Plastics in Asphalt Pavements

AMIT BHASIN

DECEMBER 2020, VIA WEB FROM AUSTIN, TEXAS

Overview

1. Plastics
2. Mixture properties
3. Binder properties

Overview

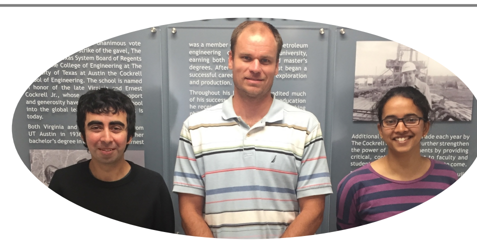
Some of the results presented here are from a joint research project with Texas A&M Qatar and sponsored by Qatar National Research Foundation (QNRF)

Prof. Eyad Masad

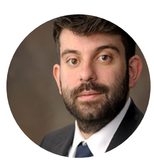
Dr. Lakshmi Roja

Overview

Dr. Angelo Filonzi
Ms. Satyavati Komaragiri
Dr. Anand Sreeram
Mr. Tyler Seay



Dr. Ramez Hajj @ UIUC



1. Plastics

What can and cannot be "repurposed"?

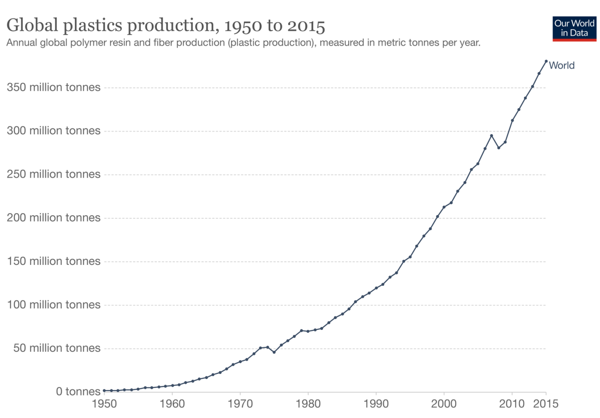
Where do we find plastics to repurpose?

Should waste plastic be repurposed in asphalt mixes?

How can plastics be repurposed in asphalt mixes?

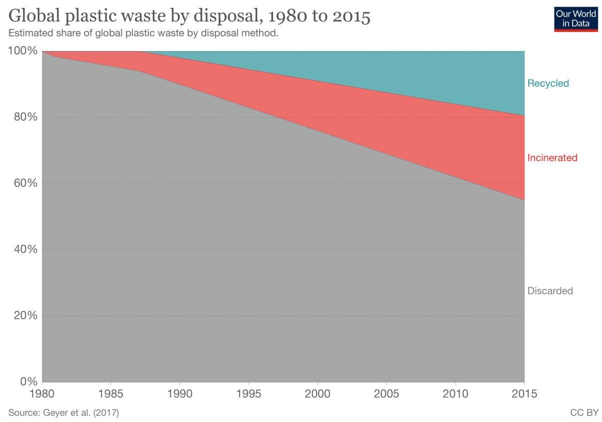
1. Plastics

Global perspective



1. Plastics

Global perspective



7

1. Plastics

- ♳ PETE/PET
- ♴ HDPE
- ♵ PVC
- ♶ LDPE
- ♷ PP
- ♸ PS
- ♹ Other

8

1. Plastics

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

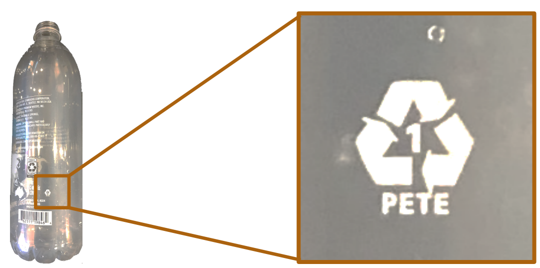
Materials that present multiple logistical / technical / health / environmental challenges to be considered for repurposing in asphalt

The University of Texas at Austin

9

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

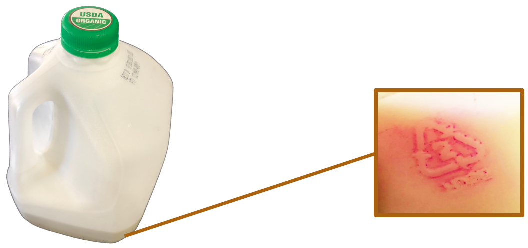
Should it be used in asphalt? ?

