Overview

1. Plastics
2. Mixture properties
3. Binder properties
Overview

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Dr. Lakshmi Roja

Overview

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Dr. Anand Sreeram
Mr. Tyler Seay

Dr. Ramez Hajj @ UIUC
1. Plastics

What can and cannot be “repurposed”? 

Where do we find plastics to repurpose? 

Should waste plastic be repurposed in asphalt mixes? 

How can plastics be repurposed in asphalt mixes?
1. Plastics

Global perspective

![Graph showing global plastic waste disposal from 1980 to 2015.](Image)

Source: Geyer et al. (2015)
### 1. Plastics

<table>
<thead>
<tr>
<th>Type</th>
<th>Is it widely collected?</th>
<th>Is it recyclable?</th>
<th>Can it be repurposed in asphalt?</th>
<th>Should it be used in asphalt?</th>
</tr>
</thead>
<tbody>
<tr>
<td>PETE/PET</td>
<td>✓</td>
<td>✓</td>
<td>Very likely</td>
<td>?</td>
</tr>
<tr>
<td>HDPE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDPE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>PS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Plastics

- **Pete/Pet**
- **HDPE**
- **PVC**
- **LDPE**
- **PP**
- **PS**
- **Other**

<table>
<thead>
<tr>
<th>Material</th>
<th>Is it widely collected?</th>
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<tr>
<td></td>
<td>✓</td>
<td>✓</td>
<td>Very likely</td>
<td>?</td>
</tr>
</tbody>
</table>
1. Plastics

- PETE/PET
- HDPE
- PVC
- LDPE
- PP
- PS
- Other

**Is it widely collected?**  

**Is it recyclable?** ✓

**Can it be repurposed in asphalt?** Very likely

**Should it be used in asphalt?** ✓
1. Plastics

- **PETE/PET**: Good candidates with collection streams that are better established.
- **HDPE**
- **PVC**
- **LDPE**: Good candidates but collection streams are not well established.
- **PP**
- **PS**
- **Other**

---

1. Plastics

- **PETE/PET**: Melting point ≈ 260°C
- **HDPE**: Melting point ≈ 120°C
- **PVC**
- **LDPE**: Melting point ≈ 105°C
- **PP**: Melting point ≈ 160°C
- **PS**
- **Other**
1. Plastics

- **PETE/PET**
  - Melting point ≈ 260°C
  - Decomposition ≈ 300+°C

- **HDPE**
  - Melting point ≈ 120°C
  - Decomposition ≈ 390+°C

- **PVC**

- **LDPE**
  - Melting point ≈ 105°C
  - Decomposition ≈ 260+°C

- **PP**
  - Melting point ≈ 160°C
  - Decomposition ≈ 325+°C

- **PS**

- **Other**
Overview

1. Plastics
2. Mixture properties
3. Binder properties

An extensive review (Masad et al.):

www.tinyurl.com/plasticinasphalt

(plastic in asphalt - one word)

Materials
- Q Control
- T Control
- Q + 3% LDPE70
- T + 3% LDPE70

Method of addition
- Wet process

Properties
- Complex modulus
- Hamburg rutting
- IDT/Ideal CT
- SCB/Flexibility index
1. Mixture Properties

Complex Modulus  Hamburg Rutting  IDT/Ideal CT  SCB/Flexibility Index

5 Temperatures x 5 Frequencies

Q Control  Q + LDPE70  T Control  T + LDPE70

E' (MPa) vs. Time (seconds)
1. Mixture Properties

<table>
<thead>
<tr>
<th>Complex Modulus</th>
<th>Hamburg Rutting</th>
<th>IDT/Ideal CT</th>
<th>SCB/Flexibility Index</th>
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</table>

![Graph showing E* (MPa) vs. Time (seconds)](image)

- Q + LDPE
- T + LDPE
1. Mixture Properties

Complex Modulus  Hamburg Rutting  IDT/Ideal CT  SCB/Flexibility Index

![Graph showing rut depth in mm for different mixture properties]
1. Mixture Properties

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</table>

The University of Texas at Austin
1. Mixture Properties

Complex Modulus | Hamburg Rutting | IDT/Ideal CT | SCB/Flexibility Index

![Graph showing load vs. displacement for different control and LDPE treatments.](image)

The University of Texas at Austin
1. Mixture Properties

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![Graph showing Load vs Displacement for different mixtures]

Overview

1. Plastics
2. Mixture properties
3. Binder properties

Materials
- Q Control
- T Control
- Q + 3% LDPE70
- T + 3% LDPE70
- Q + 3% LDPE70 + E
- T + 3% LDPE70 + E

Method of addition
- Wet process

Properties
- Dispersion
- PG
- MSCR
- Cohesion
3. Binder Properties

Dispersion

<table>
<thead>
<tr>
<th></th>
<th>PG</th>
<th>MSCR</th>
<th>Cohesion/Tensile</th>
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<tr>
<td>Q Control</td>
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<td></td>
</tr>
<tr>
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</table>

- Q Control
- Q + LDPE
- Q + LDPE + E
- T Control
- T + LDPE
- T + LDPE + E

3. Binder Properties

Dispersion

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- Unaged
- RTFO Aged

True High Grade Temperature [°C]

- Q Control
- Q + LDPE
- Q + LDPE + E
- T Control
- T + LDPE
- T + LDPE + E
3. Binder Properties

Dispersion | PG | MSCR | Cohesion/Tensile

![Bar Chart]

True Low Grade Temperature [°C]
3. Binder Properties

Dispersion | PG | **MSCR** | Cohesion/Tensile

Q Control | Q+LDPE | Q+LDPE+E | T Control | T+LDPE | T+LDPE+E

Elastic Recovery @3.2kPa - 64°C [%]

The University of Texas at Austin
3. Binder Properties

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Several band-aids to PG spec
- PPA
- REOB
- Delta Tc

Important to test binder in a realistic stress state to get its true performance

---

Cohesion aka Poker Chip Test

![Image of Poker Chip Test](image)

- Saturates Blend
- Aromatics Blend
- Parent Binder
- Resins Blend
- Asphaltenes Blend
3. Binder Properties

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Cohesion/Tensile Test

![Cohesion/Tensile Test Image]

![Cohesion/Tensile Test Image 2]

![Cohesion/Tensile Test Image 3]

![Cohesion/Tensile Test Image 4]

![Cohesion/Tensile Test Image 5]
3. Binder Properties

Dispersion  PG  MSCR  Cohesion/Tensile

Cohesion aka Poker Chip Test

LDPE + Elastomer (Elvaloy)
3. Binder Properties

Dispersion | PG | MSCR | Cohesion/Tensile

Cohesion aka Poker Chip Test

The University of Texas at Austin
3. Binder Properties

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<td>Q + LDPE</td>
<td>Q + LDPE + E</td>
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<tr>
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Concluding thoughts...

It is important to track three dimensions:
- What is available?
- What can be repurposed?
- What should be repurposed?
Concluding thoughts...

It is important to track three dimensions:
  What is available?
  What can be repurposed?
  What should be repurposed?

Typically addition of plastics:
  increases stiffness,
  increases resistance to permanent deformation,
  increases tensile strength, but
  compromises ductility to some extent.

Fatigue tests and synergy with conventional polymers must be explored further.
Acknowledgements

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And

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