An Introduction to Modified Asphalt Binders

Presented by:

Nebraska Asphalt Paving Conference
February 15, 2012
Modified Asphalt Binders

The Basics covered include:

✓ Background
✓ Chemistry
✓ Polymer modification
✓ Modified Emulsions
✓ Handling
✓ Lay down
✓ Field Experience
✓ Testing for Modified
✓ Testing to AASHTO M320
✓ Rheology Basics
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Outline – 1

• Introduction to Asphalt Modification
  – Background
  – Distresses in Asphalt Pavements – Useful Temperature Interval
  – Types of Modifiers
  – Use of Modified Asphalt
  – Use of Anti-Stripping Agents

• Handling of Modified Asphalts
  – Recommended Plant Operations
  – Handling of Asphalt Binder at the Terminal
  – Handling of Asphalt Binder at the HMA Plant
  – Laydown of Modified Asphalt Concrete
Introduction to Asphalt Modification

Presented By:
Bob Kluttz

Prepared for the Association of Modified Asphalt Producers Training Program
Reasons for Asphalt Modification

- The perception that asphalt cement has changed since the 1970s.
- Traffic factors have increased: including heavier loads, higher volumes and radial tires with higher tire pressures. (Twofold increase in truck traffic from 1974-1989.)
- Deferred maintenance because of funding shortages.
- Higher costs have created a tendency to construct thinner pavements, thus reducing the service life of the pavement.
- To meet Superpave design specifications.
Distresses in Asphalt Pavements

- High Temperature Permanent Deformation
- Low Temperature Thermal Cracking
- Load-Associated Fatigue Cracking
- Aging
- Stripping
High Temperature Permanent Deformation

- Rutting is caused by accumulated plastic deformation or flow in the asphalt mixture with repeated application of loads at upper pavement service temperatures.

- Rutting is predominantly influenced by the aggregate and mix design. However, the binder is also a significant contributor.

- Modifiers can stiffen the binder and provide a more elastic, less viscous material.
Low Temperature Thermal Cracking

- Thermal shrinkage cracking results from either a single thermal cycle where the temperature reaches a critical low temperature (Single Event Thermal Cracking) or from thermal cycling above the critical low temperature (Thermal Fatigue).

- Low Temperature Thermal Cracking is predominantly influenced by the binder properties.
- Modifiers can improve the low temperature flexibility and strength of the mixture.
Load-Associated Fatigue Cracking

- Load-associated fatigue cracking is caused by continuous application of loads over a period of time.
- Load-associated fatigue cracking is influenced by both binder and mixture properties.
- The mechanism of damage varies with the pavement design, thickness and condition.
Aging

- Aging or embrittlement of the asphalt binder occurs during the mixing and laydown process and during the service life of the asphalt. Oxidation and loss of light ends leads to an increase in stiffness and reduction of flexibility in the binder.
Stripping

- Stripping is loss of bond between the aggregates and asphalt binder which typically begins at the bottom of the HMA layer and progresses upward.
- Stripping is driven by the aggregate’s surface affinity for water.
- Additives can change the surface of the aggregate from hydrophilic (water-loving) to hydrophobic (water-hating).
- Lime
- Liquid amines and other polar liquids
Ideal Asphalt Binder and Asphalt Mixture

- Provides improved resistance to distresses
- Improves total lifecycle cost of the asphalt pavement
- Sustainable
- Improves safety
Useful Temperature Interval

• Minimum to maximum temperature range where the binder is expected to perform properly.
• Often referred to as the “True Grade” or “Continuous Grade” of the binder.
• “The Rule of 92” Typical straight run asphalts usually require modification to meet PG grades where the difference between the high and low grade temperature is 92 or greater.
Useful Temperature Interval (UTI)

- Glassy Solid
- Visco-elastic
- Liquid

Log Viscosity vs. Temperature

UTI
Performance Graded Asphalt

- Bending Beam Rheometry
- Dynamic Shear Rheometry

Log Modulus vs. Temperature, °C

-PG 58-16
-PG 64-22
-PG 76-22
Types of Modification

There are numerous categories of modifiers used for asphalt modification:

- Block Copolymers (SB, SBS, SEBS)
- SBR Latex
- Polyolefins
- Reactive Ethylene Terpolymer
- Crumb Rubber
- Chemical Additives
- Engineered Binders
Definition of a Polymer

• From the Greek - “Poly” meaning many and “Meros” meaning units.