The University of Texas at Austin

10

1. Plastics

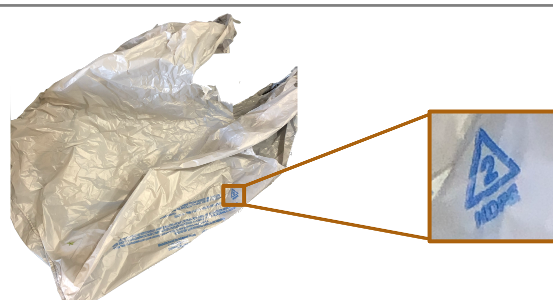
- PETE/PET
- **HDPE**
- ~~PVC~~
- LDPE
- PP
- ~~PS~~
- ~~Other~~



11

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?	?

12

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?	✓

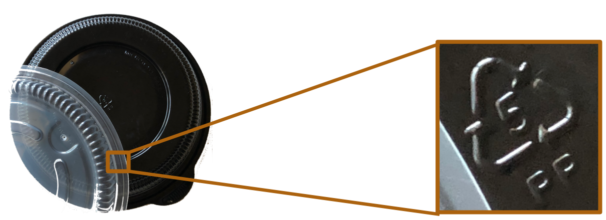
The University of Texas at Austin

Image: pexels.com by A Shvets

13

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?	?

The University of Texas at Austin

14

1. Plastics

- ♳ PETE/PET
- ♴ HDPE
- ~~♵ PVC~~
- ♶ LDPE
- ♷ PP
- ~~♸ PS~~
- ~~♹ Other~~

PETE/PET, HDPE → Good candidates with collection streams that are better established

LDPE, PP → Good candidates but collection streams are not well established

15

1. Plastics

- ♳ PETE/PET — Melting point ≅ 260ºC
- ♴ HDPE — Melting point ≅ 120ºC
- ~~♵ PVC~~
- ♶ LDPE — Melting point ≅ 105ºC
- ♷ PP — Melting point ≅ 160ºC
- ~~♸ PS~~
- ~~♹ Other~~

16

1. Plastics

♳ PETE/PET	Melting point ≅ 260ºC	Dry
♴ HDPE	Melting point ≅ 120ºC	Dry OR Wet
~~♵ PVC~~		
♶ LDPE	Melting point ≅ 105ºC	Dry OR Wet
♷ PP	Melting point ≅ 160ºC	Dry OR Wet
~~♸ PS~~		
~~♹ Other~~		

The University of Texas at Austin

17

1. Plastics

♳ PETE/PET	Melting point ≅ 260ºC	Decomposition ≅ 300+ºC
♴ HDPE	Melting point ≅ 120ºC	Decomposition ≅ 390+ºC
~~♵ PVC~~		
♶ LDPE	Melting point ≅ 105ºC	Decomposition ≅ 260+ºC
♷ PP	Melting point ≅ 160ºC	Decomposition ≅ 325+ºC
~~♸ PS~~		
~~♹ Other~~		

The University of Texas at Austin

18

Overview

1. Plastics
2. Mixture properties
3. Binder properties

An extensive review (Masad et al.):

www.tinyurl.com/plasticinasphalt

(plastic in asphalt- one word)

The University of Texas at Austin

19

Overview

1. Plastics
2. Mixture properties
3. Binder properties

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

Method of addition
- Wet process

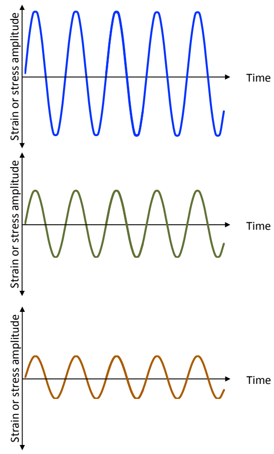
Properties
- Complex modulus
- Hamburg rutting
- IDT/Ideal CT
- SCB/Flexibility index

