



The University of
Nottingham

Effects of RAP sizes, Laboratory Mixing Methods on the Performance of Recycled Hot Asphalt Mixture

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Nottingham Transportation
Engineering Centre

Overview

- Brief summary of literature review
- Experimental procedure
- Tensile Stiffness
- Binder properties
- Further analysis of mixing using image analysis and tensile stiffness

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Summary of Findings from the Literature

- The viscosity estimation of RAP/virgin blend is inaccurate
- Complete blending assumed in design and laboratory evaluation might not occur in the production process → the design may overestimate the quality of the hot recycled asphalt mixture

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Research Objectives

- To study the factors affecting the inaccuracy of viscosity estimation for recycled bitumen blends
- To study the effects of RAP sizes on the performance of recycled hot asphalt mixtures
- To study the effects of RAP/Superheated virgin aggregate mixing time on the performance of recycled hot asphalt mixture
- To study the moisture sensitivity of recycled hot asphalt mixture related to mixing time and RAP sizes
- To study the effect of diffusion on stiffness modulus of hot recycled asphalt mixture related to mixing time and RAP sizes

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Experimental Procedure

Material

RAP materials

- DBM 10 (BS 4987-1:2005) target air void 8%, artificially aged in force draft oven at 85°C for 120 hours
- Size 40 mm: manually broken, visual size adjustment
- Size 20 mm: broken mechanically by crusher

Recycled mixture

- DBM 10, target air void 4%
- 40% RAP
- Virgin binder: Pen 160/220

Note: If the the complete blending occurs, the Recycled mixture will be the same as DBM 10 made with Pen 70/100

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RAP material



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Field Simulation method (FS)

- RAP materials, both large (LR) and small size (SR), are conditioned at room temperature. The room temperature is maintained by thermal control system at 25°C.
- Virgin aggregate is superheated at 215°C for 8 hours.
- Rejuvenator is preheated at 135°C for 2 hours.
- The mixer temperature is maintained at 135°C.
- RAP material is mixed with superheated virgin aggregate for 2, 4, 6, 8 minutes.
- The combination of RAP and virgin aggregate is then blended with virgin binder for 2 minutes.

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SHRP method

- RAP materials, both large (LR) and small size (SR), are conditioned at 110°C for 2 hours.
- Virgin aggregate is conditioned at 150°C for 8 hours.
- The mixer temperature is maintained at 135°C.
- Preheated RAP material is mixed with preheated virgin aggregate for 30 seconds in the mixer maintained at 135°C.
- The combination of RAP and virgin aggregate is then blended with virgin binder for 2 minutes.

