WELCOME!

- Instructor
- Registration
- Schedule
  - Breaks
- Course Materials
- Test

Instructors

- Ken Swedeen
  - Executive Director, Dakota Asphalt Pavement Association, 15 years (2000)
  - City Engineer-Sioux Falls, SD, 1996-2000
  - Materials/Resident/District Maintenance Engineer, Wyoming DOT, 20 years
  (Cheyenne, Jackson, Casper)
  - Registered PE in Texas, Wyoming; Graduate SDSU (BSCE) and Univ. of
  Wyoming (MBA)
- Ron Tessier
  - District Materials Engineer (Retired), NDDOT, Dickinson, ND
- Sharon Taylor
  - NDDOT Materials & Research, TTCP Coord.
  - Drop-ins: Ron Horner, State Materials Engineer, NDDOT; Joe Davis, State
  Bituminous Engineer, NDDOT

Dakota Asphalt Pavement Association

- Represent over 80 Contractor, Producer, Refiner, Engineering Firms and other
  Companies involved in the HMA Industry in North and South Dakota
- Dedicated to Quality Asphalt Construction through Education, Research & Training
- Bituminous Certification Courses
- Working with Agencies, LTAP’s
- Short Courses – HMAT
- Research – SDSU, UND, NDSU
Remember.....

This course is about the importance of YOUR job in the quality of the finished product...THE ROAD

• The quality of that finished product will:
  • Affect smoothness and therefore user costs and pavement service life
  • Affect density and therefore pavement service life
  • Affect future funding decisions and maintenance costs
  • Affect the customer, the highway user and taxpayer
  • Affect the paycheck of the Contractor and others

Let's Get Started!
Historic Paving Grades
Cutbacks and Emulsions
PG Binder Grades

Two Types of Asphalt
- Natural asphalt deposits
  - Island of Trinidad
  - Bermudez, Venezuela
- Petroleum asphalts
  - A product of the petroleum industry

Background
- First US hot mix asphalt (HMA) constructed in 1870’s
  - Pennsylvania Ave.
  - Used naturally occurring asphalt from surface of lake on Island of Trinidad

Trinidad Lake Asphalt
- Each lake asphalt source very consistent
  - Used solubility test to determine source
    - Insolubles differed substantially between sources
  - Demand for paved roads exceeded the supply of lake asphalts in late 1800’s
    - Led to use of petroleum asphalts

Petroleum Asphalt
Refinery Operation

Typical Crude Oil Distillation
Temperatures and Products

Washington National Airport, 1939

Penetration Specification
Viscosity (1950s)

Viscosity Specification

Cutbacks = Asphalt + Solvent

Cutbacks Cure

<table>
<thead>
<tr>
<th>Solvent Type</th>
<th>Grade</th>
<th>Cutback Cure</th>
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<tbody>
<tr>
<td>Gasoline, Naphtha</td>
<td>R C</td>
<td>70, 250, 800 or 3000</td>
</tr>
<tr>
<td>#2 Diesel, Kerosene</td>
<td>M C</td>
<td>30, 70, 250, 3000</td>
</tr>
<tr>
<td>Bunker fuels, heavy oils</td>
<td>S C</td>
<td>70, 250, 800 or 3000</td>
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</table>

Rapid Cure Specification

Medium Cure Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Grade</th>
<th>Cutbacks Cure</th>
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<tbody>
<tr>
<td>Gasoline, Naphtha</td>
<td>RC</td>
<td>70, 250, 800 or 3000 RC</td>
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<tr>
<td>#2 Diesel, Kerosene</td>
<td>LC</td>
<td>30, 70, 250, 3000 L</td>
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<tr>
<td>Bunker fuels, heavy oils</td>
<td>SC</td>
<td>70, 250, 800 or 3000 P</td>
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<tr>
<td>RC-800 R</td>
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</table>
**Emulsions = Asphalt + Water + Emulsifiers**

Emulsions => “Set” or “Break”

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>C R S</td>
<td>1, 2</td>
<td></td>
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<tr>
<td>C M S</td>
<td>1, 2</td>
<td></td>
</tr>
<tr>
<td>C S S</td>
<td>1, 1-h</td>
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</tbody>
</table>

Cationic - Positive Charge

Anionic - Negative charge

**Anionic Specifications**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>CRW</th>
<th>MSW</th>
<th>CWS</th>
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<tr>
<td>Penetration</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Softening point</td>
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<td></td>
<td></td>
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<tr>
<td>Hardening point</td>
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**Cationic Specifications**

**Emulsions = Asphalt + Water + Emulsifiers**

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<tr>
<td>C S S</td>
<td>1, 1-h</td>
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</tr>
</tbody>
</table>

Cationic - Positive Charge

Anionic - Negative charge

**Asphalt Binder Properties**

Asphalt is a **thermoplastic** material that softens as it is heated and hardens when cooled.

