Technical Note 183

Use of High Percentages of Reclaimed Asphalt Pavement (RAP) Material in Dense Graded Asphalt

March 2019
Copyright
© The State of Queensland (Department of Transport and Main Roads) 2019.

Licence
This work is licensed by the State of Queensland (Department of Transport and Main Roads) under a Creative Commons Attribution (CC BY) 4.0 International licence.

CC BY licence summary statement
In essence, you are free to copy, communicate and adapt this work, as long as you attribute the work to the State of Queensland (Department of Transport and Main Roads). To view a copy of this licence, visit: https://creativecommons.org/licenses/by/4.0/

Translating and interpreting assistance
The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Disclaimer
While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained within. To the best of our knowledge, the content was correct at the time of publishing.

Feedback
Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au
1 Introduction

The use of Reclaimed Asphalt Pavement (RAP) in asphalt has become standard practice in Australia and around the world. RAP is by far the most re-used construction waste material in asphalt manufacture. There are many benefits with incorporating RAP in asphalt. These benefits include:

- reduction in asphalt cost
- reduction consumption of natural resources (aggregate and binder)
- reduction material going to land fill, and
- good pavement performance (i.e. equivalent to asphalt that doesn’t contain RAP).

During 2012 – 2016 Austroads undertook a project, TT1817 Maximising the Use of Reclaimed Asphalt Pavement in Asphalt Mix Design, to:

- evaluate the performance implications of including high percentages of RAP in asphalt mixes, and
- validate mix design procedures to mitigate negative impacts associated with the inclusion of high percentages of RAP.

This Technical Note builds on the outputs of Austroads project TT1817 and provides guidance to Prequalified Asphalt Contractors (PACs) on how they can demonstrate compliance with the binder blend viscosity requirements of MRTS30 Asphalt Pavements for higher RAP content mixes (i.e. mixes containing > 15% RAP and ≤ 40% RAP).

This Technical Note only addresses the issues associated with satisfying the binder blend viscosity and minimum effective binder volume requirements of MRTS30 Asphalt Pavements. It should be noted that designing an asphalt mix which contains RAP material involves a range of other considerations (e.g. meeting/complying with the aggregate gradation tolerances, practical limitations, etc.) which should be addressed separately by the Contractor.

2 Approval to incorporate ≤ 15% RAP into asphalt mixes

Transport and Main Roads allows the incorporation of ≤ 15% RAP into dense graded asphalt mixes without any requirements beyond what is described in MRTS30 Asphalt Pavements.

3 Approval to incorporate > 15% RAP into asphalt mixes

Transport and Main Roads allows the incorporation of > 15% RAP into dense graded asphalt mixes containing bitumen binders. Up to 20% may be incorporated into surfacing layers and up to 40% may be incorporated into intermediate, base and corrector courses.

However, prior to incorporating > 15% RAP into dense graded asphalt mixes on Transport and Main Roads projects, the Contractor must first seek approval from the department. The process for gaining approval involves an assessment of the following:

- Contractor’s RAP Management (RMP) and Asphalt Quality Plans (AQP)
- capability of the Contractor to process RAP to homogeneous condition state prior to incorporation into asphalt, and
- capability of the Contractor to deliver asphalt conforming to the requirements of MRTS30 Asphalt Pavements, which is a reflection of the Contractor’s RMP, AQP and plant.
These assessments are undertaken by the department’s Asphalt Mix Design Registrar. Requests to operate at a higher RAP approval level must be submitted not less than 28 days prior to the commencement of Works to facilitate the timely assessment of the relevant information and inspections to be completed. Such requests must be submitted in writing with supporting information to the following email address asphaltmixdesign@tmr.qld.gov.au.

4 Binder blend viscosity requirements for Transport and Main Roads projects

4.1 General

For Transport and Main Roads projects, the viscosity of the binder blend can be managed in accordance with one of the following methods:

1. for up to 30% RAP, adjusting the virgin binder class in accordance with Table 4.2, or

2. for 16% up to 40% RAP, varying the mix constituents to achieve a nominated binder viscosity based on RAP testing results. Namely:
   a. varying the binder class
   b. varying the percentage of RAP, or
   c. varying the percentage of rejuvenating agent.

The method to be used by a Contractor must be outlined in the Contractor’s AQP and this section of the AQP requires approval by the department’s Asphalt Mix Design Registrar prior to implementation on Transport and Main Roads projects.