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Mixing



- RAP size after 2 minutes RAP/superheated virgin aggregate mixing time

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Mixing



- RAP size after 8 minutes RAP/superheated virgin aggregate mixing time

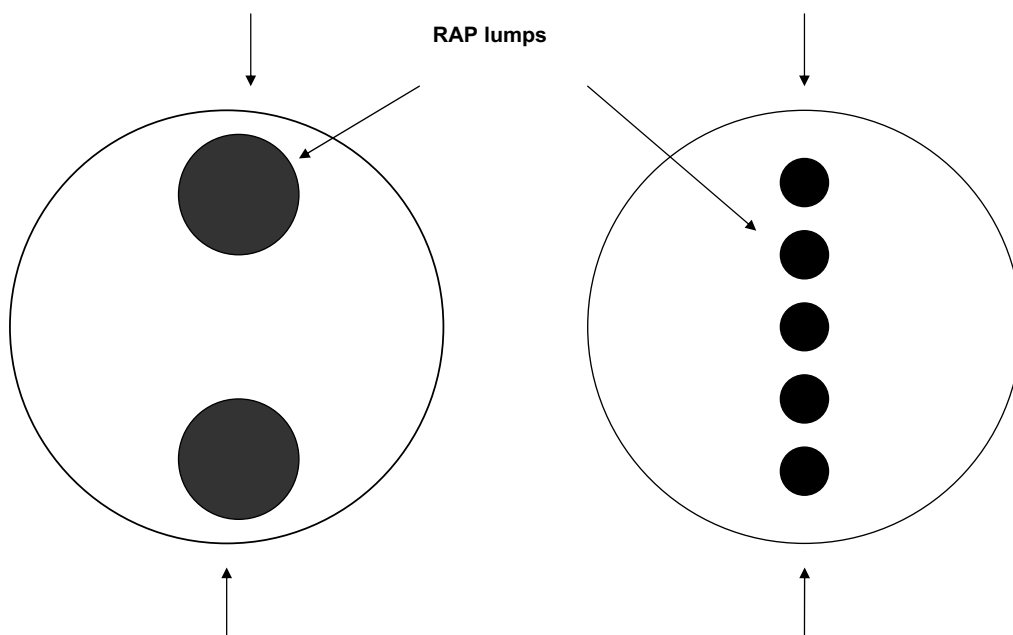
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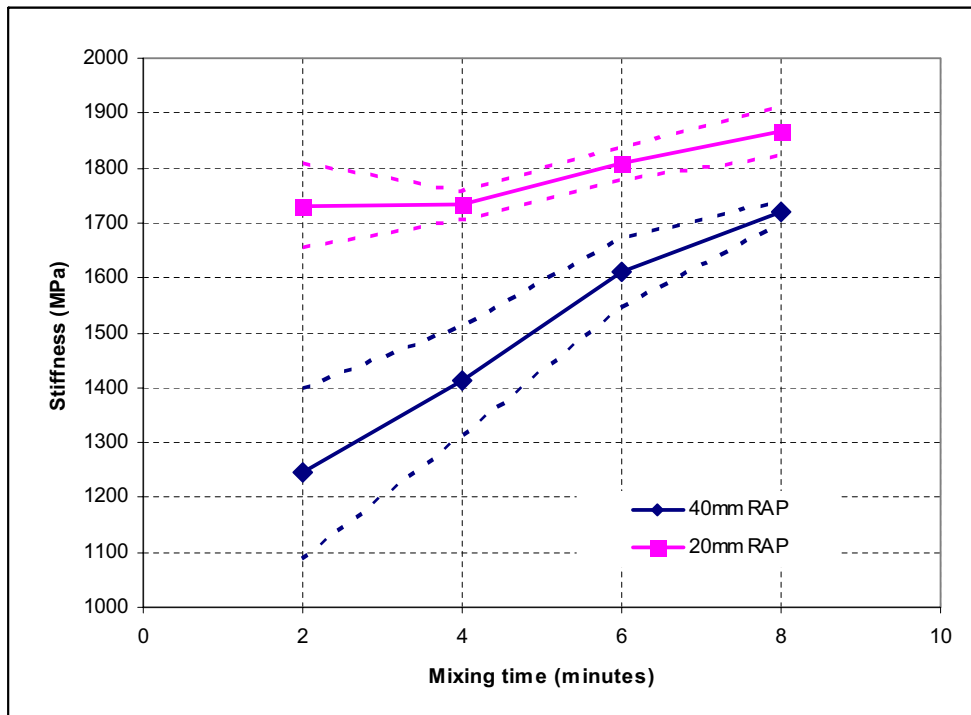
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Measuring stiffness of specimens with different RAP lump sizes



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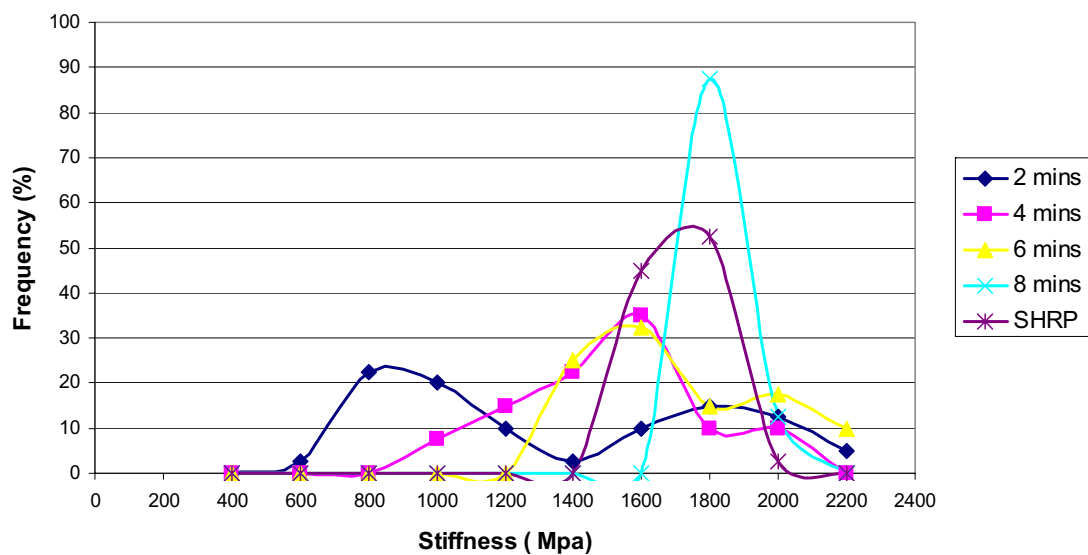
Mean with 95% confidence of 20 and 40mm RAP recycled mixture with different mixing times



