# Surface Aggregate Classification of Reclaimed Asphalt Pavement (RAP)

Texas A&M Transportation Institute

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# Presentation outline

- Introduction
- Skid resistance and SAC system
- Dynamic friction test (DFT) for measuring aggregate friction
- RAP DFT measurement and its impact on mix slab friction
- Preliminary DFT-based SAC for RAP
- Pilot implementation
- Q/A

# Introduction

- Skid resistance of asphalt pavement is critical for safety.

- TxDOT has a goal of cutting fatal crashes in half by 2035 and zero fatalities by 2050.

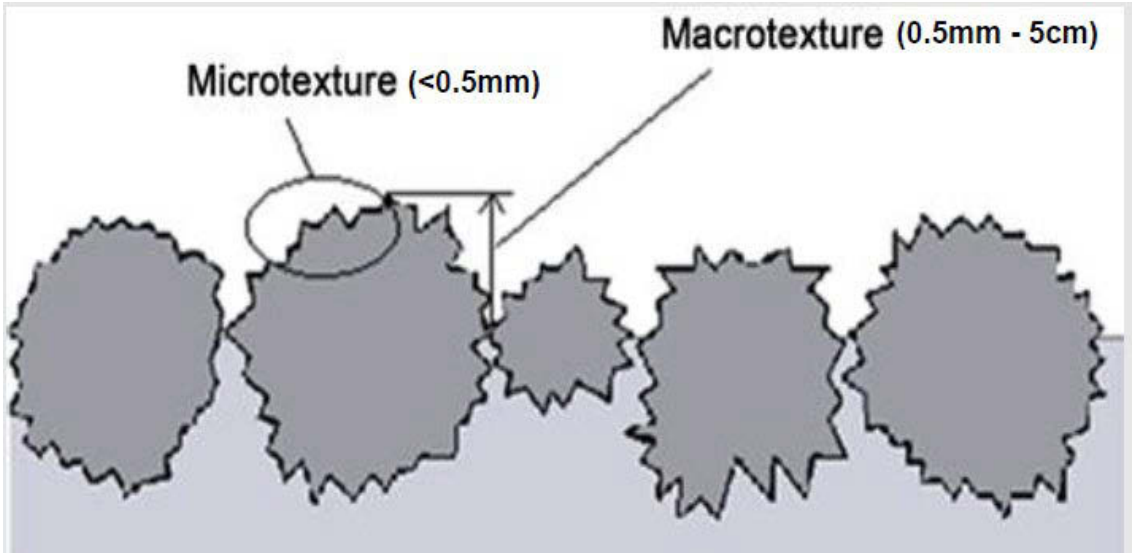
# Introduction

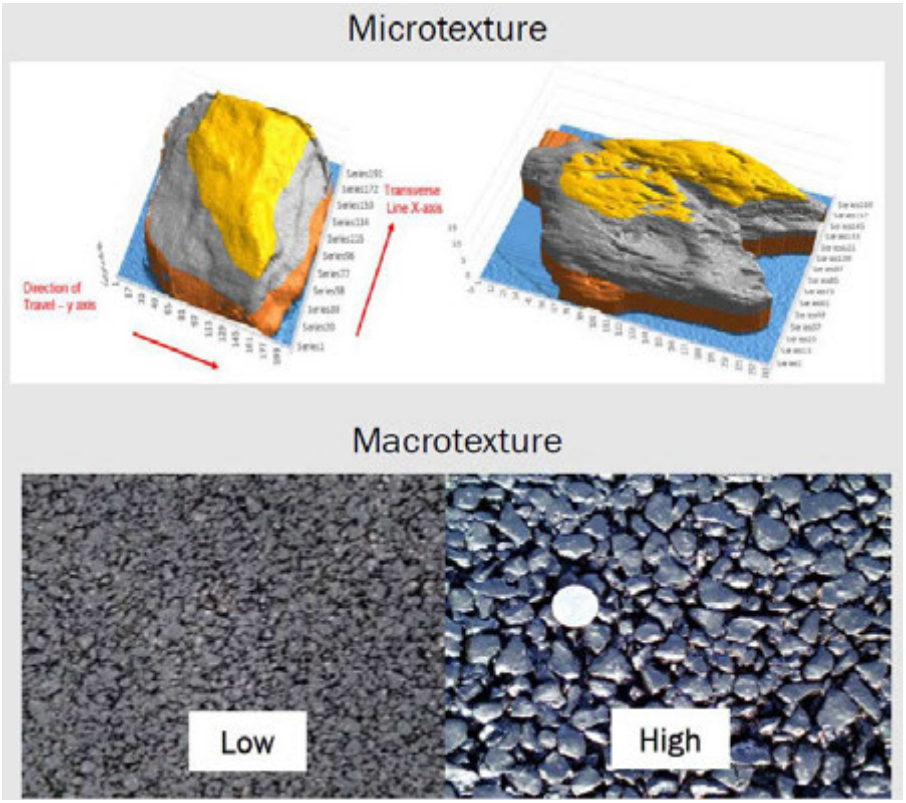
- Demand for SAC-A aggregates significantly increases year after year.
- Both TxDOT and asphalt industry advocate for sustainability.
  - **RAP** = asphalt binder + **aggregates**

- The research objective was to investigate if RAP with SAC-A aggregates can be used as SAC-A rather than SAC-B.