**Consistency (pen or vis)**

- **pen**: hard
- **vis**: soft

**Historic Specifications**

- **A**: 100-200
- **B**: 75-100
- **C**: 50-75

**Chapter 2**
Pre-Superpave Shortcomings
- Viscosity
  - viscous effects only
- Penetration
  - empirical measure of viscous and elastic effects
- No Low Temperature Properties Measured
- Problems with Modified Asphalt Characterization
- Specification Proliferation
- Long Term Aging not Considered

Superpave Asphalt Binder Specification
- Grading System Based on Climate
  - PG 58-22
    - Performance Grade
    - Average 7-day max pavement design temp
    - Min pavement design temp

Observed Air Temperatures
Topeka, KS
- very cold winter
- average winter
- > standard deviation of 4°C

Calculated Pavement Temperatures
Topeka, KS
- pvt = air
- pvt > air

PG Binder Grades
Topeka, KS
- PG 64-34 (98% minimum reliability)
- PG 58-28 (50% minimum reliability)
- PG grades - six degree increments

Asphalt Flow Behavior
- 1 hour
- 60°C
- 10 hours
- 25°C
Effect of Loading Rate on Binder Selection

- Example
  - for toll road: PG 64-22, 90 kph (90 km/h)
  - for toll booth: PG 70-22
  - for weigh stations: PG 76-22, Slow (Stopping)

Effect of Traffic Amount on Binder Selection

- 10 - 30 x 10^6 ESAL
  - Consider increasing - - one high temp grade
- 30 x 10^6 + ESAL
  - Recommend increasing - - one high temp grade

<table>
<thead>
<tr>
<th>Avg 1-day Max, °C</th>
<th>PG 46</th>
<th>PG 52</th>
<th>PG 58</th>
<th>PG 64</th>
<th>PG 70</th>
<th>PG 76</th>
<th>PG 82</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-day Min, °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ORIGINAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG Binder/Crude Impact</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Is a PG a Modified Binder?**

Effect of Loading Rate  Reliability

"Rule of 90"

PG 64-34 > 64 - 34 = 98

Probably modified !!

( Depends on Asphalt Source!)

PG Binder/Crude Impact

<table>
<thead>
<tr>
<th>High Temperature, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>34</td>
</tr>
<tr>
<td>40</td>
</tr>
</tbody>
</table>

- Crude Oil
- High Quality Crude Oil
- Modifier Required
When should a modified binder be specified?
- In extreme climatic conditions (very hot or very cold)
- In very heavy traffic conditions, especially when loading is slow or stopped
- In problem situations where rutting, shoving, instability is occurring
- Where improved elastic properties are needed (i.e. resistance of reflective cracking)
- To provide for thicker binder film thickness in open graded and gap graded mixes

Modified PG Binders
- Many different types of modified binders
  - elastomers (Stylink, Citgoflex, others) - SBS, SBR
  - plastomers (Novophalt, Vestoplast, others)
  - gelled (Multigrade)
  - blown, oxidized
- Little performance history with some modifiers
- Use of modified binder grades will increase cost (materials cost $2 - $5/ton of mix)

Effect of RAP % on Binder Selection
- RAP contains aged, oxidized asphalt binder
  - a “softer”, virgin asphalt binder must be added to get correct blended binder grade
  - grade of virgin binder depends upon:
    - hardness of old binder in RAP
    - percentage of RAP to used in HMA mix
    - desired grade of blended asphalt binder

Which PG asphalt should perform best in resisting thermal cracking?
- PG 64-22
- PG 76-22
- PG 64-28
- PG 58-34

Which PG asphalt should perform best in resisting thermal cracking?
- PG 64-22
- PG 76-22
- PG 64-28
- PG 58-34

Which of the following PG binders should perform best in resisting rutting?
- PG 82-22
- PG 76-28
- PG 70-28
- PG 76-22
Asphalt Materials

North Dakota QC/ QA Introduction

Chapter 2

Which of the following PG binders should perform best in resisting rutting?

- PG 82-22
- PG 76-28
- PG 70-28
- PG 76-22

Which of the following PG binders has been modified?

- PG 64-22 84 No
- PG 64-28 92 Maybe (yes in SD)
- PG 70-28 98 Yes
- PG 58-34 92 Maybe (yes in SD)

PG Binders Used in North Dakota

- PG 58-28 Standard Grade
- PG 64-22 Rutting is Concern
- PG 64-28 Interstate/Hi Vol.
- PG 70-28 Interstate/Hi Vol.
- PG XX-34 New Construction/Reconstruction

PG Binders Used in North Dakota

- Modified Binders
  - MS-1
  - MSCR (AASHTO TP-70)
- Reclaimed Asphalt Pavement (RAP)
  - DOT is allowing the use of RAP on a specific projects...Noted in Plans
  - Source, % RAP and Binder Grade specified on plans; Generally 20% Maximum