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Stiffness Distribution

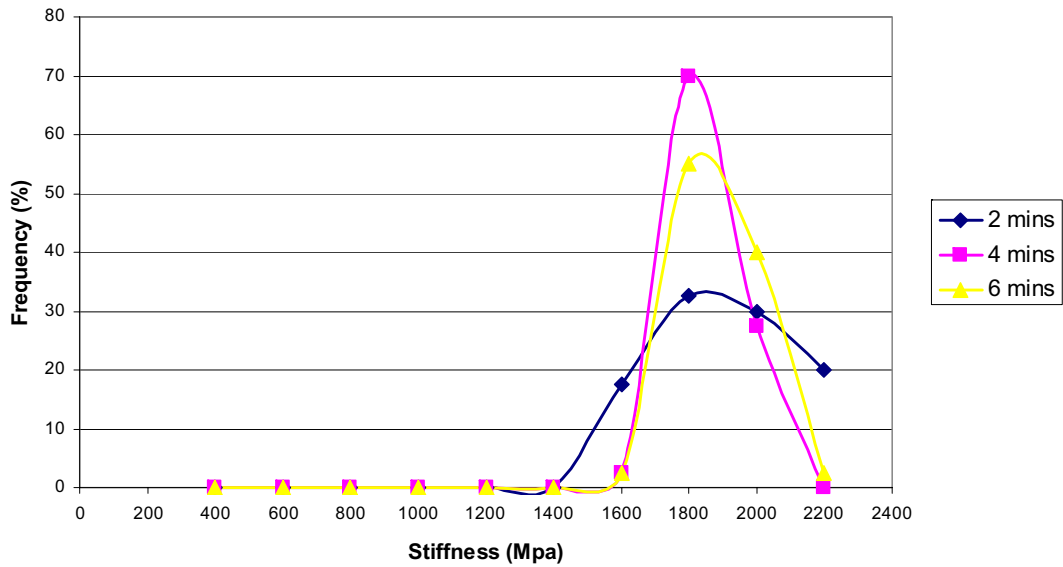
RAP size 40 mm



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Stiffness Distribution

RAP size 20 mm