# Skid resistance and SAC system

- Skid resistance is a function of Microtexture and Macrotexture.
  - *Aggregate type: Microtexture*
  - Mix type: Macrotexture

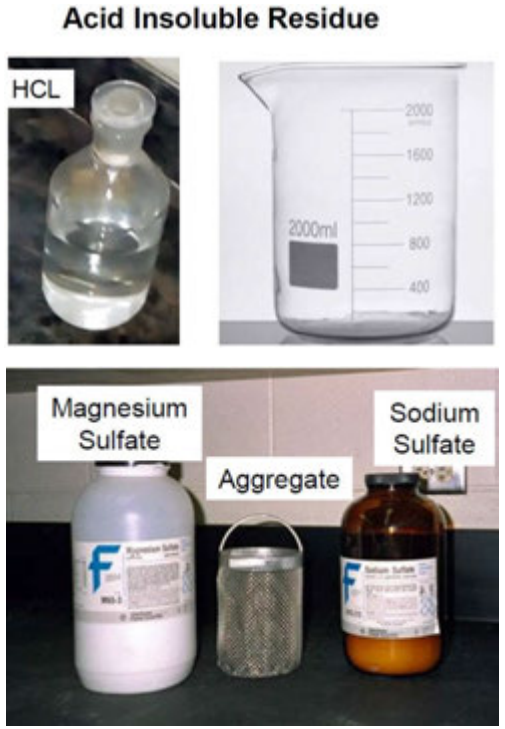


# Skid resistance and SAC system

- Current SAC system:
  - Indirect measurement of aggregate texture

| Property | Test Method | SAC A | SAC B | SAC C |
|---|---|---|---|---|
| Acid Insoluble Residue, % Minimum | Tex-612-J | 55 | ---- | ---- |
| 5-Cycle Mg Sulfate Soundness, % Maximum | Tex-411-A | 25 | 30 | 35 |



# Skid resistance and SAC system

- One SP-C mix with 53.4% SAC-A aggregate

| Class (A) Rock (Y/N): | | No | Yes | No | No | No | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sieve Size: | | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % |
| Passing | Retained | | | | | | | | |
| - | 1" | | 0.0 | 0.0 | 0.0 | | | | 0.0 |
| 1" | 3/4" | | 0.0 | 0.0 | 0.0 | | | | 0.0 |
| 3/4" | 1/2" | | 7.6 | 0.0 | 0.0 | | | | 0.0 |
| 1/2" | 3/8" | | 7.8 | 2.8 | 0.0 | | | | 0.6 |
| 3/8" | No. 4 | | 11.2 | 14.8 | 0.3 | | | | 4.8 |
| No. 4 | No. 8 | | 0.3 | 6.5 | 4.3 | | | | 5.2 |
| No. 8 | No. 16 | | 0.1 | 0.3 | 7.8 | | | | 2.4 |
| No. 16 | No. 30 | | 0.1 | 0.3 | 4.5 | | | | 1.6 |
| No. 30 | No. 50 | | 0.3 | 0.1 | 2.9 | | | | 1.4 |
| No. 50 | No. 200 | | 0.1 | 0.1 | 3.5 | | | | 2.4 |
| No. 200 | Pan | | 0.5 | 0.3 | 3.7 | | | | 1.6 |
| Total: | | | 28.0 | 25.1 | 27.0 | | | | 19.9 |
| Percent of plus No. 4 | | | 26.6 | 17.6 | 0.3 | | | | 5.4 |
| Percent of plus No. 8 | | | 26.9 | 24.1 | 4.6 | | | | 10.5 |

| | |
|---|---|
| Percent of plus No. 4 from class (A) Rock: | 26.6 |
| Total Percent of plus No. 4: | 49.8 |
| Percent of plus No. 4 from class (A) Rock: | 53.4 |

| | |
|---|---|
| Percent of plus No. 8 from class (A) Rock: | 26.9 |
| Total Percent of plus No. 8: | 66.1 |
| Percent of plus No. 8 from class (A) Rock: | 40.7 |

| Fiscal Year | Skid Number | Skid Test Date |
|---|---|---|
| 2019 | 28.6 | 5/6/2019 |
| 2019 | 23.0 | 5/6/2019 |
| 2019 | 28.1 | 5/6/2019 |
| 2019 | 30.3 | 5/6/2019 |
| 2019 | 31.0 | 5/6/2019 |
| 2019 | 36.4 | 5/6/2019 |
| 2019 | 24.8 | 5/6/2019 |
| 2019 | 25.1 | 5/6/2019 |
| 2019 | 29.0 | 5/6/2019 |
| 2019 | 22.3 | 5/6/2019 |
| 2019 | 27.5 | 5/6/2019 |
| 2019 | 27.1 | 5/6/2019 |
| 2019 | 24.4 | 5/6/2019 |
| 2019 | 30.5 | 5/6/2019 |
| 2019 | 26.2 | 5/6/2019 |
| 2019 | 30.4 | 5/6/2019 |
| 2019 | 31.1 | 5/6/2019 |
| 2019 | 28.0 | 5/6/2019 |
| 2019 | 25.4 | 5/6/2019 |
| 2019 | 19.1 | 5/6/2019 |

# Skid resistance and SAC system

- One SP-D mix with 100% SAC-A aggregates

| Class (A) Rock (Y/N) | | Yes | Yes | Yes | No | | |
|---|---|---|---|---|---|---|---|
| Sieve Size: | | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % | Individual Ret., % |
| Passing | Retained | | | | | | |
| - | 3/4" | 0.0 | 0.0 | 0.0 | 0.0 | | |
| 3/4" | 1/2" | 0.0 | 0.0 | 0.0 | 0.0 | | |
| 1/2" | 3/8" | 4.8 | 0.0 | 0.0 | 0.0 | | |
| 3/8" | No. 4 | 28.1 | 6.5 | 1.4 | 0.0 | | |
| No. 4 | No. 8 | 12.4 | 2.7 | 7.3 | 0.0 | | |
| No. 8 | No. 30 | 3.3 | 0.5 | 12.7 | 0.0 | | |
| No. 30 | No. 50 | 0.3 | 0.0 | 2.8 | 0.0 | | |
| No. 50 | No. 200 | 0.4 | 0.1 | 2.8 | 8.3 | | |
| No. 200 | Pan | 0.9 | 0.2 | 3.1 | 1.7 | | |
| Total | | 50.0 | 10.0 | 30.0 | 10.0 | | |
| Percent of plus No. 4 | | 32.9 | 6.5 | 1.4 | 0.0 | | |
| Percent of plus No. 8 | | 45.2 | 8 | 8.6 | 0.0 | | |