4.2 Method 1 – adjusting the added binder class for up to 30% RAP

Table 4.2 can be used to adjust the added binder class for mixes containing RAP contents up to 30% (i.e. RAP Approval Levels 1, 2, 3, 1S and 2S). This table has been developed based on the results from RAP sourced by prequalified asphalt contractors in South East Queensland over a 12 month period in 2016/17. Table 4.2 can only be used to select the binder class where the RAP consists predominantly of profilings from old asphalt pavements with a binder content of 4.1 ± 0.5%. For other situations, Method 2 needs to be used to determine the binder class for mixes containing > 15% RAP.
Table 4.2 – Virgin binder class selection for mixes containing RAP

<table>
<thead>
<tr>
<th>Binder Class to be Used in Mix</th>
<th>Base, Intermediate and Corrector</th>
<th>Surfacing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Course</strong></td>
<td><strong>RAP Approval Level</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>RAP Approval Level</td>
<td>1</td>
<td>13 – 22</td>
</tr>
<tr>
<td>Allowable Percentage of RAP in Mix (%)</td>
<td>Not applicable</td>
<td>4.1 ± 0.5%</td>
</tr>
<tr>
<td>Binder Content of RAP¹ (%)</td>
<td>C320</td>
<td>C240</td>
</tr>
<tr>
<td>C450</td>
<td>C450</td>
<td>C320</td>
</tr>
<tr>
<td>C600</td>
<td>C600</td>
<td>C450</td>
</tr>
<tr>
<td>M1000</td>
<td>M1000</td>
<td></td>
</tr>
<tr>
<td>PMB</td>
<td>PMB class specified</td>
<td></td>
</tr>
</tbody>
</table>

¹ For fractionated RAP, the weighted average binder content for the combined RAP should be used.

### 4.3 Method 2 – Varying the mix constituents to achieve a target binder blend viscosity for 16% up to 40% RAP

#### 4.3.1 General

This method is suitable for dense graded mixes containing 16 – 40% RAP. However, this method would typically be used where:

- the Contractor wishes to implement a higher than normal level of control of the binder blend viscosity
- the mix contains RAP that has unusual properties (e.g. very high or low binder content and/or very hard or soft bitumen), and/or
- the mix contains > 30% RAP.

#### 4.3.2 Calculation of binder blend viscosity

##### 4.3.2.1 General

In order for the viscosity of the binder blend to be managed in production, particularly those mixes that contain > 30% RAP, the binder viscosity and binder content of the RAP must first be determined. Austroads test method AGPT/T193 is used for determining the viscosity of the binder blend. The process can be summarised into the following steps:

1. determine the binder content and viscosity of the RAP binder
2. determine the binder content for the asphalt mix
3. calculate the viscosity blending index (VBIi) of all the blend components (i.e. RAP binder(s), virgin binder and rejuvenator) using Equation 1
4. calculate volume fraction of each binder blend component (xi) using Equation 2 to 4
5. calculate viscosity blending index of the blend (VBIβ) using Equation 5
6. Once the viscosity blending index of the binder blend is known, calculate the viscosity of the blend (\( \mu \)) using Equation 6.

\[
VBI_i = \frac{3 + \log \vartheta_i}{6 + \log \vartheta_i}
\]

\[
x_{\text{RAP binder(s)}} = \frac{\text{RAP content (\%)} \times \text{RAP binder content (\%)} \times 100}{\text{Asphalt mix binder content (\%)}} \tag{2}
\]

\[
x_{\text{rejuvenator}} = \text{Rejuvenator content (by mass of total binder \%)} \tag{3}
\]

\[
x_{\text{virgin binder}} + x_{\text{RAP binder(s)}} + x_{\text{rejuvenator}} = 1 \text{ or 100\%} \tag{4}
\]

\[
\Rightarrow x_{\text{virgin binder}} = 1 - (x_{\text{RAP binder(s)}} + x_{\text{rejuvenator}}) \tag{4}
\]

\[
VBI_\beta = \sum_{i=1}^{n} x_i \cdot VBI_i \tag{5}
\]

\[
\mu = 10 \left( \frac{3VBI_\beta}{1 - VBI_\beta} - 3 \right) \tag{6}
\]

Where:

- \( \vartheta_i \): Viscosity of the \( i \)th component (Pa.s)
- \( VBI_i \): Viscosity Blending Index of \( i \)th component
- \( x_{\text{RAP binder(s)}} \): RAP binder volume fraction (calculated separately for each RAP fraction, if two or more RAP fractions used, e.g. 10 mm and 14 mm)
- \( x_{\text{rejuvenator}} \): Rejuvenator oil volume fraction
- \( x_{\text{virgin binder}} \): Virgin binder volume fraction
- \( VBI_\beta \): Viscosity blending index of the blend
- \( x_i \): Volume fraction of the \( i \)th component
- \( \mu \): Viscosity of the blend (Pa.s)

The following simplifying assumption is made when using the above equations:

- The difference between densities of the blend components can be ignored/neglected (i.e. it is acceptable to assume that the RAP binder(s), virgin binder and the rejuvenator oil/agent (if used) have the same densities).

The flowchart of the binder blend viscosity calculations is shown in Figure 4.3.2(a).
Figure 4.3.2(a) – Binder blend viscosity process flowchart

Determine the binder blend equation input parameters:
1) RAP(s) content (%)
2) Rejuvenator content (% – by mass of total binder)
3) Asphalt mix binder content (%)
4) RAP(s) binder viscosity, Pa.s ($\theta_{RAP}$)
5) Rejuvenator viscosity, Pa.s ($\theta_{rejuvenator}$)
6) Virgin binder viscosity, Pa.s ($\theta_{virgin}$)

Calculate viscosity blending index of the blend components (VBI):

\[
\text{VBI}_{RAP} = \frac{3 + \log \theta_{RAP}}{6 + \log \theta_{RAP}} \\
\text{VBI}_{virgin} = \frac{3 + \log \theta_{virgin}}{6 + \log \theta_{virgin}} \\
\text{VBI}_{rejuvenator} = \frac{3 + \log \theta_{rejuvenator}}{6 + \log \theta_{rejuvenator}}
\]

Calculate volume fraction of the blend components ($x$):

\[
x_{RAP} = \frac{\text{RAP content}}{100} \times \frac{\text{RAP binder content}}{\text{Asphalt mix binder content}} \\
x_{rejuvenator} = \frac{\text{Rejuvenator content}}{100} \\
x_{virgin} = 1 - (x_{RAP} + x_{rejuvenator})
\]

Calculate the viscosity blending index of the blend (VBI$_\beta$):

\[
VBI_{\beta} = \sum_{i=1}^{n} x_i \cdot VBI_i
\]

Calculate the viscosity of the blend ($\mu$):

\[
\mu = 10^{\frac{3VBI_{\beta}}{1 - VBI_{\beta}^{\beta} - 3}}
\]

Figure 4.3.2(b) following is a schematic diagram of an asphalt mix containing RAP and rejuvenator oil. Figure 4.3.2(b) helps in better understanding the definition of the binder blend equation parameters such as the volume fraction of the blend components. Volume fractions are the contribution of each blend component to the total binder blend as illustrated in Figure 4.3.2(b).
4.3.2.2 Example of binder blend viscosity calculations

In this section, a practical example is provided to show the steps required to calculate the binder blend viscosity when two sources of RAP and a rejuvenator oil are added to an asphalt mix, where the target blend viscosity at 60°C is 600 – 880 Pa.s (for C600 bitumen) as per Table 4.3.3(a). (Normally the process would be iterative. This example is simplified as only one iteration is needed/shown.)

Input Parameters:

- Total RAP content (by mass) in the asphalt mix: 30%
- RAP fraction 1 content in the asphalt mix: 20%
- RAP fraction 2 content in the asphalt mix: 10%
- RAP fraction 1 binder content (by mass): 4.4%
- RAP fraction 2 binder content (by mass): 2.8%
- Rejuvenating oil content (by mass of total binder): 3.6%
- Asphalt mix total binder content (by mass): 4.5%
- Virgin binder viscosity at 60°C: 600 Pa.s (Class 600 bitumen)
- Rejuvenating oil viscosity at 60°C: 0.02 Pa.s
- RAP fraction 1 binder viscosity at 60°C: 19800 Pa.s
- RAP fraction 2 binder viscosity at 60°C: 15700 Pa.s
Calculations:

1. The viscosity blending index of the blend components (virgin binder, RAP fractions 1 and 2 and rejuvenator agent in this example) are calculated by Equation 1.

2. Calculation of volume fraction of the blend components: volume fractions of each blend component are calculated through Equation 2 through to 4.

