Outline

- INTRODUCTION and LITERATURE REVIEW
- OBJECTIVES
- MATERIALS and METHODOLOGY
- RESULTS
- CONCLUSIONS
Typical Pavement

- Tack Coat
- Seal Coat
- Prime coat
- Surface Course (25–50 mm)
- Binder Course (50–100 mm)
- Base Course (100–300 mm)
- Subbase Course (100–300 mm)
- Compacted Subgrade (150–300 mm)
- Natural Subgrade
Load Transfer in Pavement

Gierhart and Dietz (2017)
Problems due to Insufficient Interlayer Bond

Bond Failure
Slippage
Pothole
Delamination
Reduced Fatigue Life

FHWA (2016); Gierhart and Dietz (2017)
Tack Coats

Tack Coat

➢ A thin bituminous layer (or emulsion)
➢ Sprayed between asphalt mix layers
➢ Sprayed between asphalt and Portland Cement Concrete (PCC) layers

Purposes

➢ Improve interlayer bond
➢ Water barrier

Shear and Tensile Failure Modes in an Asphalt Pavement Structure (Raab and Parlt, 2004)
<table>
<thead>
<tr>
<th>Reference</th>
<th>Pertinent Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>West et al. (2005)</td>
<td><strong>Slippage:</strong> High horizontal stresses and insufficient bonding between the asphalt layers. At locations of wheel acceleration, deceleration, and turns.</td>
</tr>
<tr>
<td>Mohammad et al. (2009)</td>
<td><strong>Delamination:</strong> Interface shear stresses exceed the interface shear resistance. Fatigue is imposed by the shear stresses.</td>
</tr>
<tr>
<td>Mohammad et al. (2012); Mohammad et al. (2010); Cross and Shrestha (2005)</td>
<td><strong>Tack coats:</strong> Improve the interlayer bonding of asphalt pavements.</td>
</tr>
<tr>
<td>Nguyen et al. (2016); Mohammad et al. (2002); Paul and Scherocman (1988)</td>
<td><strong>Optimum tack coat material and application rate:</strong> Govern the interlayer bond strength.</td>
</tr>
<tr>
<td>Das et al. (2017)</td>
<td><strong>Non-tracking tack coats:</strong> Higher interlayer bond strength than slow-setting ones.</td>
</tr>
<tr>
<td>Tashman et al. (2006); Sholar et al. (2004); and West et al. (2005)</td>
<td><strong>Milled surfaces:</strong> Higher shear strength at the interface than non-milled ones.</td>
</tr>
<tr>
<td>Destree and Visscher (2017)</td>
<td><strong>Cleanliness:</strong> Enhance the interlayer bond strength.</td>
</tr>
</tbody>
</table>
| Ai et al. (2017); Seo et al. (2015); Leng et al. (2008); West et al. (2005) | **Temperature:** Very crucial parameter influencing the bond strength.  
An increase in temperature decreased the interlayer bond strength. |
| West et al. (2005)                            | **Confinement:** Improve the bond strength, especially at high temperatures.            |
Tack Coat Performance

- Tack Coat Type and Application Rate
- Application Method (affects uniformity)
- Temperature
- Surface Type (new pavement, old pavement, or milled surface)
- Moisture
Objectives

INTERLAYER SHEAR STRENGTH (ISS)

- **Optimum application rates** of tack coats based on ISS test with respect to different types of pavement surfaces
- **Effect of different parameters** on the bond strength of selected tack coats:
  
  a) Application Rate (no tack coat and three other rates)
  b) Asphalt Surface Age (new, and aged and worn)
  c) Surface Type (milled HMA and grooved PCC)
  d) Testing Temperature (low, intermediate and high)
  e) Moisture (moisture-conditioned and dry)
Objectives

TRACKING TEST

• Determine **setting time of tack coats** using room-temperature tracking test

IMPLEMENTATION

**Generate data** to help ODOT develop guidelines for the optimum tack coat application rates based on pavement conditions
Materials

S4 Asphalt Mix
Haskell Lemon Asphalt Plant, Norman, OK

- Mix ID: S4qc0131302900
- Nominal Maximum Aggregate Size (NMAS) : 12.5 mm
- #4 (4.75 mm) passing – 64%
- Binder Type – PG 64-22 OK
- Binder Content – 5.2%