• A polymer is a large molecule which is made up of many small chemical units called “monomers”.
SBR and SBS

Block Copolymer

Random Copolymer

Butadiene

Styrene
Chemical Modification

- Polyphosphoric acid (PPA)
- Air blown or catalytically blown.
- Others
Polyphosphoric Acid

• Polyphosphoric acid consists of higher molecular weight species with a distribution of chain lengths, mainly monomer, dimer and trimer.
• Concentration nomenclature is based on upon equivalent $\text{P}_2\text{O}_5$ content versus $\text{H}_3\text{PO}_4$.
  - Common types used:
    – 105%
    – 115%
• Use of ortho acid is not recommended. The residual water content can cause foaming.
AMAP Position Statement

The Association of Modified Asphalt Producers supports the responsible use of modification of asphalt materials for improved performance. AMAP believes that through the innovation of material suppliers, new and improved products will be made available that will improve life cycle costs. AMAP does not endorse any specific form of modification.

After a review of the available information on the use of polyphosphoric acid in the modification of paving grade asphalts, it is the position of AMAP that the correct use of the proper acid in the appropriate amount can improve the physical properties of bituminous paving grade binders. AMAP endorses appropriate testing on the modified asphalt after the addition of any and all additives to determine the final product specification is met. However, incorrect application of the technology, as with many additives, can result in problems associated with construction and/or performance.
Crumb Rubber

- Crumb Rubber is made up of two different materials from the waste stream
  - Reclaimed Rubber (raw unprocessed rubber)
  - Recycled Rubber (Processed - example tires)

- Ground Tire can contain a wide range of polymers including Natural Rubber, SBR, Polybutadiene. Also Carbon Black, Silica and other ingredients which were compounded into the rubber are still present
Chemistry of Asphalt Cements & Modifiers
Chemistry of Asphalt Cements

• Many factors affect the composition of the asphalt binder. The major causes of variation are the crude source and refining process.
• There are approximately 123 different crude sources used in the United States and Canada.
• There are several different refinery processes being used:
  – Fractional crude oil distillation under atmospheric pressure with steam
  – Topped crude distillation under vacuum with or without steam
  – Solvent Refining (Propane Deasphalting, Residual Oil Supercritical Extraction)
  – Air Blowing

## Crude Oils Used in Asphalt Production

<table>
<thead>
<tr>
<th>North Atlantic Region</th>
<th>North Central Region</th>
<th>Southern Region</th>
<th>Western Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska North Slope</td>
<td>Alaska North Slope</td>
<td>Alaska North Slope</td>
<td>Alaska North Slope</td>
</tr>
<tr>
<td>Bachaquero (Venezuela)</td>
<td>Canadian Sweet Mix</td>
<td>Amdel Sour</td>
<td>Amoco Pipeline</td>
</tr>
<tr>
<td>Boscan (Venezuela)</td>
<td>Chauvin (Canada)</td>
<td>Arabian Heavy</td>
<td>Bonanza</td>
</tr>
<tr>
<td>Bow River (Canada)</td>
<td>Coastal Mix</td>
<td>Boscan (Venezuela)</td>
<td>Bow River (Canada)</td>
</tr>
<tr>
<td>Menemota (Venezuela)</td>
<td>Lloydminster (Canada)</td>
<td>Baxtenville (Mississippi)</td>
<td>Canadian Sweet</td>
</tr>
<tr>
<td>Tia Juana Pesado (Venezuela)</td>
<td>Maya (Mexico)</td>
<td>Kirkuk (Iraq)</td>
<td>Coalinga (SJV)</td>
</tr>
<tr>
<td>Venezuelan</td>
<td>Mexican</td>
<td>Local Sweet</td>
<td>Cottonwood</td>
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<tr>
<td></td>
<td>Michigan Sweet</td>
<td>Maya (Mexico)</td>
<td>Elk Hill (SJV)</td>
</tr>
<tr>
<td></td>
<td>Middle East</td>
<td>Oklahoma Domestic</td>
<td>Gulf Alberta (SJV)</td>
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<tr>
<td></td>
<td>Montana Mix</td>
<td>South Alabama</td>
<td>Halsey Canyon</td>
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<tr>
<td></td>
<td>North Dakota Sour</td>
<td>Sweet Oklahoma Mix</td>
<td>Kern River (SJV)</td>
</tr>
<tr>
<td></td>
<td>Peace River (Canada)</td>
<td>West Texas Intermediate</td>
<td>Lloydminster</td>
</tr>
<tr>
<td></td>
<td>West Texas Intermediate</td>
<td>West Texas Sour</td>
<td>San Joaquin Valley</td>
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<tr>
<td></td>
<td>Wyoming Sour</td>
<td>Wyoming</td>
<td>Santa Maria</td>
</tr>
<tr>
<td></td>
<td>Trinidad</td>
<td></td>
<td>California Coastal</td>
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Asphalt Composition