3. The viscosity blending index of the binder blend (VBI\_β) can then be calculated using Equation 5.

4. Once VBI\_β is obtained, the viscosity of the binder blend can be calculated by Equation 6.

5. Summary: adding 30% RAP in total (including 20% RAP #1 fraction and 10% RAP #2 fraction) to an asphalt mix with the given details (above) will result in a binder blend viscosity of 600 Pa.s.

\[
\text{VBI}_{\text{virgin binder}} = \frac{3 + \log 600}{6 + \log 600} = 0.6582
\]

\[
\text{VBI}_{\text{RAP1 binder}} = \frac{3 + \log 19800}{6 + \log 19800} = 0.7086
\]

\[
\text{VBI}_{\text{RAP2 binder}} = \frac{3 + \log 15700}{6 + \log 15700} = 0.7058
\]

\[
\text{VBI}_{\text{rejuvenator}} = \frac{3 + \log 0.02}{6 + \log 0.02} = 0.3025
\]

\[
x_{\text{RAP1}} = \frac{20}{100} \times \frac{4.4}{4.5} = 0.1956
\]

\[
x_{\text{RAP2}} = \frac{10}{100} \times \frac{2.8}{4.5} = 0.0622
\]

\[
x_{\text{rejuvenator}} = \frac{3.6}{100} = 0.0360
\]

\[
x_{\text{virgin}} = 1 - (0.1956 + 0.0622 + 0.0360) = 0.7062
\]

\[
\text{VBI}_\beta = \sum_{i=1}^{n} x_i \cdot \text{VBI}_i = 0.7062 \times 0.6582 + 0.1956 \times 0.7086 + 0.0622 \times 0.7058 + 0.0360 \times 0.3025
\]

\[
= 0.6582
\]

\[
\mu = 10^{\left(\frac{3 \times \text{VBI}_\beta - 3}{1 - \text{VBI}_\beta}\right)} = 10^{\left(\frac{3 \times 0.6582 - 3}{1 - 0.6582}\right)} = 600 \text{ Pa.s}
\]
4.3.3 Target binder blend viscosity at 60°C

Table 4.3.3(a) outlines the binder blend viscosity at 60°C the Contractor must target in production. Achieving consistent compliance with this requirement will typically require adjustment to one of the following:

- binder class
- percentage of RAP, or
- percentage of rejuvenating oil.

**Table 4.3.3(a) – Target viscosity at 60°C for binder blend**

<table>
<thead>
<tr>
<th>Specified Binder Class</th>
<th>Target Binder Blend Viscosity at 60°C (Pa.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C320</td>
<td>320 – 500</td>
</tr>
<tr>
<td>C450</td>
<td>430 – 640</td>
</tr>
<tr>
<td>C600</td>
<td>600 – 880</td>
</tr>
</tbody>
</table>

Calculations are made using:

- design (target) binder content for the mix
- percentage of rejuvenating oil to be used (where applicable)
- percentage of RAP(s) to be used in the mix, and
- binder content and binder viscosity at 60°C results for the five most recent RAP stockpile results.

For example, calculations would need to be completed every time there is a new RAP stockpile to be used. Therefore, each stockpile must be tested for binder content and RAP binder viscosity at 60°C prior to use.

Given that the bitumen viscosity at 60°C for the virgin binder is typically not tested for each day’s production, the virgin binder viscosity at 60°C given in Table 4.3.3(b) is used for these calculations.

**Table 4.3.3(b) – Assumed viscosity at 60°C for the virgin binder**

<table>
<thead>
<tr>
<th>Binder Class</th>
<th>Viscosity at 60°C (Pa.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C170</td>
<td>170</td>
</tr>
<tr>
<td>C240</td>
<td>240</td>
</tr>
<tr>
<td>C320</td>
<td>320</td>
</tr>
<tr>
<td>C450</td>
<td>430</td>
</tr>
<tr>
<td>C600</td>
<td>600</td>
</tr>
</tbody>
</table>

4.3.4 Examples

4.3.4.1 General

Examples of how the Contractor could demonstrate compliance with the binder blend viscosity at 60°C requirements are outlined in the following sections.
The following assumptions are used for these example calculations:

- binder content of the mix is 4.5% by mass
- the specified binder class for the work is Class 600 bitumen
- binder class to be used in the mix (where rejuvenating oil is not used) is Class 320 bitumen
- target RAP content is 30% (consisting to 20% ‘fine RAP’ and 10% ‘coarse RAP’)
- viscosity at 60°C of the rejuvenating agent is 0.02 Pa.s
- target rejuvenating oil content is 3.2% (by mass of the total binder) where a rejuvenating oil is used, and
- binder content and viscosity at 60°C of RAP (over time) is listed in Table 4.3.4.1.