PCC and HMA Cores
Provided by ODOT projects in Oklahoma

<table>
<thead>
<tr>
<th>Bin No.</th>
<th>Aggregate</th>
<th>Aggregate Type</th>
<th>Amount of Aggregate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/8&quot; Chips</td>
<td>Granite</td>
<td>37</td>
</tr>
<tr>
<td>2</td>
<td>Man. Sand</td>
<td>Limestone</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>Man. Sand</td>
<td>Granite</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Scrns.</td>
<td>Granite</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Sand</td>
<td>Sand</td>
<td>15</td>
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</tbody>
</table>
## Materials

### Tack Coats

Six types
Collected from Oklahoma and Louisiana

<table>
<thead>
<tr>
<th>Tack Coat Type</th>
<th>Anionic</th>
<th>Cationic</th>
<th>Non-Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-1</td>
<td>✔️</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRS-1S</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>CBC-1H</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>CRS-1</td>
<td></td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>NTQS-1HH</td>
<td>✔️</td>
<td></td>
<td>✔️</td>
</tr>
<tr>
<td>NTHAP</td>
<td></td>
<td></td>
<td>✔️</td>
</tr>
</tbody>
</table>

- **C** – Cationic
- **SS** – Slow Setting
- **1** – Low viscosity
- **H** – Hard Base Binder
- **P** – Polymer-modified
- **QS** – Quicker Setting
- **RS** – Rapid Setting
- **NT** – Non-Tracking
- **S** – Soft Base Binder
Test – Louisiana Interlayer Shear Strength Tester

Materials and Methodology
Sample Preparation for LISST Test

1st Step
- Apply Tack Coat

Layer 1

2nd Step
- Compact Second Layer

Layer 1

3rd Step
- Layer 2
- Application Rates:
  - 0.031 gal/yd²
  - 0.062 gal/yd²
  - 0.0155 gal/yd²

Surface Types:
- Unaged HMA
- Aged and Surface Conditioned Milled HMA
- Grooved PCC

Tack Coat
Step 1: Preparation of Bottom Layer

Laboratory-Compacted Bottom Layer

- Diameter slightly less than 150 mm
- Metal strips to reduce diameter
- 15 minutes cooling inside the mold after compaction
Step 1: Preparation of Bottom Layer

Surface Conditioning and Aging

1. **Polish the surface**
   - laboratory-compacted unaged sample
   - 100-grit sand paper for 2.5 minutes

2. **Clean the dust**
   - regular brush
   - Pressured air

3. **Age the sample**
   - Aged as per AASHTO R30
   - Aged the samples at 85°C for 5-days
Step 1: Preparation of Bottom Layer

HMA and PCC Field Cores

a. Marking sample
b. Cutting to required height
c. Oven – drying.
Step 2: Application of Tack Coats

- **Applied with paint brush**
- Residual application rates:
  1. 0.031 gal/yd$^2$
  2. 0.062 gal/yd$^2$
  3. 0.155 gal/yd$^2$
- **Breaking of tack coat**: color change from brown to black
- Duck tape around the field cores due to improper edges
Step 3: Compaction of Top Layer

Bottom layer sample heated at 50°C and inserted in the mold after tack coat application.

Asphalt mix placed in the mold and compacted to 7.0% ± 0.5% Air Voids.
Step 4: Moisture-Conditioning of Samples

1. Place the sample in MIST
2. Fill the water
3. Secure the chamber lid
4. Fill the overflow cups by 2/3rd
5. Start conditioning.
   ✓ Default setting:
   ✓ 20 hours of adhesion time at 60°C
   ✓ 3500 Cycles of 40 psi at 60°C.

Note: MIST takes a day to complete the conditioning.
Step 4: Louisiana Interlayer Shear Strength Tester

Materials and Methodology
### Typical Results – Unaged HMA Surface

#### Peak Load (lbf.)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Peak Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>2560</td>
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<tr>
<td>Sample 2</td>
<td>2560</td>
</tr>
<tr>
<td>Sample 3</td>
<td>2740</td>
</tr>
</tbody>
</table>

#### Surface Area (in.²)

| Area    | 28.3 |

#### Stress (psi)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>90</td>
</tr>
<tr>
<td>Sample 2</td>
<td>90</td>
</tr>
<tr>
<td>Sample 3</td>
<td>97</td>
</tr>
</tbody>
</table>