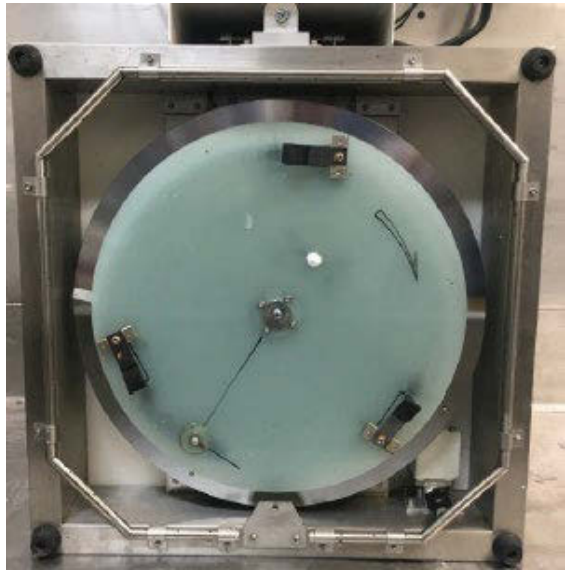
| | |
|---|---|
| Percent of plus No. 4 from class (A) Rock | 40.7 |
| Total Percent of plus No. 4 | 40.7 |
| Percent of plus No. 4 from class (A) Rock | **100.0** |

| | |
|---|---|
| Percent of plus No. 8 from class (A) Rock | 63.1 |
| Total Percent of plus No. 8 | 63.1 |
| Percent of plus No. 8 from class (A) Rock | 100.0 |

| Fiscal Year | Skid Number | Skid Test Date |
|---|---|---|
| 2016 | 32.0 | 7/18/2016 |
| 2016 | 30.0 | 7/18/2016 |
| 2016 | 28.0 | 7/18/2016 |
| 2016 | 27.0 | 7/18/2016 |
| 2016 | 30.0 | 7/18/2016 |
| 2016 | 35.0 | 7/18/2016 |
| 2016 | 33.0 | 7/18/2016 |
| 2016 | 36.0 | 7/18/2016 |
| 2016 | 38.0 | 7/18/2016 |
| 2018 | 20.6 | 6/20/2018 |
| 2018 | 19.4 | 6/20/2018 |
| 2018 | 19.6 | 6/20/2018 |
| 2018 | 19.6 | 6/20/2018 |
| 2018 | 24.4 | 6/20/2018 |
| 2018 | 21.6 | 6/20/2018 |
| 2018 | 34.7 | 6/21/2018 |
| 2018 | 38.0 | 6/21/2018 |
| 2018 | 36.1 | 6/21/2018 |

# DFT for measuring aggregate friction

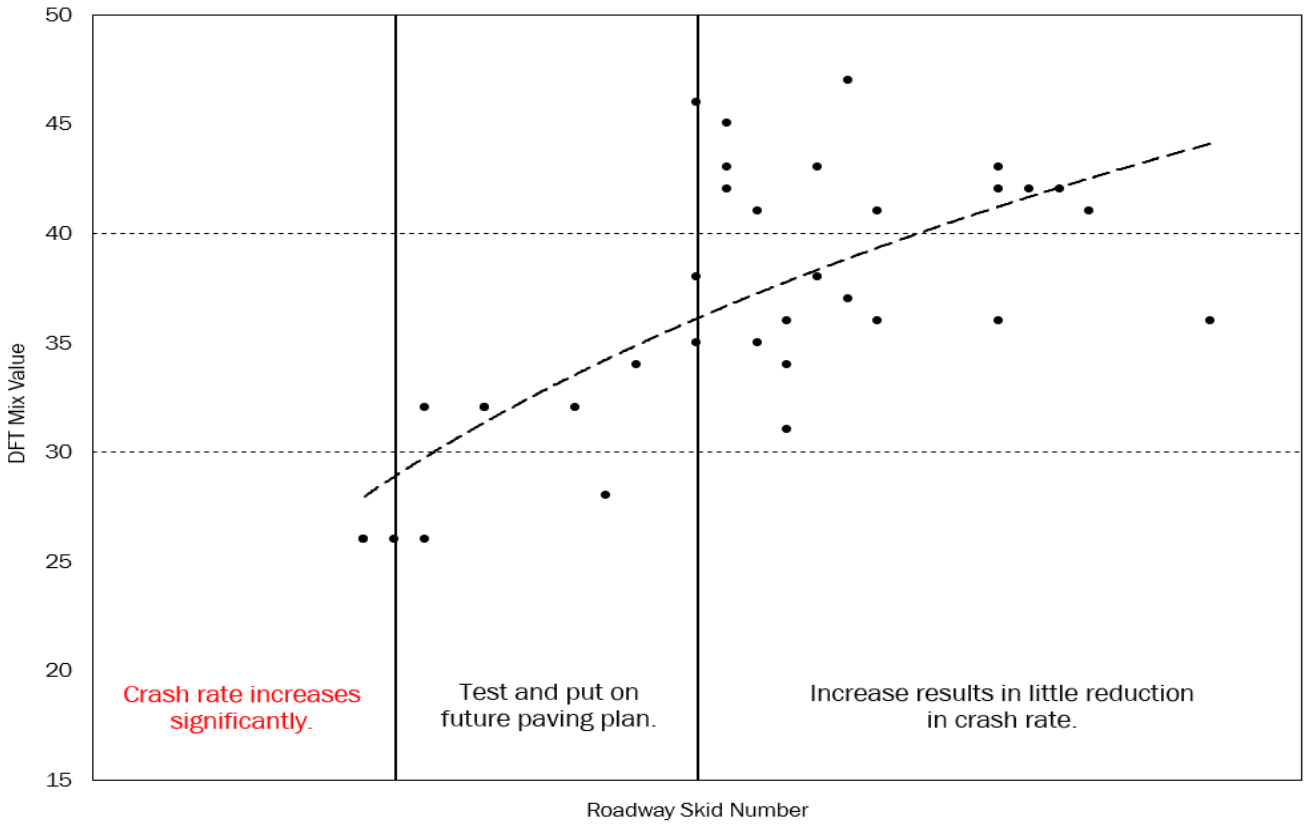
- Dynamic friction test (DFT): direct measurement
  - Measures a friction value on wet pavement surface (ASTM E1911)
  - Spinning disk with 3 rubber sliders contacting surface as disk rotates.



