Producing High Quality Recycled Hot Asphalt with Increased Reclaimed Asphalt Content – Qatar Experience

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ABSTRACT

Under the Public Works Authority (PWA) maintenance framework contract in the State of Qatar, road rehabilitation and maintenance generate considerable amounts of Reclaimed Asphalt (RA) than can be used in recycled Hot Mix Asphalt (HMA). Therefore, there is a great necessity to develop a national experience to understand the constraints and limitations of increasing RA content in recycled HMA while aligning this with the PWA initiatives on using and increasing RA in HMA. This paper sets out a guideline on how to increase RA content in HMA, considering the RA and virgin material characteristics, setup and capabilities of the asphalt plant. The study aimed to produce several recycled HMA mixes with increased RA contents using a dense-graded 19.0 mm Nominal Maximum Aggregate Size (NMAS) PEN 60/70 mix. Instead of performing design for each RA content, adjustments on the blending proportions were made accordingly as such to meet the same Job Mix Formula (JMF) of an approved HMA mix. Characterizing the RA besides data of the virgin material properties helped in adjusting the proportion during the HMA production as such to meet the control JMF. Qatar Construction Specification (QCS) 2014 was used to benchmark the results of various HMA mixtures that were prepared according to the Marshall mix design method. This paper draws a practical guideline and best practices on how to produce and optimize RA content in recycled HMA, in addition to highlighting and improving key parameters surrounding the production, from milling to laying, to produce stable, workable yet performing mixes.

Keywords: Reclaimed asphalt; Recycled asphalt mix; Job mix formula; Marshall properties

1 INTRODUCTION

Reclaimed asphalt (RA) in recycled hot-mix asphalt (HMA) is an invaluable component of asphalt mixes as it provides economic and environmental benefits. When managed efficiently, the generated RA material creates value for both the client and the contractor, as it aligns with the Public Works Authority (PWA) roadmap for recycling initiatives and the requirements for the Zonal Framework contract for road maintenance. However, it is important to set a general guideline and practical means to design, produce, and place HMA mix with high RA content to improve the experience of using RA in recycled HMA in Qatar. Due to the fluctuation of RA material characteristics as a result of variation in source and cold panning process, additional challenges impact the consistency of recycled HMA mixes. However, adequate cold planning, stockpiling management, and further processing of RA material prior to recycled HMA production improves its quality and extend visibility to control identified variables.

Additionally, proper evaluation and characterization of RA material allows for a dynamic adjustment during HMA production, which thus enables consistent recycled HMA properties. When properly designed, recycled asphalt mixes are expected to perform equally or better than HMA with 100% virgin material (Reyes-Ortiz et al., 2012). With higher RA content, there are more benefits and value (NAPA, 2015); further challenges related to the rheological properties of aged binder would impact the combined blended binder (AASHTO, 2010).

Alternatively, key production parameters need to be addressed considering the RA characteristics and content in the mix, and the properties of the virgin material to use in the recycled HMA (Willis et al., 2013). In other words, the production parameters need to be carefully examined during every stage of the production process encompassing the cold planning (milling process), management, mix design, plant verification, placing, compacting and quality control.

2 MAIN RESEARCH TOPIC AND WORK METHODOLOGY

While recycled HMA is an economic and strategic choice for road rehabilitation and maintenance, it reduces the utilization of virgin aggregates and binder and provides a sustainable solution for aggregate consumption. Considering that Qatar imports Gabbro and lacks high quality aggregate suitable for HMA, it is important to align the usage of RA with PWA initiatives to use and increase RA in recycled HMA mixes. This research aims to develop an understanding of constraints to increase high RA content in asphalt mix on one hand, and to get insight on limitations in the mix during HMA construction on the other hand. Necessary information, process related parameters and test results were collected from the various activities carried to produce the recycled HMA, starting from cold planning to stockpile management, screening and characterization of RA, production of recycled HMA, and placement and compaction of the recycled asphalt mix.