### Table 4.3.4.1 – Properties of RAP used for example calculations

<table>
<thead>
<tr>
<th>Stockpile Number</th>
<th>Fine RAP Stockpile</th>
<th>Coarse RAP Stockpile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Binder Content (%)</td>
<td>Binder Viscosity at 60°C (Pa.s)</td>
</tr>
<tr>
<td>1F</td>
<td>4.4</td>
<td>19800</td>
</tr>
<tr>
<td>2F</td>
<td>4.5</td>
<td>29100</td>
</tr>
<tr>
<td>3F</td>
<td>4.8</td>
<td>15000</td>
</tr>
<tr>
<td>4F</td>
<td>4.6</td>
<td>27400</td>
</tr>
<tr>
<td>5F</td>
<td>4.1</td>
<td>21100</td>
</tr>
<tr>
<td>6F</td>
<td>4.6</td>
<td>19300</td>
</tr>
<tr>
<td>7F</td>
<td>4.5</td>
<td>13900</td>
</tr>
<tr>
<td>8F</td>
<td>4.2</td>
<td>20400</td>
</tr>
<tr>
<td>9F</td>
<td>4.4</td>
<td>11500</td>
</tr>
<tr>
<td>10F</td>
<td>4.1</td>
<td>25100</td>
</tr>
<tr>
<td>11F</td>
<td>4.6</td>
<td>23600</td>
</tr>
<tr>
<td>12F</td>
<td>4.7</td>
<td>13300</td>
</tr>
</tbody>
</table>

### 4.3.4.2 Checking compliance

Examples of how the Contractor could check compliance with the binder blend viscosity at 60°C requirements are outlined in Appendix A.

### 5 Determination of effective binder volume for mixes containing RAP

The effective binder volume requirement for mixes containing RAP shall be determined using the Q311 and the percentage of absorbed binder is determined using the binder absorption/water absorption relationship referenced in Q311. The amount of binder absorption of RAP aggregate shall be assumed to be 0.4% by mass of aggregate.
Appendix A: Examples of Checking Compliance of the Viscosity of the Binder Blend using Method 2

Example 1 – Checking the added binder (virgin binder) class complies with the target binder blend viscosity range (C600 in this example)