The University of Texas at Austin

20

1. Mixture Properties

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



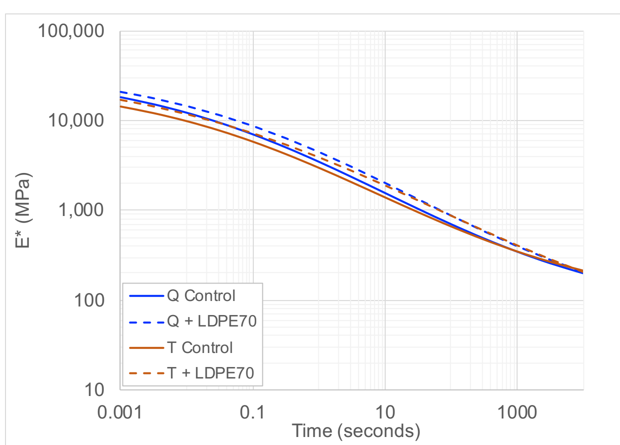
5 Temperatures x 5 Frequencies

The University of Texas at Austin

21

1. Mixture Properties

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

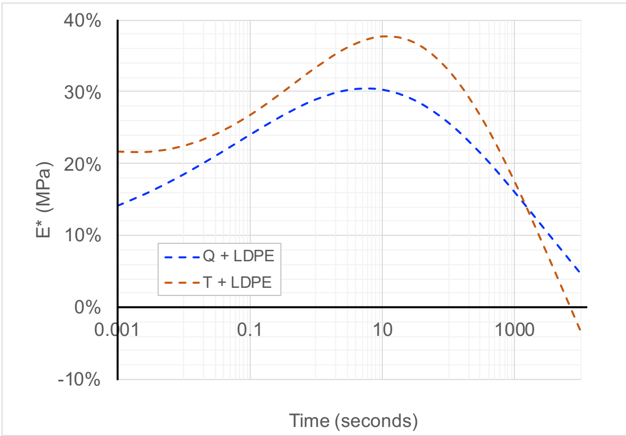


The University of Texas at Austin

22

1. Mixture Properties

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



The University of Texas at Austin

23

1. Mixture Properties

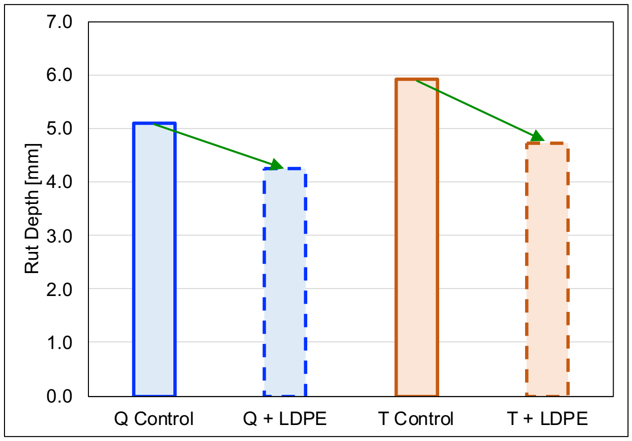
Complex Modulus Hamburg Rutting IDT/Ideal CT SCB/Flexibility Index