#### Average Shear Stress (psi)

| Average Shear Stress | 93 |

#### Standard Deviation (psi)

| Standard Deviation | 3.0 |
### Application Rates

1) 0.031 gal/yd²
2) 0.062 gal/yd²
3) 0.155 gal/yd²

### Surface Conditions

1) Unaged HMA
2) Aged and worn HMA
3) Milled HMA
4) Grooved PCC

<table>
<thead>
<tr>
<th>No.</th>
<th>Tack coat Type</th>
<th>Residual Application Rate (gal/yd²)</th>
<th>Surface Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unaged HMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aged and Conditioned HMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Milled HMA Cores from Field</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grooved PCC Cores from Field</td>
</tr>
<tr>
<td>1</td>
<td>No Tack Coat</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>SS-1</td>
<td>0.031</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>SS-1</td>
<td>0.062</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>SS-1</td>
<td>0.155</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>CRS-1S</td>
<td>0.031</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>CRS-1S</td>
<td>0.062</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>CRS-1S</td>
<td>0.155</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>CBC-1H</td>
<td>0.031</td>
<td>3</td>
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<tr>
<td>9</td>
<td>CBC-1H</td>
<td>0.062</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>CBC-1H</td>
<td>0.155</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>CRS-1</td>
<td>0.031</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>CRS-1</td>
<td>0.062</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>CRS-1</td>
<td>0.155</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>NTQS-1HH</td>
<td>0.031</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>NTQS-1HH</td>
<td>0.062</td>
<td>3</td>
</tr>
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<td>16</td>
<td>NTQS-1HH</td>
<td>0.155</td>
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</tr>
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<td>17</td>
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<td>0.08</td>
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<td>18</td>
<td>NTHAP</td>
<td>0.12</td>
<td>3</td>
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<td>19</td>
<td>NTHAP</td>
<td>0.155</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total 57 57 38 38</td>
</tr>
</tbody>
</table>
Test Matrix: LISST Test

- **Temperatures**
  - 1) 7°C
  - 2) 25°C
  - 3) 60°C

- **Moisture-Conditioning Effect**

- **Total of 302 Samples**

<table>
<thead>
<tr>
<th>No.</th>
<th>Tack coat Type</th>
<th>Surface Type</th>
<th>Unconditioned</th>
<th>Moisture-Conditioned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7°C</td>
<td>25°C</td>
</tr>
<tr>
<td>1</td>
<td>No Tack Coat</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>SS-1</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>CRS-1S</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>CBC-1H</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>CRS-1</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>NTQS-1HH</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>NTHAP</td>
<td>Unaged HMA</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Aged and Conditioned HMA</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

| Total Samples Tested | 42 | 42 | 42 | 28 |
Room-Temperature Tracking Test

1. 8 in. x 15.5 in. roofing paper
2. 0.5 mm uniform thickness using a mechanical spreader
3. Weight (steel cylinder with O-ring) rolled over the roofing paper and then on regular white paper
4. Weight rolled over every 10 minute until no tracking marks were visible
Room-Temperature Tracking Test

Application of a Tack Coat using a Mechanical Spreader

Room-Temperature Tracking Test Setup
Room-Temperature Tracking Test

Hand Push for Free Rolling of Steel Cylinder

Rolling of Steel Cylinder on Roofing Paper and an A4 Sheet

Final Tracking Mark on an A4 Sheet
### Test Matrix: Room-Temperature Tracking Test

#### Materials and Methodology

<table>
<thead>
<tr>
<th>No.</th>
<th>Tack coat Type</th>
<th>Spreader Type</th>
<th>Tack Coat Thickness (mm)</th>
<th>Number of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SS-1</td>
<td></td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>CRS-1S</td>
<td>Variable Thickness</td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>CBC-1H</td>
<td>Mechanical Spreader (Path Width - 8 inch)</td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>CRS-1</td>
<td></td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>NTQS-1HH</td>
<td></td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>NTHAP*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Can not apply at room-temperature (Setting time: 15 to 20 seconds, according to manufacturer)

**Total Number of Tests**  **15**
Typical Results: SS-1 Tack Coat

Pass No. 1
Time: 10 min

Pass No. 2
Time: 20 min

Pass No. 3
Time: 30 min

Pass No. 4
Time: 40 min

Pass No. 5
Time: 50 min

Pass No. 6
Time: 60 min

Pass No. 7
Time: 70 min

Pass No. 8
Time: 80 min

Pass No. 9
Time: 90 min

Pass No. 10
Time: 100 min
Results and Discussions
Effect of Surface Type: No Tack Coat