2.1 Cold planning

Prior to cold planning, coring was performed in different locations of the selected road sections to assess the existing pavement type and the number of layers, thicknesses and the aggregate used in each layer. Knowing the core thickness helped to determine the depth of milling that was carried at 95% of the total asphalt layer(s) thickness as such to avoid contamination with the underneath layer, especially when such layer is an unbound material (roadbase or subbase). The following details were recorded: 1) source (i.e. location, chainage, number of layers, total thickness, age of pavement); 2) date of milling and the generated quantity; 3) milling depth and number of layers; and, 4) stockpile identification number.

2.2 Stockpile management characterization

After milling, the RA material was shifted to the asphalt plant yard and stockpiled as such to avoid segregation and/or contamination with foreign material (Hussain &

Yanjun, 2013). The main RA stockpile collected from milled material was screened to produce two sizes of RA, respectively 0-5 and 5-21 mm. The two screened RA sizes were stockpiled and identified for characterization: gradation, binder content, the grade of recovered binder and moisture content. The characterization data combined with the details of the virgin material were used to determine the right proportion and necessary adjustment to make during the production of recycled HMA.

2.3 Asphalt plant details

The production facility used in this study was a CB 240 AMMANN asphalt batching plant, having a capacity of 240 tons/h and equipped with a ring in dryer to process up to 40% of RA in the mix.

3 THE RESEARCH APPROACH

In this paper, six different recycled HMA mixes were prepared using respectively, 15, 20, 25, 30, 35 and 40% RA content, and they were used in a dense-graded 19.0 mm Nominal Maximum Aggregate Size (NMAS) Pen 60/70 HMA mix. HMA samples were prepared according to the Marshall mix design method (Asphalt Institute, 2007). The main goal of producing the six mixes was based on meeting the limits of the Job Mix Formula (JMF) of an existing mix design used as a control reference to produce and compare results with the ones of the mix using 100% virgin material. The objective of this study is to explore the extent and limitations at the mix level and compliance with QCS, and thereafter to identify the constraints during production and construction of the recycled HMA layers (Willis et al., 2013). The same aggregates, filler type and neat binder source were used to produce the six recycled HMA batches. The virgin aggregate was gabbro imported from Oman, while the neat binder was Pen 60/70 supplied by Qatar petroleum (Woqod).

During the production of recycled HMA, the HotBin aggregate gradation and percentage of neat binder were considered to continuously adjust the recipe to meet the reference control JMF as stipulated in the approved mix design certificate. The recovered binder was PG 70-22, while the extracted aggregate was gabbro. For recycled HMA mixes using RA above 20%, a rejuvenator at 0.1% of the total binder in mix was added during HMA mixing. The rejuvenator improves the binder performance and the asphalt mix workability at higher RA content (Cooper, 2011); thus, it allows to achieve adequate compaction efforts during construction at lower compaction temperature range.

Approximately 200 tons of each mix were produced. Six samples from each mix were collected to assess the Marshall properties (QCS, 2014), binder content and gradation (Figure 1). Moreover, asphalt was paced and compacted in one 70 mm layer. Cores were extracted afterwards from the constructed layer to assess the in-place air void.

4 RESULTS SUMMARY AND DISCUSSION

While the purpose of this study was to increase RA content in recycled HMA, evaluate and optimize the processes surrounding the production (Willis et al., 2013) from milling to asphalt mix production, the goal was to establish a general guideline for best practices to produce consistent and performing recycled HMA with high RA and enable contractors to overcome related challenges (West, 2015). However, it is required to maintain high-quality control on RA material and exact proportion and adjustment throughout the asphalt production process to help achieve consistent, compliant yet constructible and performing mixes.