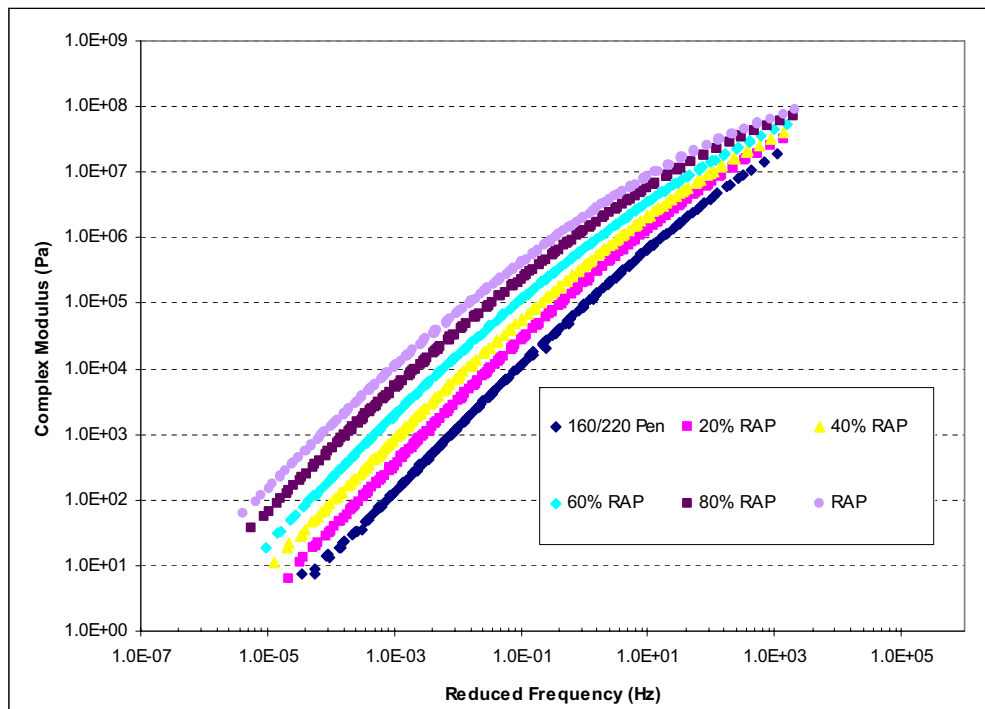
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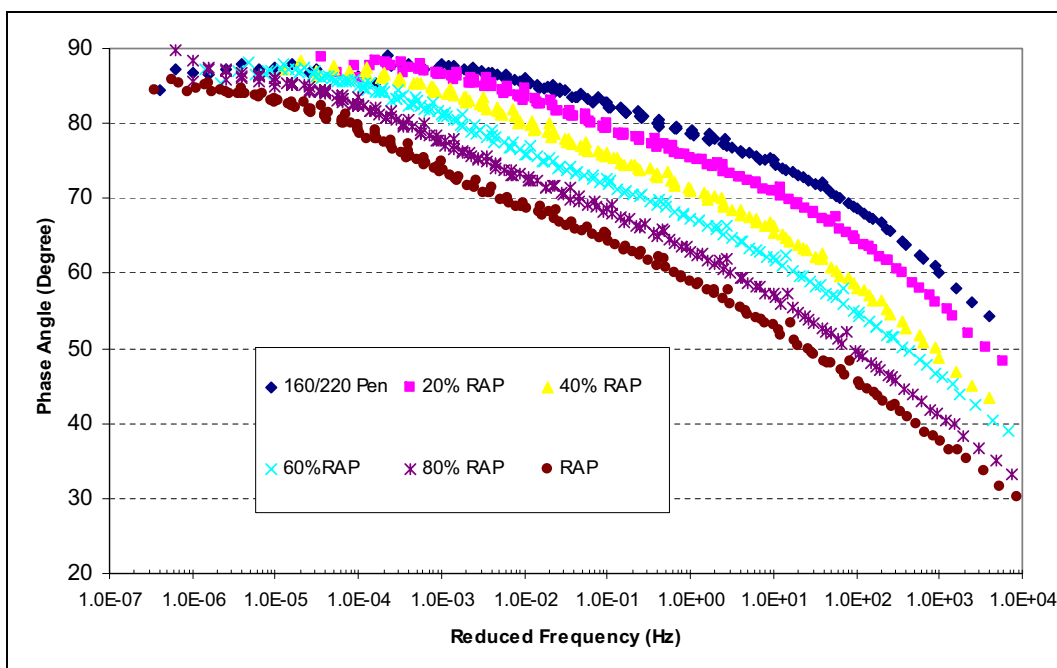
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Complex modulus versus frequency with different proportion of RAP binder