The University of Texas at Austin

24

1. Mixture Properties

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

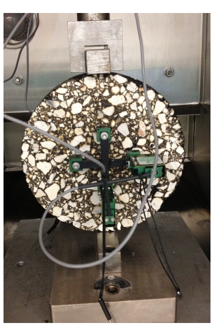


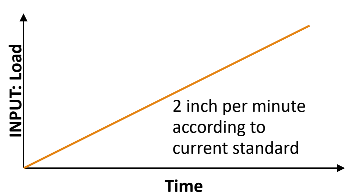
The University of Texas at Austin

25

1. Mixture Properties

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



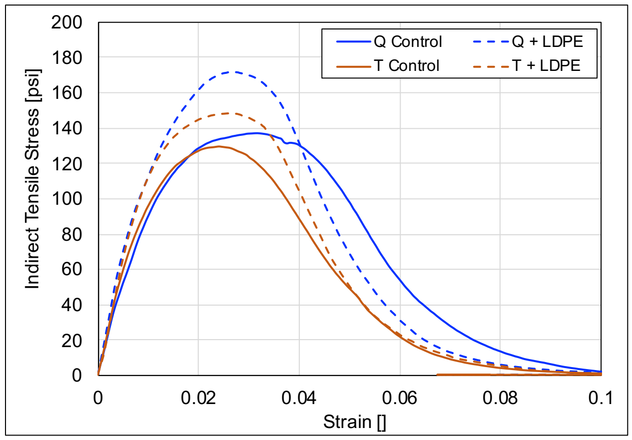


The University of Texas at Austin

26

1. Mixture Properties

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

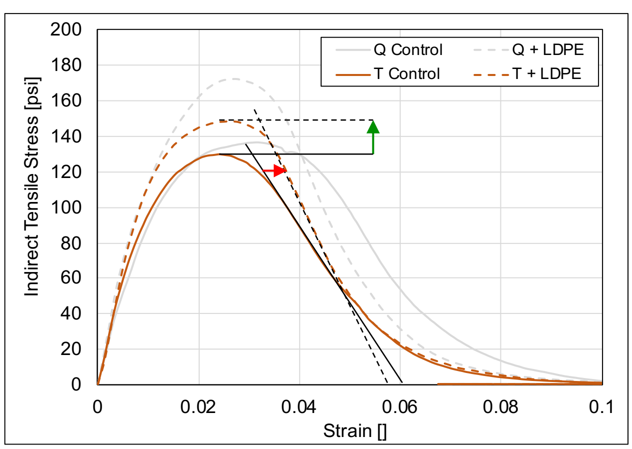


The University of Texas at Austin

27

1. Mixture Properties

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

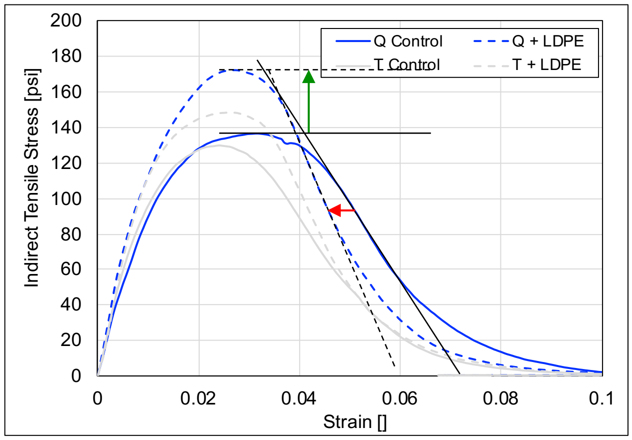


The University of Texas at Austin

28

1. Mixture Properties

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



The University of Texas at Austin

29

1. Mixture Properties

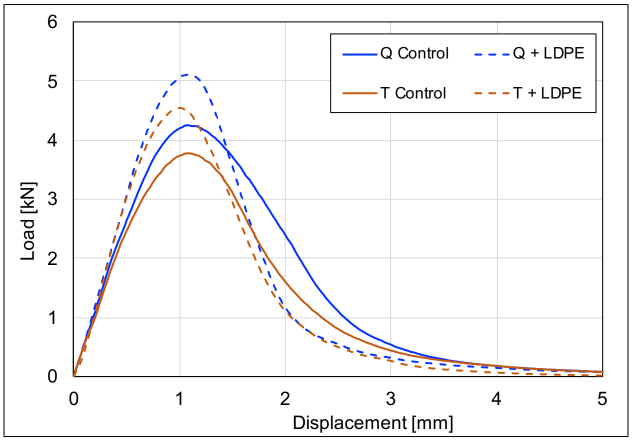
Complex Modulus | Hamburg Rutting | IDT/Ideal CT | SCB/Flexibility Index