<table>
<thead>
<tr>
<th>Element</th>
<th>Mexican Blend</th>
<th>Arkansas-Louisiana</th>
<th>Boscan</th>
<th>California</th>
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</thead>
<tbody>
<tr>
<td>Carbon (%)</td>
<td>83.77</td>
<td>85.78</td>
<td>82.9</td>
<td>86.77</td>
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<tr>
<td>Hydrogen (%)</td>
<td>9.91</td>
<td>10.19</td>
<td>10.45</td>
<td>10.93</td>
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<tr>
<td>Nitrogen (%)</td>
<td>0.28</td>
<td>0.26</td>
<td>0.78</td>
<td>1.1</td>
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<tr>
<td>Sulfur (%)</td>
<td>5.25</td>
<td>3.41</td>
<td>5.43</td>
<td>0.99</td>
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<tr>
<td>Oxygen (%)</td>
<td>0.77</td>
<td>0.36</td>
<td>0.29</td>
<td>0.2</td>
</tr>
<tr>
<td>Vanadium (ppm)</td>
<td>180</td>
<td>7</td>
<td>1380</td>
<td>4</td>
</tr>
<tr>
<td>Nickel (ppm)</td>
<td>22</td>
<td>0.4</td>
<td>109</td>
<td>6</td>
</tr>
</tbody>
</table>

Handling Modified Binders
Contractors View

Presented By: Bob Kluttz

Prepared by Ron Corun for the Association of Modified Asphalt Producers Training Program
Handling Modified Asphalts
Handling Modified Asphalts

- Between 5-20% of all asphalts are currently modified
- Most modified binders are in the PG 64-28 to PG 76-22 range
- Be safe and follow manufacturer’s recommendations
Handling Modified Asphalts

- Mixing PMA with other asphalts can cause the asphalt to fail to meet the PG grade requirements
- Reduce contamination at the terminal
  - Tanker truck empty before loading at terminal
  - Load from correct loading arm at terminal
Residue as Percent of Load

![Graph showing the relationship between inches of residue and percentage of total load. The x-axis represents inches of residue, and the y-axis represents percentage of total load. The graph includes bars for 1 to 6 inches, with percentages ranging from 0.00% to 10.00%. The highest percentage is at 6 inches, reaching 8.00%.](image-url)
Handling PMA at the Plant

- Reduce contamination at the HMA plant
  - Pump into correct tank at HMA plant
  - Use dedicated tanks, if possible
  - If dedicated tank is not available
    - Empty tank as much as possible if previous material was different
    - Add 2 or 3 full loads of PMA before testing and/or using the material in the tank
- Diluted PMA may fail PG grade!!!
Handling PMA at the Plant

- Vertical or Horizontal tanks?
  - Very few PMAs requires agitation to prevent separation
  - Vertical tanks provide more efficient agitation
  - Check with supplier

- Check and maintain proper temperatures
Handling PMA at the Plant

• Vertical or Horizontal Tanks?
  – Horizontal tanks work fine for most PMAs
  – Circulate to achieve uniform temperatures above and below heating coils
Proper Circulation in Horizontal Tanks

- Suction and return lines at opposite ends of tank to completely circulate material
- Return line near bottom of tank to prevent oxidation
Handling PMA at the Plant