Based on the analysis of the trend of results of the six recycled HMA mixes and the mix with virgin material (Figure 2), the following can be drawn: 1) an increased percentage of a known and controlled RA stockpile allowed production of a compliant recycled HMA, 2) RA above 35% content; a mix design is required to yield to a performing and compliant mix, 3) with higher RA content, it is harder to control the blended binder characteristics, 4) It was observed that the air voids (Va) in the lab prepared samples had slightly increased with the increase of RA contents, while the in-place air void of the compacted mat decreased with the increase of RA content. This was caused by the change in the properties of blended binder since the assumption that complete blending would occur between both binders (AASHTO, 2010) was not investigated.

The lab samples were compacted at the same temperature range, assuming that the final blend did not impact the binder grade characteristics; whereas, determining the binder mix and compaction temperature would have helped to achieve accurate results. The compaction at site demonstrated that at a higher RA content, the mixes have an apparently higher binder with thicker film, and this had yielded to lower in-place air voids considering the same compaction efforts for all mixes. The rejuvenator that was used for mixes with high RA 25% and above had improved the mix workability and binder properties, and thus, it improved the compaction efforts to achieve adequate compaction degree at a wider temperature range.

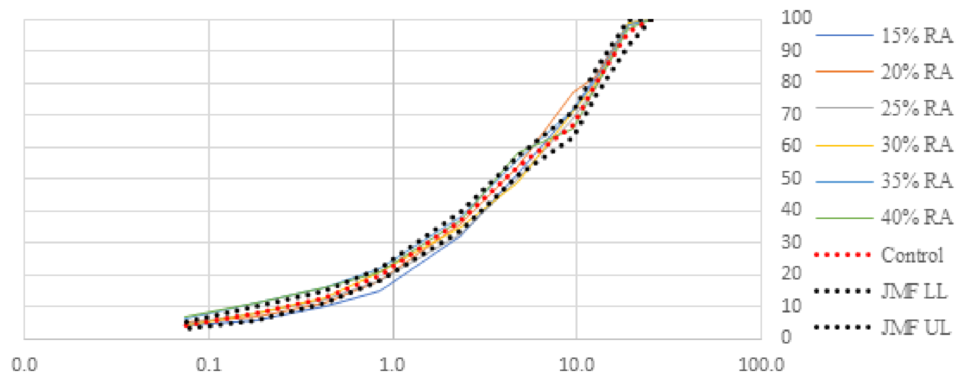

Figure 1: Summary of recycled HMA gradation

5 CONCLUSION

The test results have demonstrated that with a controlled and proper characterization of RA material, a predictive methodology can be developed using this study as a guideline to control the recycled HMA and optimize the RA content. However, the selection of the neat binder grade to use for RA higher than 25% needs to take into consideration the grade of the final blended binder and its appropriateness for the traffic type and suitability to the weather in Qatar.

Prior to milling, the existing pavement should be properly assessed to develop a better understanding of the existing layer thickness and aggregate properties. With controlled and consistent RA, a percentage up to 30% maximum can be used without compromising the properties of HMA compliance with the QCS (2014). The adjustment of virgin material is necessary during the production of the first batches, especially the neat binder content proportion, in order to make sure that the right amount of binder is added.

Considering the existing plant setup, it was possible to produce a recycled HMA mix up to 40% RA with compliant properties. This is achieved through continuous assessment and control of RA material and proactively adjusting the proportion of virgin material in the plant during production.

Excess of binder and harsher mix with higher RA percentage might reduce the compaction efforts efficiency, thus leading to fluctuating in-place air void.

Generally, mixes with RA between 20 and 30% have performed significantly better than mix with virgin material.