# DFT for measuring aggregate friction

- Maryland DOT used DFT to measure aggregate friction.

- Richard Izzo's group at MTD established its own test procedure.



# DFT for measuring aggregate friction

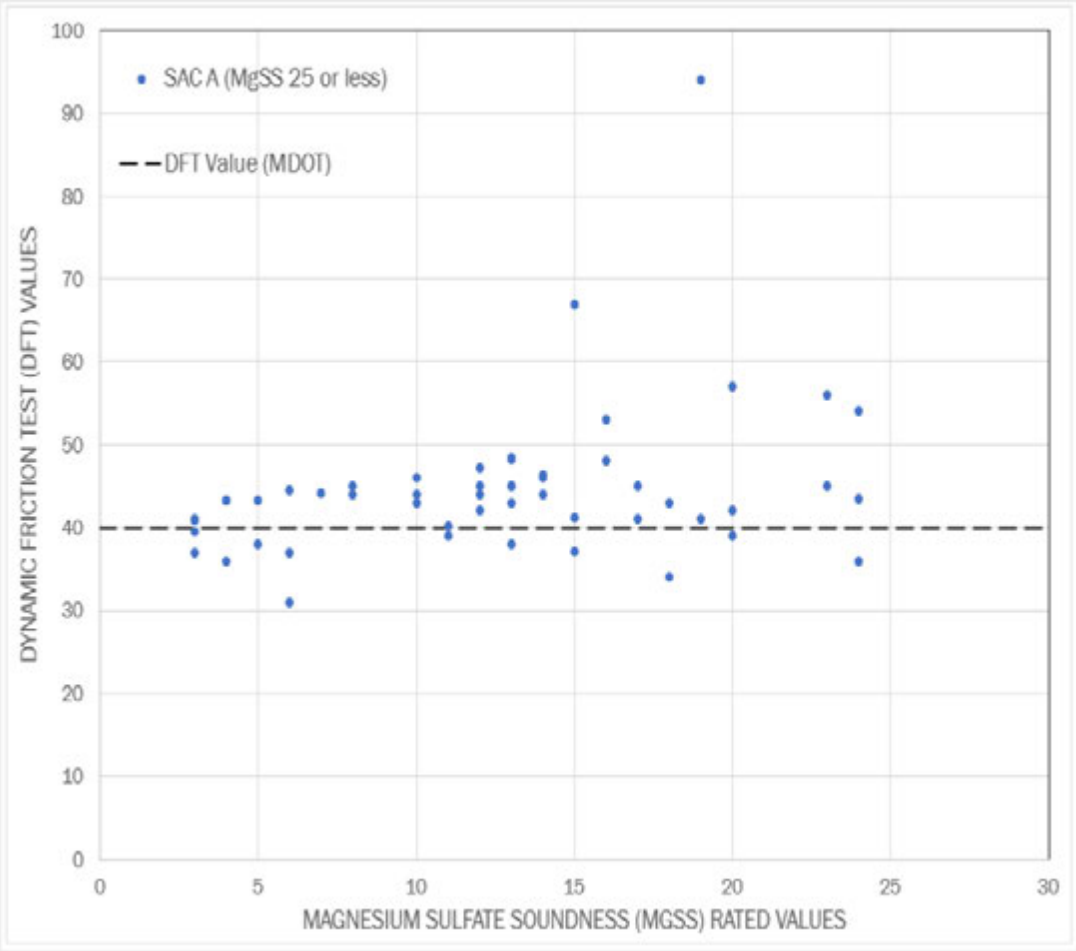
- TxDOT DFT test
  - Micro-Deval polishing aggregates: 10,500 revolutions for 1-3/4 hours
  - Prepare an aggregate ring: passing 3/8" sieve and retaining on ¼" sieve
  - Run DFT to measures aggregate frictional property: DFT value




# DFT for measuring aggregate friction

- Richard Izzo
  - 2020 TxDOT short course

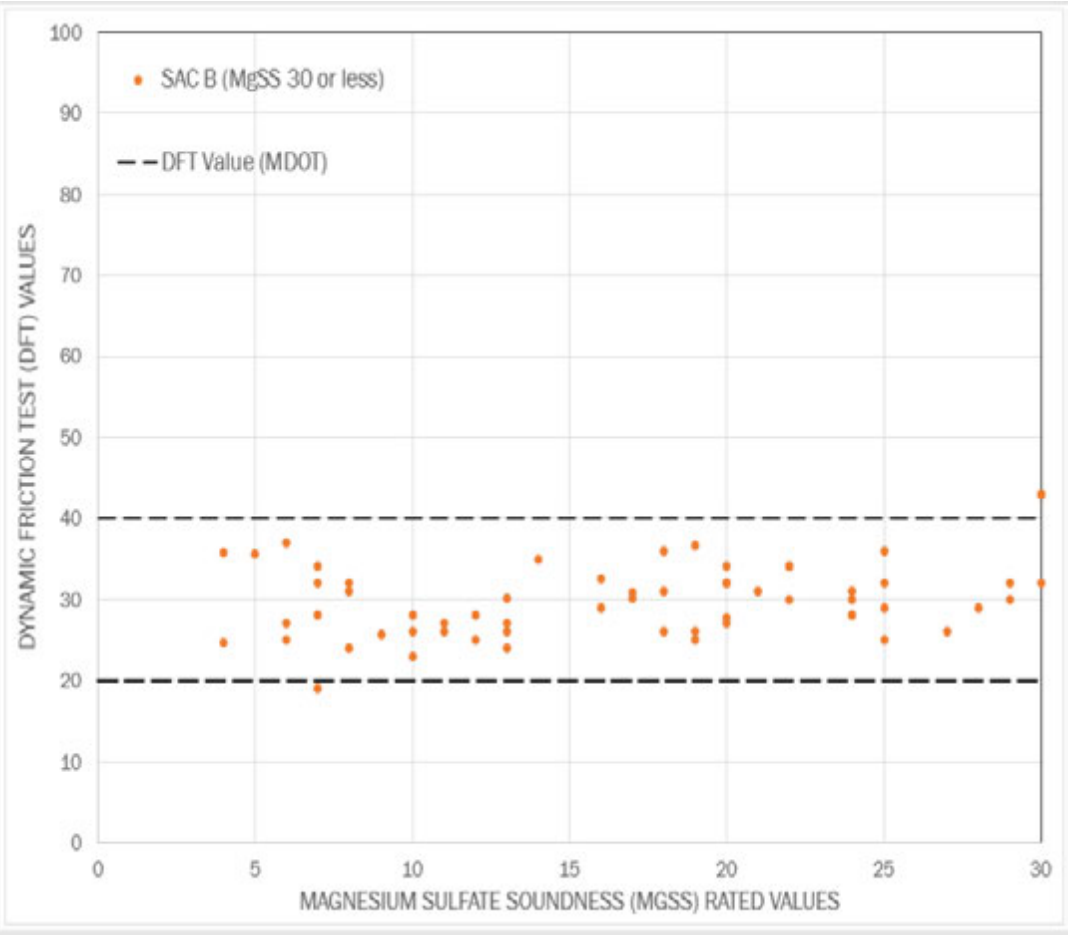
- DFT values of individual aggregate sources, not blended values.
- All material codes combined – Dolomite, Gravel, Igneous, Lightweight, Limestone, and Sandstone.
- Poor correlation/trend of Soundness to DFT Value for SAC A sources.
- Soundness not a strong indicator of friction for SAC A sources.



