must be clear if RAP can be re-used in production of asphalt mixes or should it be downgraded for in-place recycling. Thus evaluation of pavement road cores before milling of pavement, while rarely performed, can be highly beneficial. The difficulty of this action lays in the fact that road cores demonstrate results that are different from milled asphalt. The coring action changes RAP gradation and so does the milling operation. From a contractor point of view an early decision of the RAP application will save costs on RAP processing. Pavement milling can be expected to increase filler content and reduce RAP variability because of crushing the aggregates. Homogenisation of the material should also be expected because of blending during loading and unloading of RAP in trucks. Mixing of RAP in stockpile can be further expected to improve homogeneity. Reasonable prediction of quantitative changes in variability during milling and RAP homogenisation operations will allow the contractor to make an early decision of the optimum application of the material and thus allow saving resources.

The evaluation of RAP variability in this research includes testing of road cores followed by evaluation of millings from this road section and finally testing samples from RAP stockpile after mixing of the material using excavator. A 270 m long pavement stretch with visually highly variable pavement was isolated for the action as part of reconstruction project of highway A2 Riga-Sigulda in Latvia.

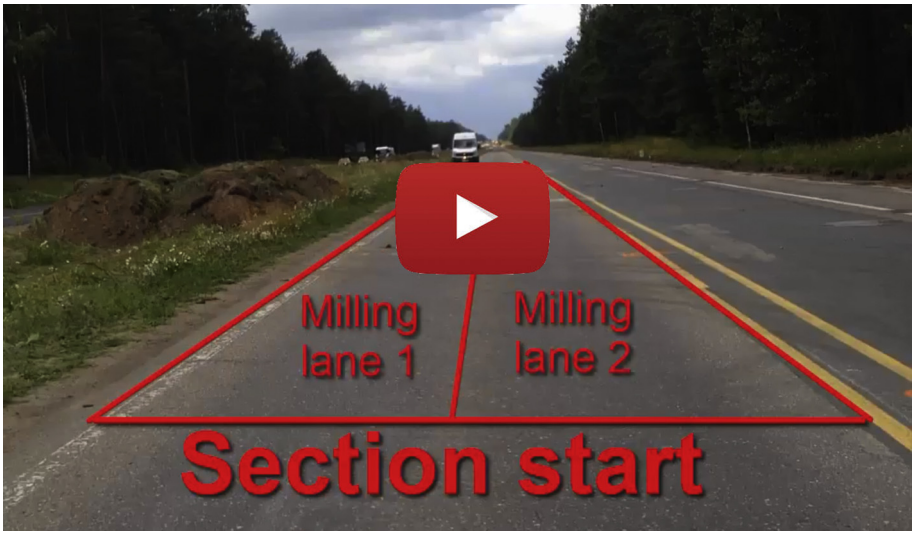
2. Objective

The objective of the study is to quantify the changes in variability of reclaimed asphalt pavement during milling and stockpile homogenisation (mixing) operations.

3. Materials and methods

3.1. Materials

Highway section of 270 m between km 17.050 and km 17.320 on National road A2 connecting Riga and Sigulda was chosen for the experiment. The selection was made due to the severe patching work evident on the wearing coarse (see Fig. 1). This was hoped to ensure the desired high variability of aggregate gradation, bitumen content and bitumen properties. High variability would provide a good basis to further trace the changes in these parameters during milling and stockpiling operations. The visual state of experimental section and the research approach are summarized in Video 1.



Video 1. Experimental section and research approach (click link to access online video: https://youtu.be/JmkjavMwhao).