<table>
<thead>
<tr>
<th>Stockpile</th>
<th>Total RAP % (fine:coarse)</th>
<th>RAP proportions (%)</th>
<th>Binder content (%)</th>
<th>Viscosity (θi Pa.s)</th>
<th>Volume fraction (xi%)</th>
<th>Viscosity index (VBIi)</th>
<th>VBIg</th>
<th>Blend viscosity (600 - 880 Pa.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RAP 1  RAP 2</td>
<td>% RAP 1  RAP 2  Asphalt mix</td>
<td>RAP 1  RAP 2  Virgin</td>
<td>RAP 1  RAP 2  Virgin</td>
<td>RAP 1  Virgin</td>
<td>RAP 1  Virgin</td>
<td>RAP 1  Virgin</td>
</tr>
<tr>
<td>1</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.4  2.8  4.50</td>
<td>19800  15700  320</td>
<td>19.56  6.22  74.22</td>
<td>0.7086  0.7058  0.6473</td>
<td>0.6629</td>
<td>794  794</td>
</tr>
<tr>
<td>2</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.5  2.6  4.50</td>
<td>29100  25000  320</td>
<td>20.00  5.78  74.22</td>
<td>0.7133  0.7115  0.6473</td>
<td>0.6642</td>
<td>858  826</td>
</tr>
<tr>
<td>3</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.8  3.2  4.50</td>
<td>15000  9760  320</td>
<td>21.33  7.11  71.56</td>
<td>0.7052  0.6997  0.6473</td>
<td>0.6634</td>
<td>816  823</td>
</tr>
<tr>
<td>4</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.6  2.7  4.50</td>
<td>27400  35200  320</td>
<td>20.44  6.00  73.56</td>
<td>0.7126  0.7155  0.6473</td>
<td>0.6647</td>
<td>887  839</td>
</tr>
<tr>
<td>5</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.1  2.5  4.50</td>
<td>21100  15800  320</td>
<td>18.22  5.56  76.22</td>
<td>0.7094  0.7058  0.6473</td>
<td>0.6619</td>
<td>744  820</td>
</tr>
<tr>
<td>6</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.6  2.5  4.50</td>
<td>19300  23200  320</td>
<td>20.44  5.56  74.00</td>
<td>0.7083  0.7106  0.6473</td>
<td>0.6633</td>
<td>811  823</td>
</tr>
<tr>
<td>7</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.5  2.6  4.50</td>
<td>13900  15900  320</td>
<td>20.00  5.78  74.22</td>
<td>0.7042  0.7059  0.6473</td>
<td>0.6621</td>
<td>754  802</td>
</tr>
<tr>
<td>8</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.2  2.5  4.50</td>
<td>20400  14000  320</td>
<td>18.67  5.56  75.78</td>
<td>0.7090  0.7043  0.6473</td>
<td>0.6620</td>
<td>750  789</td>
</tr>
<tr>
<td>9</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.4  2.7  4.50</td>
<td>11500  18000  320</td>
<td>19.56  6.00  74.44</td>
<td>0.7018  0.7075  0.6473</td>
<td>0.6615</td>
<td>731  758</td>
</tr>
<tr>
<td>10</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.1  2.8  4.50</td>
<td>25100  12300  320</td>
<td>18.22  6.22  75.56</td>
<td>0.7115  0.7027  0.6473</td>
<td>0.6624</td>
<td>771  763</td>
</tr>
<tr>
<td>11</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.6  3.0  4.50</td>
<td>23600  14170  320</td>
<td>20.44  6.67  72.89</td>
<td>0.7108  0.7045  0.6473</td>
<td>0.6641</td>
<td>852  771</td>
</tr>
<tr>
<td>12</td>
<td>30 (2:1)</td>
<td>20.0  10.0</td>
<td>4.7  2.8  4.50</td>
<td>13200  18600  320</td>
<td>20.89  6.22  72.89</td>
<td>0.7037  0.7079  0.6473</td>
<td>0.6628</td>
<td>790  779</td>
</tr>
</tbody>
</table>

Rejuv% is expressed as the percentage (by mass) of the total binder content

VBIg: Blend viscosity index
Example 2 – Checking the rejuvenation oil content complies with the target binder blend viscosity range (C600 in this example)

<table>
<thead>
<tr>
<th>Stockpile</th>
<th>Total RAP % (fine:coarse)</th>
<th>RAP proportions (%)</th>
<th>Binder content (%)</th>
<th>Viscosity (θ, Pa.s)</th>
<th>Volume fraction (x%)</th>
<th>Viscosity index (VBI)</th>
<th>Blend viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RAP 1</td>
<td>RAP 2</td>
<td>%</td>
<td>RAP 1</td>
<td>RAP 2</td>
<td>Asphalt mix</td>
<td>RAP 1</td>
</tr>
<tr>
<td>1</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.4</td>
<td>2.8</td>
<td>4.50</td>
</tr>
<tr>
<td>2</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.5</td>
<td>2.6</td>
<td>4.50</td>
</tr>
<tr>
<td>3</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.8</td>
<td>3.2</td>
<td>4.50</td>
</tr>
<tr>
<td>4</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.6</td>
<td>2.7</td>
<td>4.50</td>
</tr>
<tr>
<td>5</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.1</td>
<td>2.5</td>
<td>4.50</td>
</tr>
<tr>
<td>6</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.6</td>
<td>2.5</td>
<td>4.50</td>
</tr>
<tr>
<td>7</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.5</td>
<td>2.6</td>
<td>4.50</td>
</tr>
<tr>
<td>8</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.2</td>
<td>2.5</td>
<td>4.50</td>
</tr>
<tr>
<td>9</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.4</td>
<td>2.7</td>
<td>4.50</td>
</tr>
<tr>
<td>10</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.1</td>
<td>2.8</td>
<td>4.50</td>
</tr>
<tr>
<td>11</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.6</td>
<td>3.0</td>
<td>4.50</td>
</tr>
<tr>
<td>12</td>
<td>30 (2:1)</td>
<td>20.0</td>
<td>10.0</td>
<td>3.2</td>
<td>4.7</td>
<td>2.8</td>
<td>4.50</td>
</tr>
</tbody>
</table>

$R_{\text{Rejuv}}\%$ is expressed as the percentage (by mass) of the total binder content

$VBI_{\beta}$: Blend viscosity index