- BEWARE OF MIXING MODIFIED ASPHALTS FROM DIFFERENT SUPPLIERS!!
  - Different suppliers may use different polymer technologies
  - Differing technologies may not be compatible
  - Polymer separation may occur
Handling PMA at the Plant

- **BEWARE OF USING DIRECT-FIRE HEATERS WITH MODIFIED ASPHALTS!!!**
  - Direct-fire heat tubes may develop hot spots
  - Hot spots will immediately destroy the polymer network in the asphalt
EC-101 Recommendations

<table>
<thead>
<tr>
<th>Grade</th>
<th>Min EC101</th>
<th>Max EC101</th>
<th>Midpoint EC101</th>
<th>Poly. (Midpoint EC101)</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>300</td>
<td>340</td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td>52</td>
<td>300</td>
<td>340</td>
<td>320</td>
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<td>82</td>
<td>300</td>
<td>340</td>
<td>320</td>
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</tbody>
</table>
## General Guidelines for Storage and Mixing Temperatures

<table>
<thead>
<tr>
<th>PG Binder</th>
<th>Storage Temperature (°F)</th>
<th>Mixing Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>64-22</td>
<td>285-315</td>
<td>265-320</td>
</tr>
<tr>
<td>70-22</td>
<td>300-325</td>
<td>280-330</td>
</tr>
<tr>
<td>76-22</td>
<td>315-340</td>
<td>285-335</td>
</tr>
<tr>
<td>Extended Storage</td>
<td>&lt;275 °F</td>
<td></td>
</tr>
</tbody>
</table>

Source: EC-101
Effect of Mixing Time and Temperature

Fluorescence micrographs showing the effect of time and temperature on the compatibility of a 10% SBS/10% Aromatic Oil/80% asphalt binder

(D) 430 °F 1 hour
(E) 430 °F 4 hours
(F) 430 °F 7 hours

Ref: B Brule, Y Brion and A. Tanguy,
Asphalt Paving Technology 60, 43 (1991)
Effect of Time and Temperature on Asphalt Properties

Long Term Storage of Modified Binders

- If storing PMA for longer than 60 days, turn heat down or off
- Lower temperatures minimize danger of damaging the PMA
Long Term Storage of Modified Binders

- Re-heating PMA binders
  - Bring temperature up slowly
  - If material has been held over the winter, heat incrementally 20 degrees increase at a time
  - Allow 3 or 4 days to get material up to circulation temperature

- As a precaution, you may want to test before using after winter shutdown
HMA Plant Asphalt Pump

- Adequately sized AC pump
  - PMA will cause higher amperage draw
- AC pump in good condition
- Calibrated
- Strainer
  - Larger than std holes – ¼”
  - Clean
HMA Plant Asphalt Pump Operation

- Circulate unmodified asphalt first before start-up
- Switch to PMA and circulate before start-up
- Switch to unmodified asphalt and circulate through pump after shutdown at end of shift
- Unmodified asphalt in AC pump, meter and strainer until next shift
HMA Plant Slat Conveyor

• Properly sized
• Good condition
• PMA will increase amperage draw on conveyor
  – Start at reduced tonnage rate
  – Start on unmodified mix to heat conveyor
Modified HMA Storage

- DO NOT STORE OVERNIGHT!!!
Transporting Modified HMA to Paver

- Clean, smooth truck beds
- Release agent
  - Type
  - Amount
- Tarps
Placing Modified HMA

- No modifications to equipment
- Handwork is more difficult
- Attention to detail
- Weather Conditions – 50 °F minimum
Compacting Modified HMA

- Compaction Equipment
  - Number - 3 or 4
  - Type – high frequency
  - Size
- Mix temperature
  - Only high enough to allow proper compaction
  - Extra 10 °F doubles fumes
  - High temperatures can damage PMA

- Roller pattern – Front roller close to paver
- Field monitoring – Temperature, Density
Compacting Modified HMA

• Compacting mixes with PMA may actually be easier than un-modified asphalt mixes
  – Compaction requires confinement
  – PMA may eliminate tender zone
Contractor QC Plan