The University of Texas at Austin

30

1. Mixture Properties

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

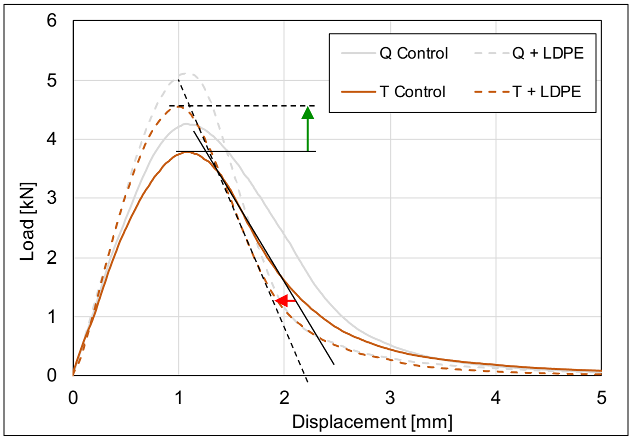


The University of Texas at Austin

31

1. Mixture Properties

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

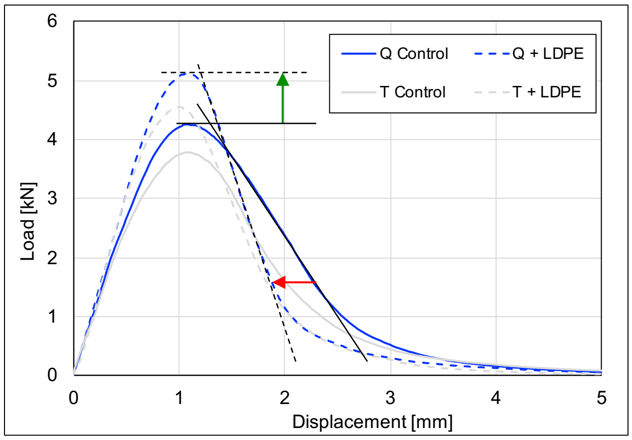


The University of Texas at Austin

32

1. Mixture Properties

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



Overview

1. Plastics
2. Mixture properties
3. Binder properties

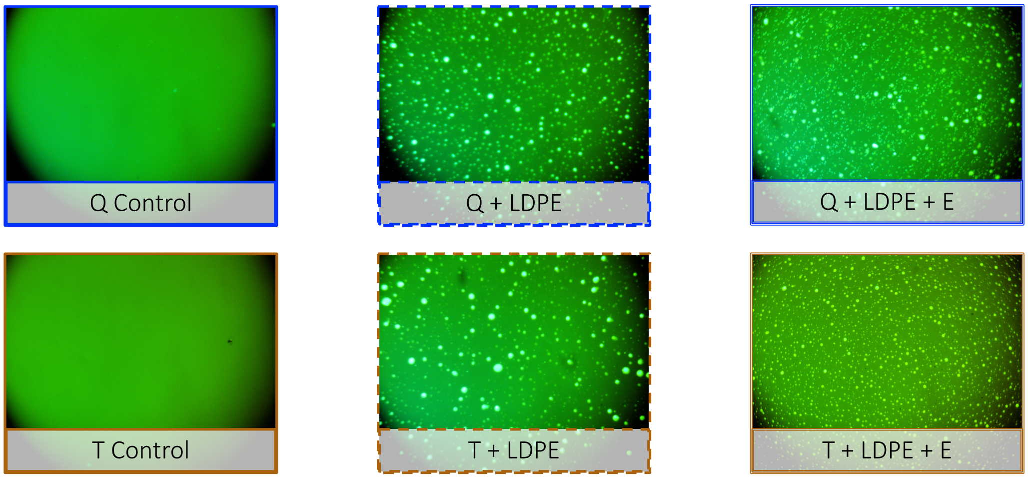
Materials
- Q Control
- T Control
- Q + 3% LDPE70
- T + 3% LDPE70
- Q + 3% LDPE70 + E
- T + 3% LDPE70 + E