# DFT for measuring aggregate friction

- Richard Izzo
  - 2020 TxDOT short course

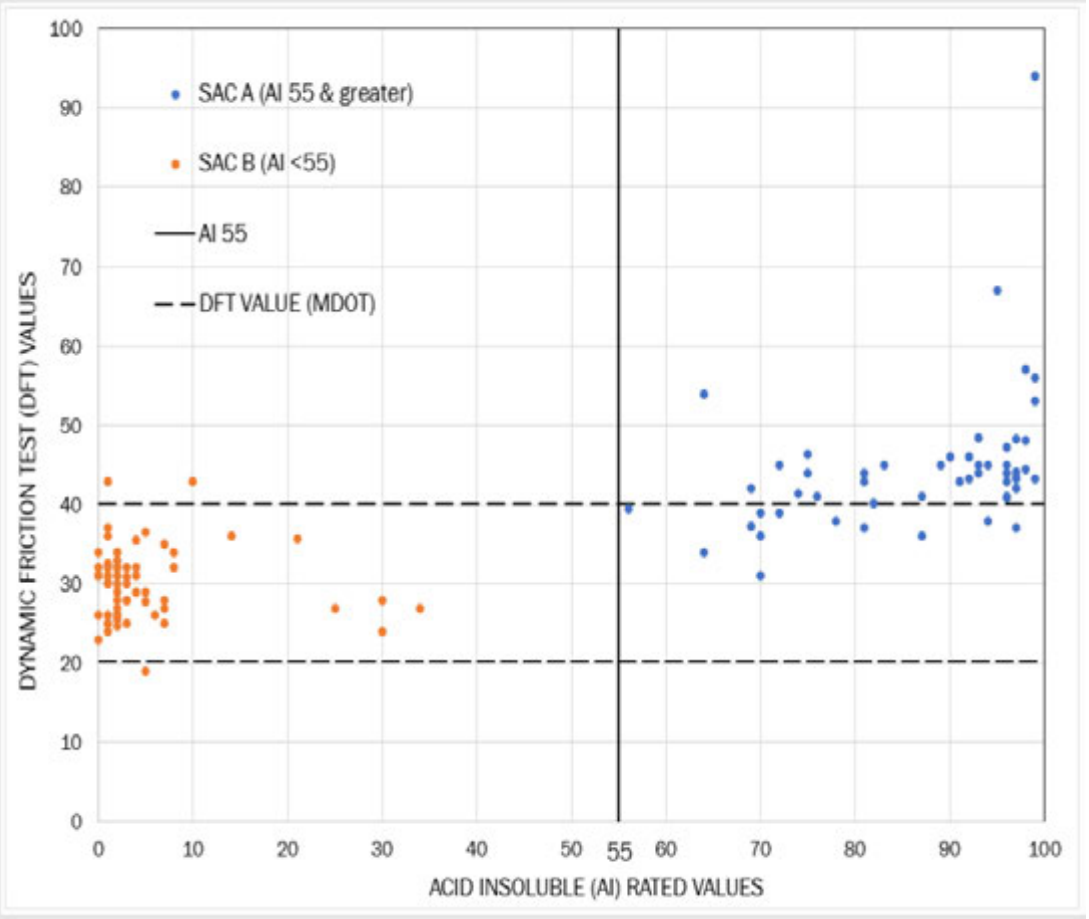
- All material codes combined – Dolomite, Gravel, Igneous, Lightweight, Limestone, and Sandstone.
- Poor correlation/trend of Soundness to DFT Value for SAC B sources.
- Soundness not a strong indicator of friction for SAC B sources.