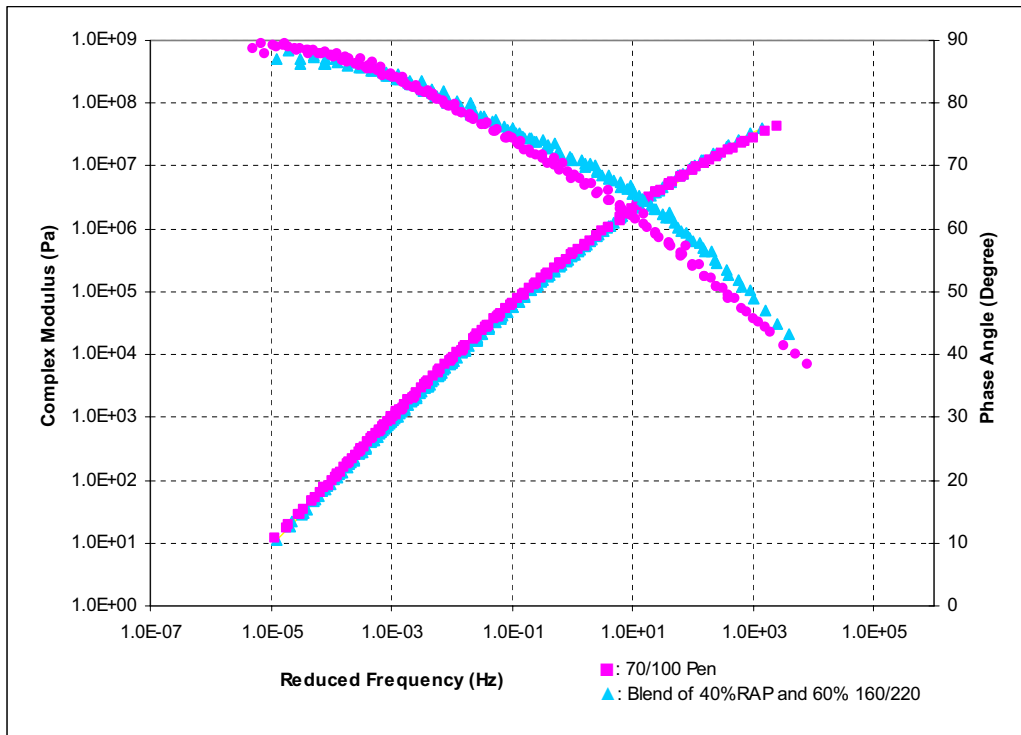
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Phase Angle versus frequency with different proportion of RAP binder



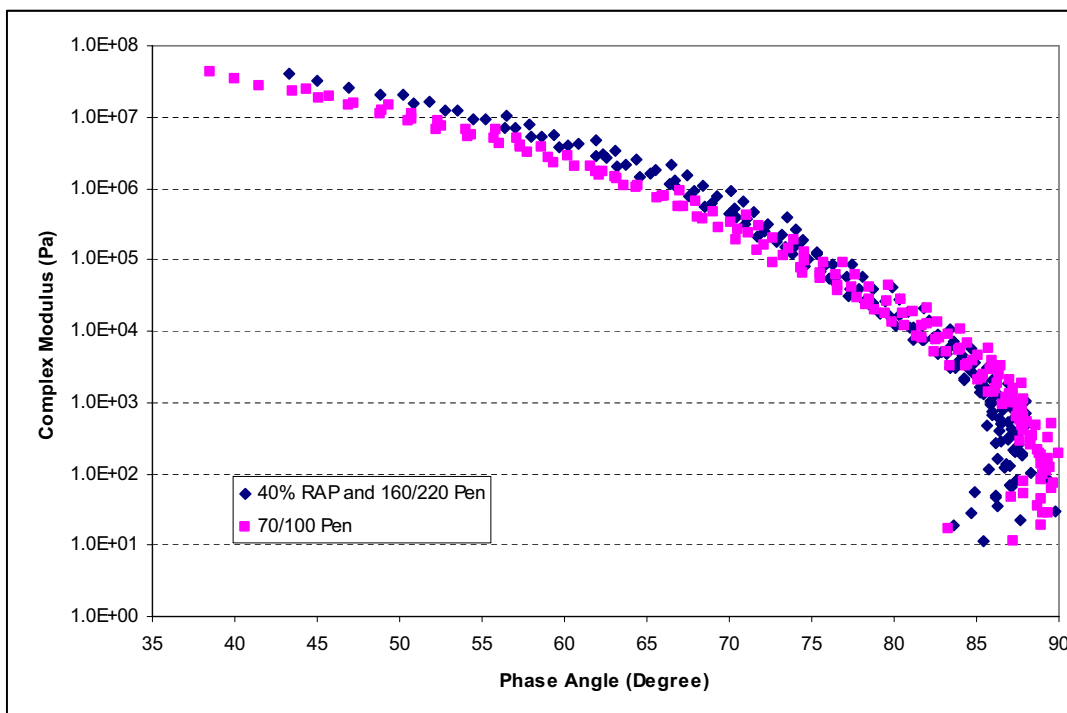
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Complex viscosity and phase angle versus frequency of 70/100 Pen and recycled asphalt



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Black diagram of 70/100 Pen and recycled asphalt