Method of addition
- Wet process

Properties
- Dispersion
- PG
- MSCR
- Cohesion

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile

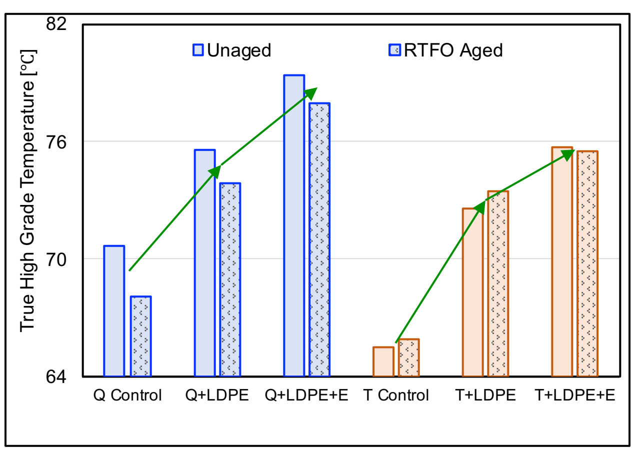


The University of Texas at Austin

35

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile

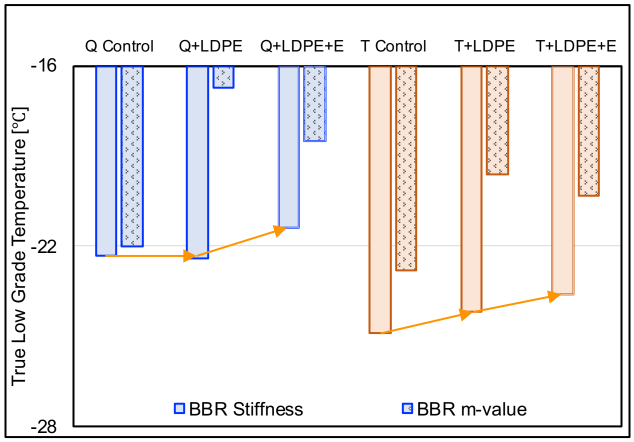


The University of Texas at Austin

36

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile

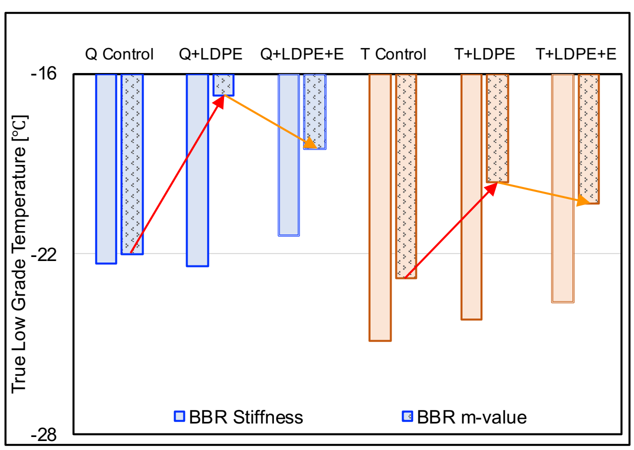


The University of Texas at Austin

37

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile

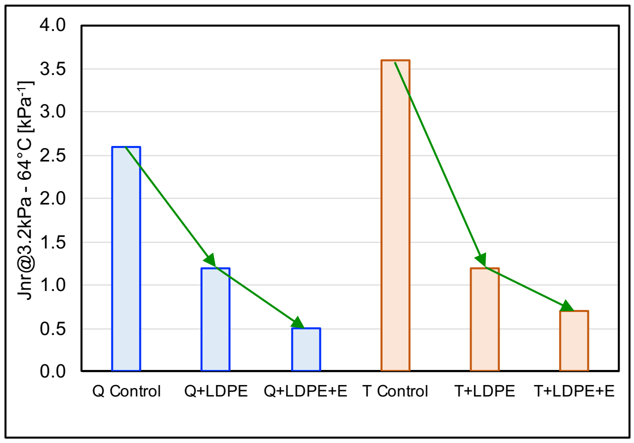


The University of Texas at Austin

38

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile

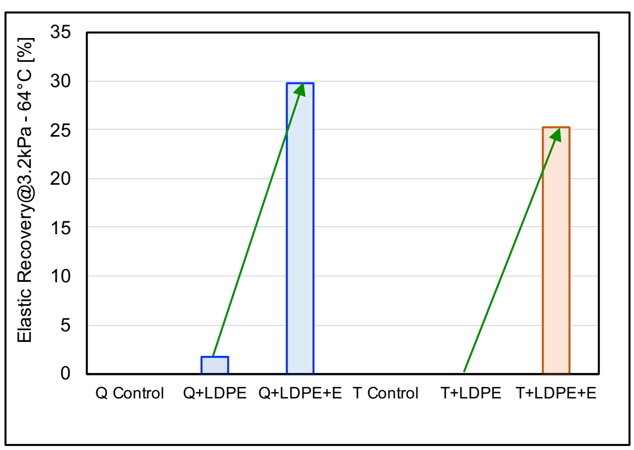


The University of Texas at Austin

39

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile



The University of Texas at Austin

40

3. Binder Properties

Dispersion PG MSCR <u>Cohesion/Tensile</u>

Several band-aids to PG spec

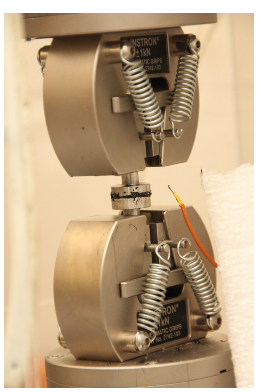
- PPA
- REOB
- Delta Tc

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

3. Binder Properties

Dispersion PG MSCR <u>Cohesion/Tensile</u>

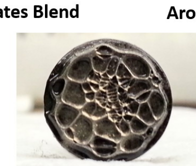
Cohesion aka Poker Chip Test



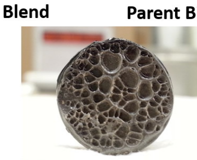
Saturates Blend

Aromatics Blend

Parent Binder



Resins Blend

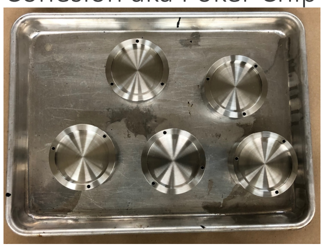
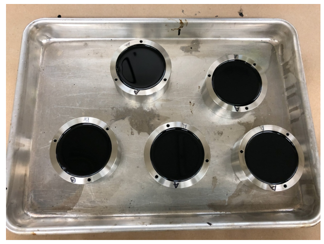