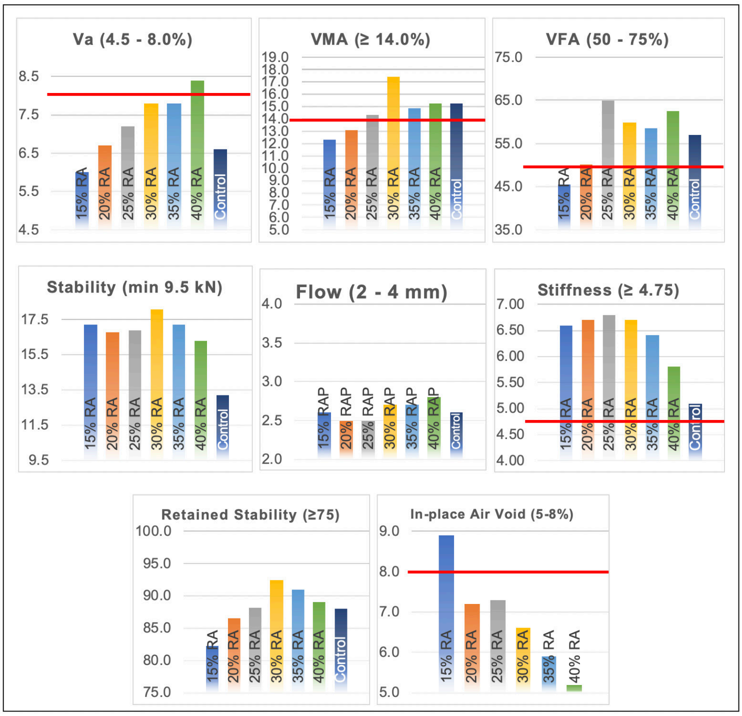

Figure 2: Summary of MARSHALL properties and in-place air void

6 RECOMMENDATION

Best practices and techniques should be used for quality control of RA material during milling, stockpiling, and processing RA (Yousefi, 2013) as elaborated in Figure 3. Fractionation and/or screening helped improve the fractions of RA material, thus allowing to practice additional quality control on the recycled material prior to production.

At RA contents higher than 25%, the workability of the mix becomes harsh; thus, a rejuvenator must be used to avoid excessive compaction efforts to achieve the desired in-place air void. Moreover, rejuvenators lead to adequate compaction at lower temperatures (approximately around 130ºC when Pen 60/70 virgin bitumen is used).

However, softer binder such as 80-100 was not necessary to produce recycled HMA with RA 25% and above in order to maintain the performance of the mix, as the resulting blended binder grade was closer to PG 76-10 which is recommended considering the nature of environment and traffic in Qatar (QCS, 2014).

This study was intended to assess the trends in results, especially the volumetrics in the mixes and in-place air voids when increasing RA in recycled HMA. However, further investigation is necessary to assess the mixtures performance characteristics e.g. permanent deformation, rut depth, fatigue, modulus and sensitivity to moisture.

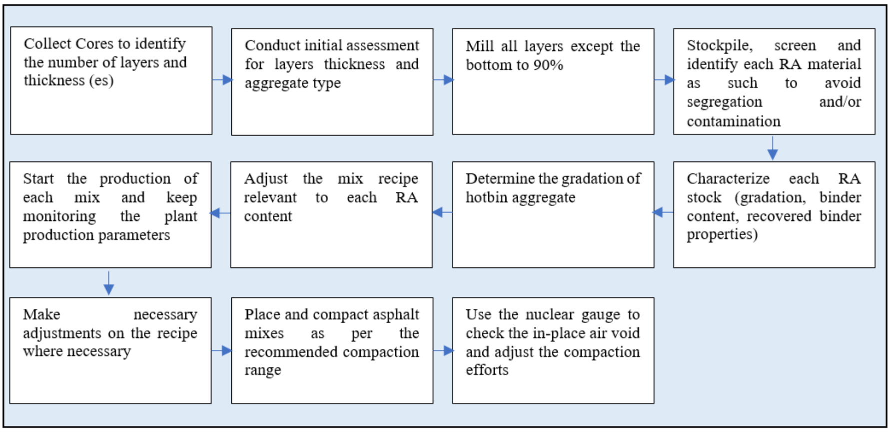

Figure 3: RA cold planning and stockpiling best practice

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