Contents

• Introduction – outline of current recycling position in UK;
• Experience with re-use of two materials in asphalt:
  – Binder additive; and
  – Aggregate replacement
• Functionality
• Challenges
Recycling – Is it all worth it?
Introduction

• In the UK, asphalt recycling is common, encouraged and is specified by national standards.

  – In-situ recycling comprises three processes:
    • Repaving
    • Remixing

    \{ \text{Hot – Wirtgen Machine} \}

• Retread – Cold (may adopt emulsion or foam bitumen)
Introduction

- Plant recycling (off-site)
  - Hot recycled materials in modified batch plants have been used. More recently, cold recycled materials have evolved using bitumen emulsion or foam.
Provisions for use of secondary and recycled materials in UK pavements

<table>
<thead>
<tr>
<th>Application and Series</th>
<th>Capping</th>
<th>Unbound Mixtures for Sub-base</th>
<th>Hydraulically Bound Mixtures for Sub-base and Base</th>
<th>Bitumen Bound Layers</th>
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</table>
Recent and current research on materials re-use in asphalt pavements
Recycled rubber (wet process)
Incinerator Bottom Ash Aggregate (IBAA)

- Stack gases: 5-8,000 cubic meters per tonne
- Fly ash: 10-30 kg per tonne
- Bottom ash: 250-350 kg per tonne

Domestic waste
Crumb tyre rubber - rheology

![Crumb tyre rubber - rheology](image)

**Graph:**

- **Label:** $G^*(\text{Pa})$
- **X-axis:** Frequency ($a_T^* \text{ Hz}$)
- **Y-axis:** $10\text{pen KSR}$ $T_{\text{ref}} = 25^\circ C$
- **Legend:**
  - 0% CRM
  - 5% CRM
  - 10% CRM
Crumb tyre rubber - fatigue

![Image of testing equipment]

**Graph:**
- **X-axis:** Initial Strain (µ m/m)
- **Y-axis:** Number of Cycles
- **Legend:**
  - Neat SMA
  - 5% CRM
  - 10% CRM

The graph illustrates the relationship between initial strain and the number of cycles for different rubber compositions.
Crumb tyre rubber - rutting

<table>
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<tr>
<th>Binder Content (%)</th>
<th>CRM Content (%)</th>
<th>Temperature (°C)</th>
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<tr>
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<td>Rut Depth (mm)</td>
<td>Rutting Rate (mm/hr)</td>
<td>Rut Depth (mm)</td>
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<td>6</td>
<td>10</td>
<td>1.0</td>
<td>0.21</td>
<td>1.9</td>
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</table>

14mm SMA including 50 Pen binder
Crumb tyre rubber - cracking resistance

Notched prismatic beam specimen
Crumb tyre rubber – site trial
Rubber asphalt - Challenges

• No cross-linking between rubber and bitumen – *storage problems*

• Long-term performance – *ageing*

• Potential for recycling - *recyclability*

• Cost implications – *legislation/tax-relief*
IBAA in asphalt

- IBAA has been used to replace virgin (limestone) aggregate in an asphalt mixture suitable for base or binder course.
Mix design – (HMA)

Limestone control mixture

100 Pen binder

IBAA replacement at different levels
Mix design – cold asphalt

- 60% IBAA
- 80% IBAA
Moisture sensitivity (durability)

Mixtures saturated, immersed in water at 60°C for 6 hrs, then in water at 5°C for 16 hrs – 3 cycles
Challenges - problems

- Viability of IBAA mixtures;
- Durability.
Grazie per vostra attenzione
Thank you for your attention
Merci pour votre attention