Asphaltenes Blend

3. Binder Properties

Dispersion PG MSCR **Cohesion/Tensile**

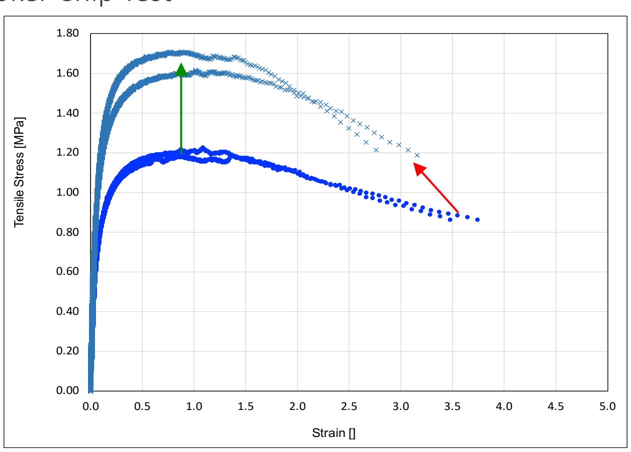
Cohesion aka Poker Chip Test

3. Binder Properties

Dispersion PG MSCR **Cohesion/Tensile**

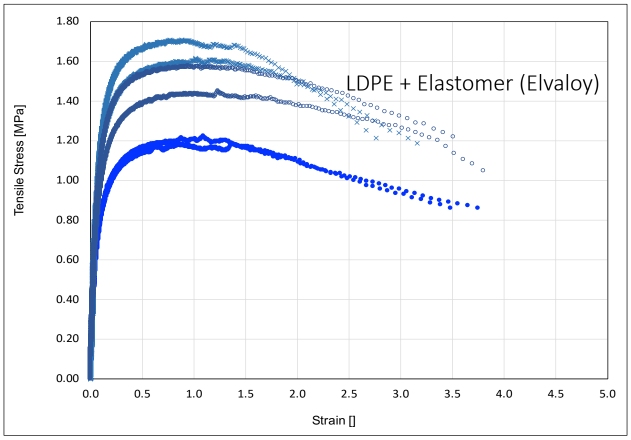
Cohesion aka Poker Chip Test



3. Binder Properties

Dispersion PG MSCR **Cohesion/Tensile**

Cohesion aka Poker Chip Test

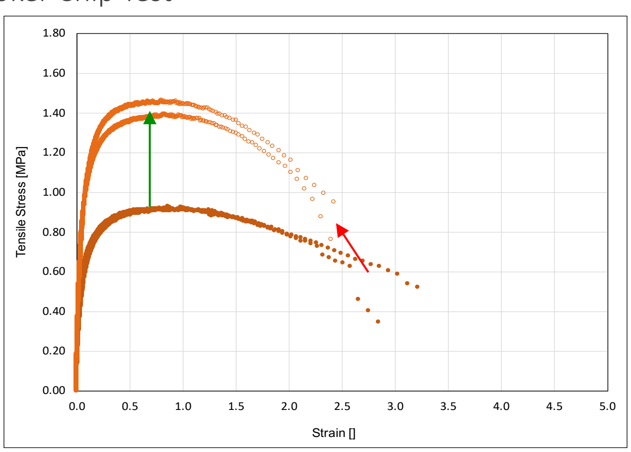


45

3. Binder Properties

Dispersion PG MSCR **Cohesion/Tensile**

Cohesion aka Poker Chip Test

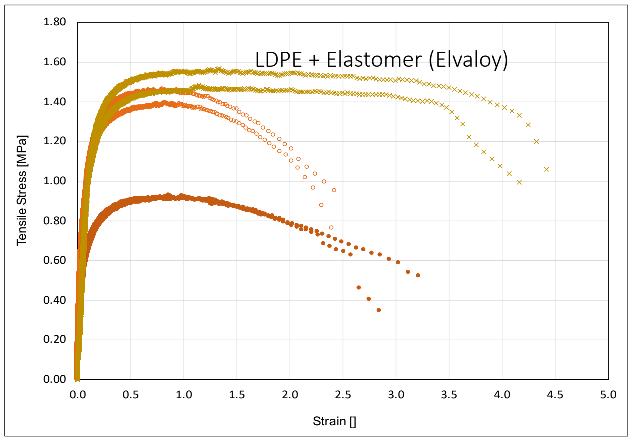


46

3. Binder Properties

Dispersion PG MSCR **Cohesion/Tensile**

Cohesion aka Poker Chip Test

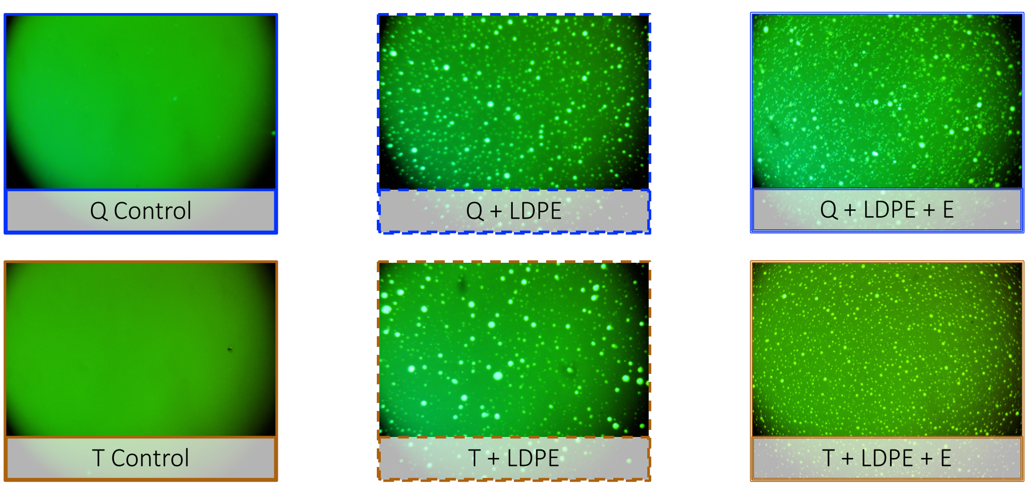