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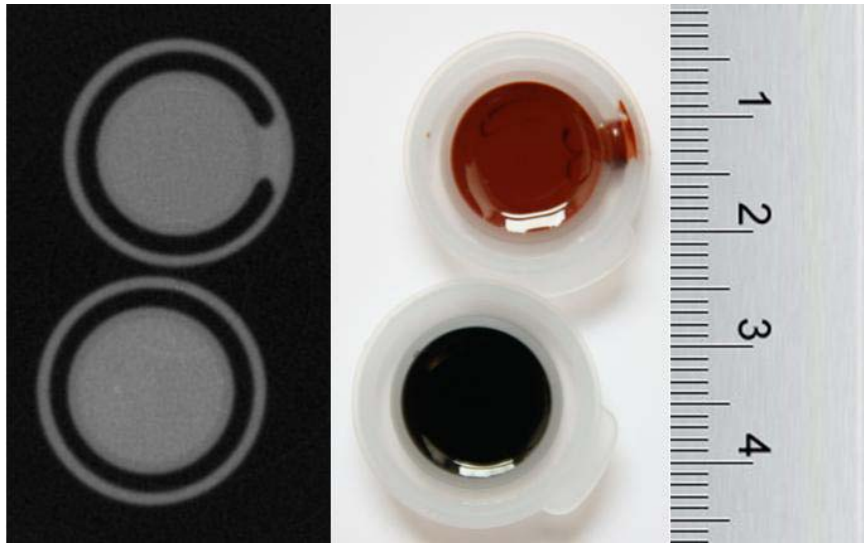
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Mixing process

- Step 1: Virgin aggregate is superheated to 215°C for 8 hours. Virgin binder is preheated at 135°C for 2 hours
- Step 2: RAP, (large (LR), small sizes (SR), blended with superheated virgin aggregate at ambient temperature at 135°C for different durations. For large RAP (LR) these are 2, 4, 6, 8 and 1, 2, 4, 6, 8 minutes for small RAP (SR).
- Step 3: blend of RAP and virgin aggregate is mixed with virgin binder for 2 minutes. Virgin binder stirred to prevent settlement of iron oxide.

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Mexphalt



Images taken by X-Ray scanner and normal digital camera of Shell Mexphalte C dyed by 10 % iron oxide and RAP binder

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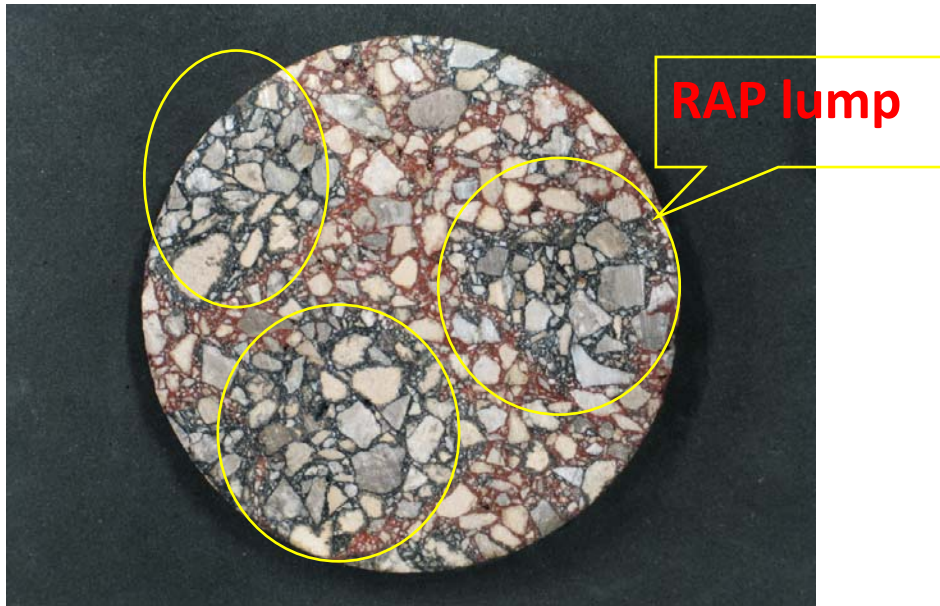
Visual assessment for segregation



Small particles tend to move downward to the bottom during mixing process

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Visual assessment for segregation



Large RAP Mixture – 2 minutes mixing time

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