Results

![Bar chart showing interlayer shear strength (psi) for different surface types: Unaged HMA Surface, Conditioned and Aged HMA Surface, Milled HMA Surface, Grooved PCC. The values are 93.1, 86.3, 85.3, and 43.5 respectively.]
Interlayer Shear Strength

Results

Unaged HMA Surface

Interlayer Shear Strength (psi)

Residual Application Rate (gal/yd²)
Interlayer Shear Strength

Aged and Conditioned HMA Surface

Interlayer Shear Strength (psi)

Residual Application Rate (gal/yd²)
Interlayer Shear Strength

Milled HMA Surface

Interlayer Shear Strength (psi)

Residual Application Rate (gal/yd²)

No Tack Coat
NTHAP
NTQS-1HH
CRS-1
CBC-1H
SS-1
CRS-1S
Interlayer Shear Strength

Results

![Graph showing Interlayer Shear Strength](image-url)
Effect of Surface Type: SS-1 and CRS-1

Results

**SS-1**
- Unaged HMA Surface
- Aged and Conditioned HMA Surface
- Milled HMA Surface
- Grooved PCC

**CRS-1**
- Unaged HMA Surface
- Aged and Conditioned HMA Surface
- Milled HMA Surface
- Grooved PCC
Effect of Surface Type: CRS-1S and CBC-1H

**Results**

![Graph of CRS-1S](image)

![Graph of CBC-1H](image)
Effect of Surface Type: NTQS-1HH and NTHAP

**Results**

**NTQS-1HH**

- Unaged HMA Surface
- Aged and Conditioned HMA Surface
- Milled HMA Surface
- Grooved PCC

**NTHAP**

- Unaged HMA Surface
- Aged and Conditioned HMA Surface
- Milled HMA Surface
- Grooved PCC
## Optimum Residual Application Rates

<table>
<thead>
<tr>
<th>No.</th>
<th>Tack coat Type</th>
<th>Test Temperature (°C)</th>
<th>Unaged HMA Surface</th>
<th>Aged and Conditioned HMA Surface</th>
<th>Milled HMA Cores from Field</th>
<th>Grooved PCC Cores from Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SS-1</td>
<td>25</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td>2</td>
<td>CRS-1S</td>
<td>25</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td>3</td>
<td>CBC-1H</td>
<td>25</td>
<td>0.031</td>
<td>0.031</td>
<td>0.062</td>
<td>0.031</td>
</tr>
<tr>
<td>4</td>
<td>CRS-1</td>
<td>25</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
<td>0.031</td>
</tr>
<tr>
<td>5</td>
<td>NTQS-1HH</td>
<td>25</td>
<td>0.062</td>
<td>0.062</td>
<td>0.031</td>
<td>0.062</td>
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<tr>
<td>6</td>
<td>NTHAP</td>
<td>25</td>
<td>0.08</td>
<td>0.08</td>
<td>0.12</td>
<td>0.155</td>
</tr>
</tbody>
</table>
Interlayer Shear Strength at Optimum Residual Application Rates

Results
Effect of Temperature

Results

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Interlayer Shear Strength (psi)</th>
<th>Unaged HMA Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>7°C</td>
<td>0.031 gal/yd²</td>
<td>0.062 gal/yd²</td>
</tr>
<tr>
<td>25°C</td>
<td>0.031 gal/yd²</td>
<td>0.08 gal/yd²</td>
</tr>
<tr>
<td>60°C</td>
<td>0.031 gal/yd²</td>
<td></td>
</tr>
</tbody>
</table>

No Tack Coat | SS-1 | CRS-1S | CBC-1H | CRS-1 | NTQS-1HH | NTHAP |
Effect of Temperature

Aged and Conditioned HMA Surface

Interlayer Shear Strength (psi)