The University of Texas at Austin

47

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile

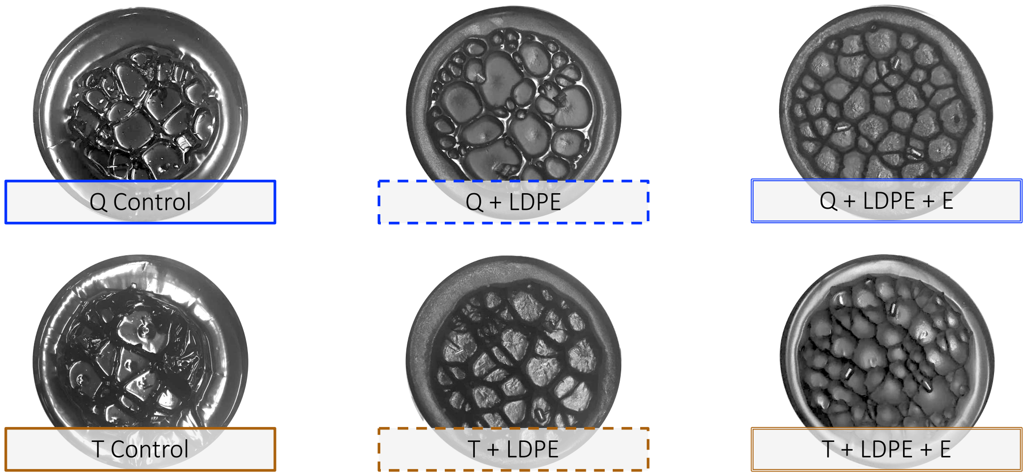


The University of Texas at Austin

48

3. Binder Properties

Dispersion PG MSCR Cohesion/Tensile



Concluding thoughts…

It is important to track three dimensions:

- What is available?
- What can be repurposed?
- What should be repurposed?

The University of Texas at Austin

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.

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

Sponsors

Qatar National Research Foundation

Texas Department of Transportation (0-6925 and 5-6925)

Ergon Asphalt and Emulsions Fellowship Program

And

DOW Chemical for polymer modifier used in this study