# DFT for measuring aggregate friction

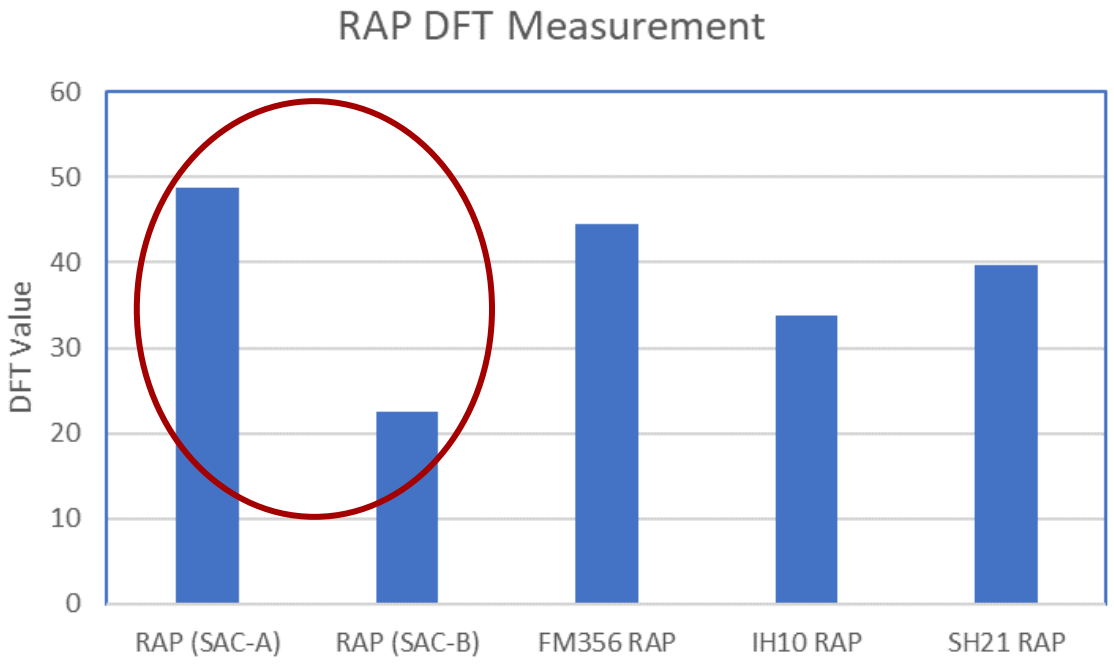
- Richard Izzo
  - 2020 TxDOT short course

- DFT value compared with acid insoluble for SAC A and SAC B sources.
- All material codes combined – Dolomite, Gravel, Igneous, Lightweight, Limestone, and Sandstone.
- Generally, a high AI > 55 will produce a higher DFT Value.
- DFT does a good job differentiating aggregate sources with lower AI values.



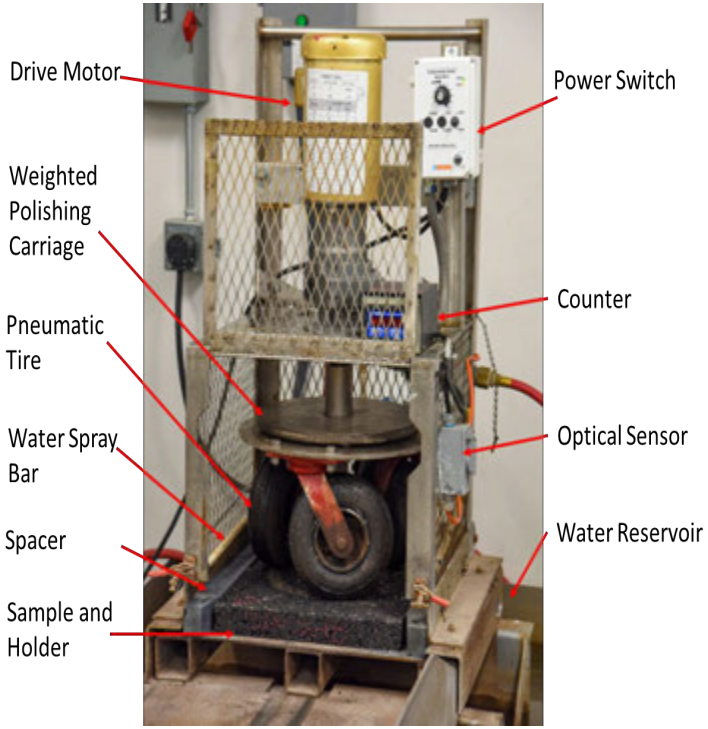
# RAP DFT and its impact on mix slab DFT

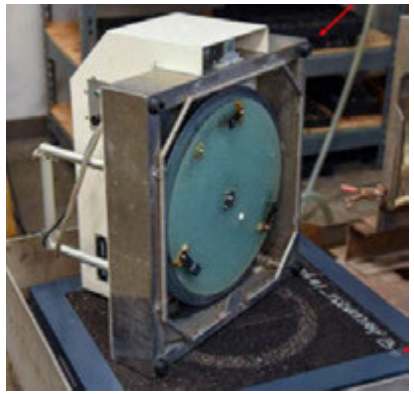
- RAP DFT
  - Ignition oven test
  - Micro-Deval polishing aggregates: 10,500 revolutions for 1-3/4 hours
  - Prepare an aggregate ring: passing 3/8" sieve and retaining on ¼" sieve
  - Run DFT to measures aggregate frictional property