- Contractors need to establish QC plan to prevent PG asphalt contamination and failing test results
  - Identify all hardware – label or number
    - Tanks
    - Pumps
    - Piping
    - Valves
    - Sample points
    - Heat system

- Establish standard procedures and hardware settings for asphalt flow into storage and into HMA plant
Summary

- PMA improves the performance of HMA pavements
- Understand the product you are using and treat it with respect
  - Follow suppliers recommendations
  - Best Practices
Visit our website...

www.modifiedasphalt.org

- Contact AMAP directly by:
- Phone: (314) 843-2627
- E-mail: amap@sbcglobal.net
Performance and Design of Thin, Highly Modified Pavements

Bob Kluttz, Kraton Polymers
Association of Modified Asphalt Producers – 13th Annual Meeting
Santa Ana Pueblo, NM – February 9, 2012
Phase Morphology

Bitumen phase  Swollen polymer phase

Bitumen + 2\(\frac{1}{2}\) % polymer

Bitumen + 5 % polymer

Bitumen + 7\(\frac{1}{2}\) % polymer

Polymer absorbs bitumen swelling 5-10X
Proposed System

old

new

This an example; depending on local conditions other types may apply
<table>
<thead>
<tr>
<th>mix type</th>
<th>thickness</th>
<th>cost per ton</th>
<th>per sq yd</th>
<th>total</th>
<th>cost reduction</th>
<th>% cost reduction</th>
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</thead>
<tbody>
<tr>
<td>modified wearing course</td>
<td>1.75 &quot;</td>
<td>$84.00</td>
<td>$16.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unmodified binder course</td>
<td>1.75 &quot;</td>
<td>$70.00</td>
<td>$13.77</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>unmodified base course</td>
<td>6.5 &quot;</td>
<td>$65.00</td>
<td>$47.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>10.0 &quot;</td>
<td></td>
<td></td>
<td>$77.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| modified wearing course  | 1.75 "    | $84.00       | $16.52    |         | -$21.75        | -29%            |
| modified binder course   | 1.75 "    | $84.00       | $16.52    |         |                |                 |
| modified base course     | 6.5 "     | $91.00       | $66.48    | $99.52  | -$21.75        | -29%            |
|                         | 5.5 "     | $91.00       | $56.25    | $89.29  | -$11.52        | -15%            |
|                         | 5.0 "     | $91.00       | $51.14    | $84.18  | -$6.41         | -9%             |
|                         | 4.5 "     | $91.00       | $46.02    | $79.07  | -$1.29         | -2%             |
|                         | 4.0 "     | $91.00       | $40.91    | $73.95  | $3.82          | 5%              |
|                         | 3.5 "     | $91.00       | $35.80    | $68.84  | $8.94          | 12%             |
|                         | 3.0 "     | $91.00       | $30.68    | $63.73  | $14.05         | 19%             |

Based on example from previous slide, material costs only

Base data:
- SMA unmodified wearing mix: $70/ton
- unmodified base mix: $65/ton

Assumptions:
- PMA wearing mix + 20%
- PMA base mix + 40%
Dense Graded Crushed Aggregate Base
\( M_r = 12,500 \text{ psi} \)
\( n = 0.40 \)

Test Track Soil
\( M_r = 28,900 \text{ psi} \)
\( n = 0.45 \)

Lift thicknesses limited by 3:1 thickness:NMAS requirement

Control (178mm HMA)
- 1 ¼” (PG 76-22; 9.5mm NMAS; 80 Gyrations)
- 2 ¾” (PG 76-22; 19mm NMAS; 80 Gyrations)
- 3” (PG 67-22; 19mm NMAS; 80 Gyrations)

Experimental (145mm HMA)
- 1 ¼” (Kraton Modified, 9.5 mm NMAS)
- 2 ¼” (7½% polymer; 19mm NMAS; 80 Gyrations)
- 2 ¼” (7½% polymer; 19mm NMAS; 80 Gyrations)