- No Tack Coat
- SS-1
- CRS-1S
- CBC-1H
- CRS-1
- NTQS-1HH
- NTHAP

Temperatures:
- 7°C
- 25°C
- 60°C

Results:
- 0.031 gal/yd²
- 0.062 gal/yd²
- 0.08 gal/yd²
Effect of Moisture

Results

Unaged HMA Surface

<table>
<thead>
<tr>
<th>Tack Coat Type</th>
<th>Interlayer Shear Strength (psi)</th>
<th>Moisture Conditioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Tack Coat</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>SS-1</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>CRS-1S</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>CBC-1H</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>CRS-1</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>NTQS-1HH</td>
<td>140.0</td>
<td>140.0</td>
</tr>
<tr>
<td>NTHAP</td>
<td>140.0</td>
<td>140.0</td>
</tr>
</tbody>
</table>

Moisture Application Rates:
0.031 gal/yd², 0.62 gal/yd²
Effect of Moisture

Aged and Conditioned HMA Surface

- Unconditioned
- Moisture-Conditioned

Interlayer Shear Strength (psi)

- No Tack Coat
- SS-1
- CRS-1S
- CBC-1H
- CRS-1
- NTQS-1HH
- NTHAP

Results

- 0.031 gal/yr²
- 0.031 gal/yr²
- 0.031 gal/yr²
- 0.062 gal/yr²
- 0.08 gal/yr²
## Setting Time

<table>
<thead>
<tr>
<th>No.</th>
<th>Tack coat Type</th>
<th>Setting Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Test #1</td>
</tr>
<tr>
<td>1</td>
<td>SS-1</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>CRS-1S</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>CBC-1H</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>CRS-1</td>
<td>120</td>
</tr>
<tr>
<td>5</td>
<td>NTQS-1HH</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>NTHAP</td>
<td>Can not apply at room-temperature (Setting time: 15 to 20 seconds, according to manufacturer)</td>
</tr>
</tbody>
</table>

### Average Setting Time (minutes)

<table>
<thead>
<tr>
<th></th>
<th>SS-1</th>
<th>CRS-1S</th>
<th>CBC-1H</th>
<th>CRS-1</th>
<th>NTQS-1HH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>113</td>
<td>57</td>
<td>80</td>
<td>123</td>
<td>57</td>
</tr>
</tbody>
</table>

Can not apply at room-temperature (Setting time: 15 to 20 seconds, according to manufacturer)
Conclusions

1. **Interlayer Shear Strength (ISS)** Depends on tack coat type, residual application rate, surface type, temperature, and moisture conditions.

2. **Shear Strength with vs. without Tack Coat**
   - SS-1 ➡ CRS-1 ➡ CRS-1S ➡ NTQS-1HH ➢ NTHAP ➢ (For new HMA surface)
   - CBC-1H (**effective** between PCC and HMA layers at a rate of 0.031 gal/yd²)
   - In general, Tack Coats are more Effective on Milled HMA and **Grooved PCC** than new HMA

3. **In General Residual Application Rate ➢ Interlayer Shear Strength ➢**

4. **Effect of Surface Type on ISS**
   - Milled HMA ➢ Aged and Polished HMA ➢ Unaged HMA ➢ Grooved PCC
   - NTQS-1HH and NTHAP improved bond between HMA ➢ PCC layers
5. **Optimum Residual Application Rate**
   - 0.031 gal/yd\(^2\) for SS-1, CRS-1S, CBC-1H, and CRS-1 tack coats
   - NTQS-1HH and NTHAP varied with surface types

6. **Temperature**
   - Interlayer Shear Strength

7. At high temperature (60°C), all tack coats had relatively the same ISS.

8. **All tack coats improved the resistance to moisture.** (at optimum residual application rate)

9. **Setting time**
   - 50 - 120 minutes: CRS-1 > SS-1 > CBC-1H > CRS-1H > NTQS-1HH
Recommendations

- **Trackless Tack Coats** (NTQS-1HH and NTHAP): Always good choices for any surface.

- **HMA Overlay on PCC** Use of Trackless Tack Coats is highly recommended for structural integrity of the pavement structure.

- **Milled HMA Surfaces** Small amount of tack coat may help in improving the interlayer shear strength.

- **Moisture Resistance** Any tack coat can be used to improve the at the interface of two HMA layers.

- **Excessive Application Rate**

- **Field Validation**
Acknowledgement

➢ Oklahoma Department of Transportation (ODOT)

➢ Silver Star Construction Co.

➢ Haskell Lemon Construction Co.

➢ Mr. Michael Schmitz (Mike)
References


Thank you!