# RAP DFT and its impact on mix slab DFT

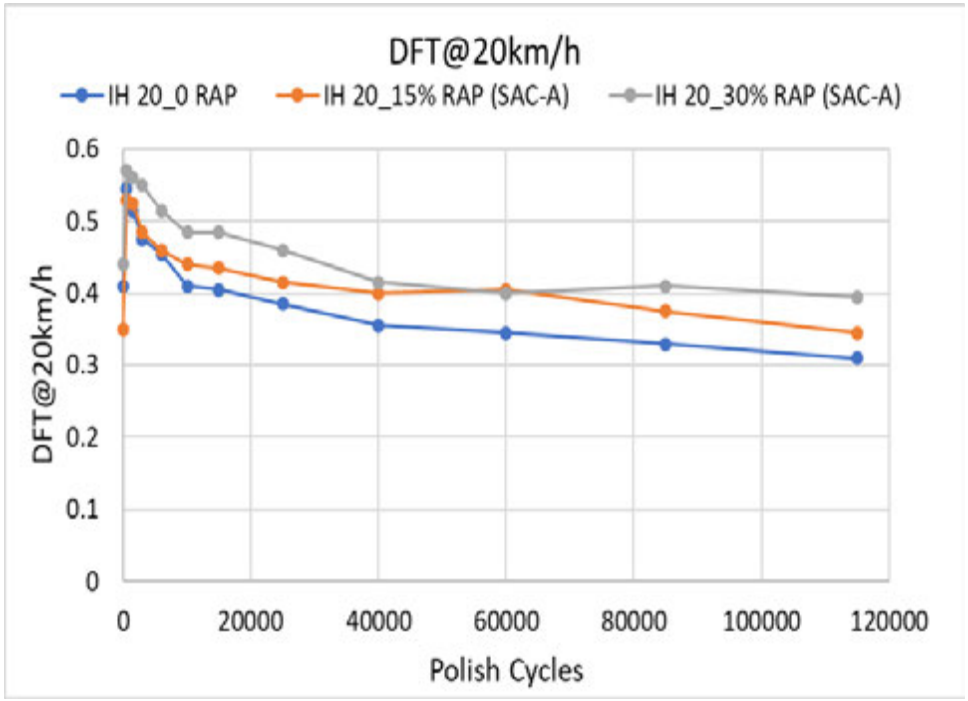
- RAP impact on mix slab DFT

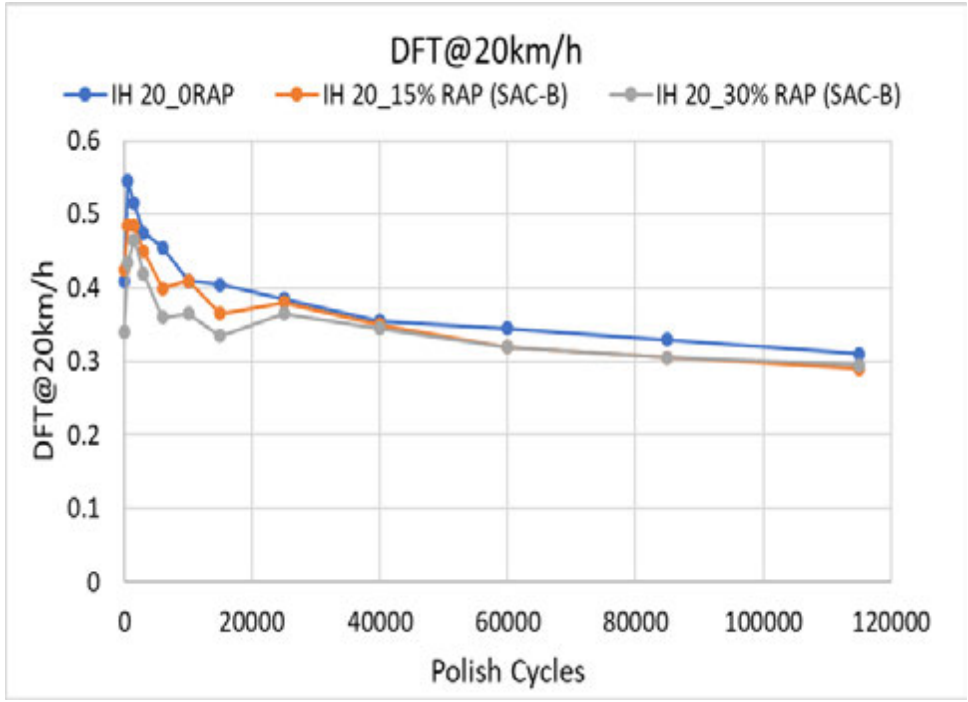



# RAP DFT and its impact on mix slab DFT

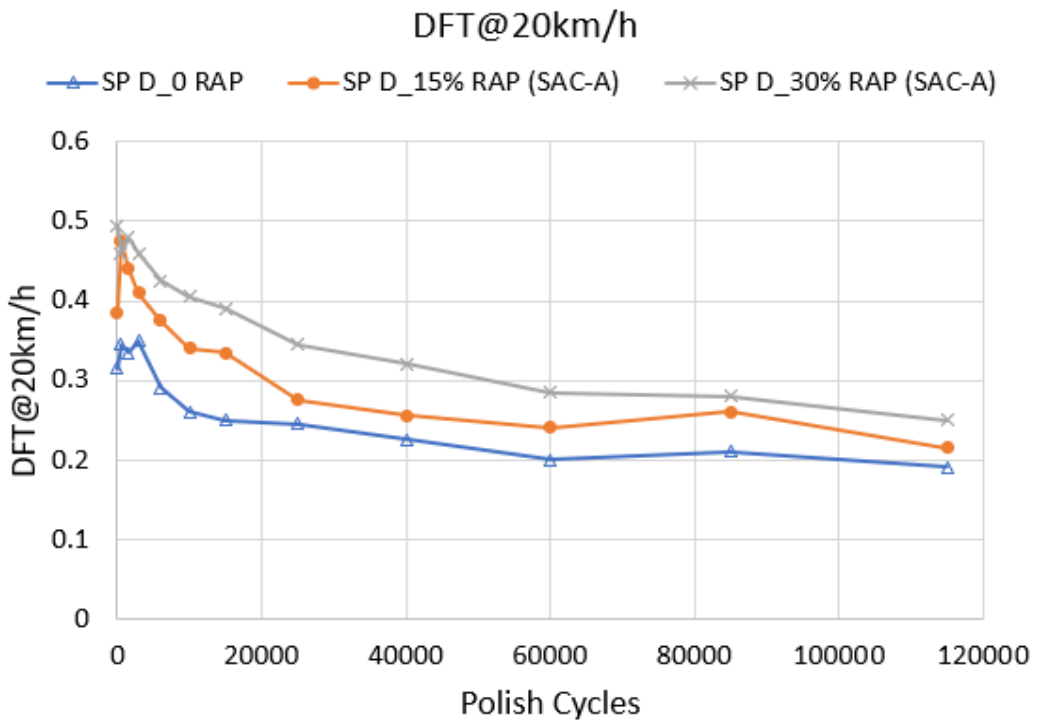
- RAP impact on mix slab DFT: one curve=one week