 Courtesy Prof. David Timm, Auburn U.
So far, no cracking on any of the pooled fund group experiment sections
<table>
<thead>
<tr>
<th>Kraton Polymers HiMA Experiment</th>
<th>Oklahoma Perpetual Pavement Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N7</strong> - 5 3/4” HIMA over sound base</td>
<td><strong>N8</strong> - 10” HMA over weak base</td>
</tr>
<tr>
<td><strong>5 3/4” HiMA Pavement</strong></td>
<td><strong>5” Conventional Structural Overlay</strong></td>
</tr>
<tr>
<td>Standard subgrade = good soil for construction</td>
<td>Oklahoma Pavement – Failed due to severe subgrade rutting</td>
</tr>
<tr>
<td>Weak subgrade = poor soil for construction</td>
<td>Oklahoma Pavement – Still Sound</td>
</tr>
</tbody>
</table>
10” pavement
paved Aug. 2006
5” rehabilitation
Aug. 2009
10 months old
10” pavement
paved Aug. 2006
5” rehabilitation
Aug. 2009
10 months old
### Oklahoma proposed design modification

<table>
<thead>
<tr>
<th>N7 - 5 ¾” HIMA over sound base</th>
<th>N8 – 10” HMA over weak base</th>
<th>N9 – 14” HMA over weak base</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ¼” (7½% polymer; 9.5 mm NMAS)</td>
<td>1 ¼” (7½% polymer; 9.5 mm NMAS)</td>
<td></td>
</tr>
<tr>
<td>2 ¼” (7½% polymer; 19mm NMAS; 80 Gyrations)</td>
<td>2 ¼” (7½% polymer; 19mm NMAS; 80 Gyrations)</td>
<td></td>
</tr>
<tr>
<td>2 ¼” (7½% polymer; 19mm NMAS; 80 Gyrations)</td>
<td>2 ¼” (7½% polymer; 9.5mm NMAS; 80 Gyrations)</td>
<td></td>
</tr>
</tbody>
</table>

- **Oklahoma Pavement – Failed due to severe subgrade rutting**
- **Oklahoma Pavement – Still Sound**

**Standard subgrade = good soil for construction**

**Weak subgrade = poor soil for construction**
10” pavement paved Aug. 2006
5” rehabilitation Aug. 2009
5 ½” mm HiMA rehab Aug. 2010
10 months old
Similar crack appeared in first overlay at 2.7 MM ESALs
Oklahoma will sponsor this section through the 2012 cycle to monitor further deterioration and evaluate preservation strategies.
**Thickness reduction capability with weak sub grades**

<table>
<thead>
<tr>
<th></th>
<th>270 mm standard Asphalt (1)</th>
<th>-34%</th>
<th>294 mm standard Asphalt (1)</th>
<th>-22%</th>
</tr>
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<tbody>
<tr>
<td>Sub base</td>
<td>100 MPa</td>
<td></td>
<td>Sub base</td>
<td>100 MPa</td>
</tr>
<tr>
<td>Sub grade</td>
<td>50 MPa</td>
<td></td>
<td>Sub grade</td>
<td>20 MPa</td>
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<tr>
<td></td>
<td>179 mm HiMA Asphalt (2)</td>
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<tr>
<td>Sub grade</td>
<td>50 MPa</td>
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</tbody>
</table>

(1) Thickness determined by asphalt strain criterion
(2) Thickness determined by sub grade strain criterion

HiMA = Highly Modified Asphalt
Thickness reduction capability with good quality sub base

(1) Thickness determined by asphalt strain criterion
(2) Thickness determined by sub grade strain criterion

HiMA = Highly Modified Asphalt
TSP2 Projects

- TSP2 – Transportation Systems Preservation Technical Services Program managed by the National Center for Pavement Preservation
- Thin Overlay Projects
  - Construction Complete – MN, NH, VT
  - Committed – OR
  - In Discussion – MA, TN

- Mix Designs & Testing in Conjunction with Prof. Walaa Mogawer, U Mass Dartmouth
- Mix design, construction, testing and performance data will be posted on the NCPP website.
Conclusions

- Highly modified binders can give dramatic improvement in pavement resistance to rutting and fatigue damage.
- Thickness reduction can more than offset increased material costs.
- In severe distress situations, highly modified binders can possibly double pavement life.
- Current modeling and design software may be used to predict material performance characteristics and rationally design pavements.
- Current field trials in the northeast will help determine if there is benefit for preservation strategies.
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