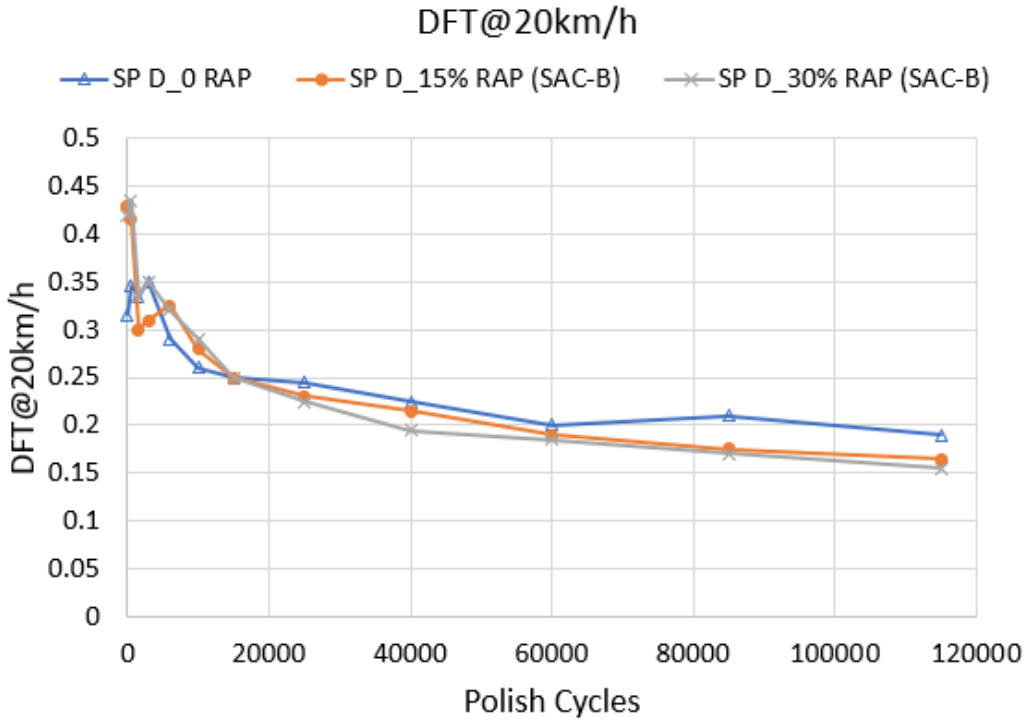


# RAP DFT and its impact on mix slab DFT

- RAP impact on mix slab DFT: one curve=one week



# Preliminary DFT-based SAC for RAP

- 20 mixes (40 slabs=8 months' testing)
- SN is a function of mixture microtexture (DFT) and macrotexture (measured by circular track meter-CTM in mean profile depth-MPD)

| Mixture Name | Slab DFT * 100 (@ 3000 Cycles) | Blended DFT * 100 (AMD, +#4) | Macro-MPD, mm | IFI | SN (50) |
|---|---|---|---|---|---|
| FM 356_0 RAP | 49 | 41.8 | 0.748 | 0.261 | 26.3 |
| FM 356_15% RAP (SAC-A) | 52 | 42.8 | 0.661 | 0.278 | 28.4 |
| FM 356_30% RAP (SAC-A) | 50.5 | 42.8 | 0.641 | 0.270 | 27.3 |
| FM 356_15% RAP (SAC-B) | 46.5 | 40.7 | 0.865 | 0.247 | 24.7 |
| FM 356_30% RAP (SAC-B) | 45 | 38.5 | 0.537 | 0.239 | 23.7 |
| IH 20_0 RAP | 47.5 | 32 | 0.682 | 0.253 | 25.3 |
| IH 20_15% RAP (SAC-A) | 48.5 | 33.5 | 0.730 | 0.259 | 26.0 |
| IH 20_30% RAP (SAC-A) | 55 | 35.1 | 0.694 | 0.296 | 30.5 |
| IH 20_15% RAP (SAC-B) | 45 | 31.2 | 0.473 | 0.239 | 23.7 |
| IH 20_30% RAP (SAC-B) | 42 | 30.4 | 0.408 | 0.223 | 21.8 |
| IH 10_0 RAP | 26 | 29.3 | 0.513 | 0.147 | 13.2 |
| IH 10_15% RAP (SAC-A) | 31 | 31.1 | 0.500 | 0.169 | 15.6 |
| IH 10_30% RAP (SAC-A) | 38 | 32.2 | 0.460 | 0.202 | 19.4 |
| IH 10_15% RAP (SAC-B) | 25.5 | 29.3 | 0.772 | 0.144 | 12.9 |
| IH 10_30% RAP (SAC-B) | 22.5 | 28.7 | 0.473 | 0.132 | 11.7 |
| SP D_0 RAP | 35 | 33.4 | 0.775 | 0.188 | 17.7 |
| SP D_15% RAP (SAC-A) | 41 | 34.2 | 0.653 | 0.218 | 21.2 |
| SP D_30% RAP (SAC-A) | 46 | 35.7 | 0.657 | 0.245 | 24.3 |
| SP D_15% RAP (SAC-B) | 31 | 31.8 | 0.462 | 0.169 | 15.6 |
| SP D_30% RAP (SAC-B) | 35 | 31 | 0.460 | 0.188 | 17.7 |

# Preliminary DFT-based SAC for RAP

- Preliminary recommendation

| Property | Test Method | SAC-A for RAP |
|---|---|---|
| *Micro-Deval loss, % max (TxDOT 0-6959)* | *Tex-461-A* | *15* |
| *DFT *100 (After Micro-Deval), min* | *ASTM E1911 TxDOT aggregate ring* | *43* |

# Pilot implementation project 5-7025-01

- Select 3 field projects with milled RAP
- Evaluate RAPs using both SAC aggregate tests and DFT
- Design the mixes using the SAC-A RAPs
- Construct field test sections with the SAC-A RAPs
- Monitor and measure field skid number and DFT friction
- Verify and adjust the preliminary SAC-A RAP criteria
- Training workshops

# Q/A

Thank You All!