2014 In Review

- 1,600,699 tons of HBP
  - Class 27 1,872 tons
  - Class 29 54,987 tons
  - Class 31 652 tons
  - Class 33 0 tons
  - Superpave 1,542,616 tons
  - Patching 572 tons

Quantity of HBP

Tons

Year


Chapter 2

8
2014 In Review
- 79,445 tons of asphalt cement
  - PG 58-28: 59,500 tons
  - PG 58-34: 203 tons
  - PG 64-28: 15,370 tons
  - PG 64-34: 1,534 tons
  - PG 70-28: 2,838 tons

Method of Acceptance for Asphalt Binders
- Combined State Binder Group
- States Participating: ND, SD, IA, NE, MN, WS
- “Supplier” is certified to supply binder in any/all states in group (approved list)
- Supplier tests and certifies binder grade based on approved testing program
- Certification statement on shipping ticket
- NDDOT obtains samples for monitor testing at minimum rate in NDDOT 1, *Sampling of Bituminous Materials*

Performance Graded Binders
LTPPBIND software to identify appropriate binder grade at weather stations nationwide based on climate data…also has procedure to change selected binder grade based on traffic volume and traffic speed.

The most recent version of LTPPBIND software can be downloaded from the FHWA Turner-Fairbanks website:
http://www.tfhrc.gov/pavement/ltpp/ltppbind.htm

For More Information See

Questions???
Mineral aggregate has a great influence on the performance of an asphalt pavement as aggregates comprise 90 to 96 percent of the mixture weight and/or 82 to 88 percent of the aggregate volume.

Aggregates are also referred to as rock, granular material, mineral aggregate. Aggregates consist of any hard, inert mineral used in the production of hot mix asphalt.

Rock materials are divided into three main categories descriptive of the mode of deposition:
- **Sedimentary** - water or wind-borne fine-grained particles precipitated in layers
- **Metamorphic** - Sedimentary or igneous rock that have been changed by intense pressure and/or heat within the earth
- **Igneous** - molten material (magma) that has cooled and solidified

Aggregates in Asphalt Construction

Geology of ND

Aggregates in Asphalt Construction

Synthetic Aggregates - product or by-product of chemical or physical process:
- Ore Refining - Bingham Chat
- Blast-furnace Slag
- Clay Clinker - Fired clay

Advantages:
- High resistance to wear (skid resistance)
- Creates VMA
- Productive use of waste products
- Light weight (Chip seal chips)
Aggregates in Asphalt Construction

- Aggregate Sources
  - Natural Aggregates (Sand or Gravel) with little or no processing required prior to use
    - Glacial Materials - eskers, kames, kettles, drumlins
    - Alluvium - glacial terraces, bank deposits, bars
    - Sand Dune - blow sand
  - Processed aggregates require processing; i.e., crushing, sizing, and/or washing to remove fines prior to use
    - Natural Pit Materials
    - Quarry Bedrock

Aggregates in Asphalt Construction

- Aggregate Sources
  - Reasons for crushing rock
    - To reduce size
    - To improve particle distribution
    - To change surface texture to rough
    - To change particle shape to angular

Chapter 3
Aggregates in Asphalt Construction

- Reasons for washing rock
  - To remove clay adhering to rock surface
  - To remove crusher dust

Aggregate Properties

- Aggregate Gradation
  - Two methods of performing test
    - Dry sieve Analysis (ASTM 136/AASHTO T 27)
    - Wet sieve Analysis (ASTM 117/AASHTO T 11)
  - Three methods of reporting results
    - Percent passing
    - Percent retained
    - Percent passing/retained

Standard Aggregate Sieves

- 50 mm (2")
- 37.5 mm (1-1/2")
- 25 mm (1")
- 19 mm (3/4")
- 12.5 mm (1/2")
- 9.5 mm (3/8")
- 4.75 mm (1/4")

- 2.36 mm (1/8")
- 1.18 mm (#16)
- 0.60 mm (#30)
- 0.30 mm (#50)
- 0.15 mm (#100)
- 0.075 mm (#200)

Chapter 3
Chapter 3

Aggregate Properties

- Aggregate Gradation
  - Determined from a sieve analysis
- Aggregate Fractions
  - Coarse aggregate - Mat'l retained by the No 8 sieve
  - Fine aggregate - Mat'l passing the No 8 sieve
  - Mineral filler - Fraction passing No 30 sieve
  - Mineral dust - Fraction passing the No 200 sieve

Aggregate Properties

- Aggregate Gradation
  - Results typically presented in graphical form
  - Semi-log chart
  - 0.45 power chart

0.45 Power Grading Chart

Example:

4.75 mm sieve plots at \((4.75)^{0.45} = 2.02\)

Purpose of Superpave Gradation Requirements

- Use of 0.45 Power Chart
- achieve VMA
- Control Points
  - define mix types
- Restricted Zone
  - prevent excess of fine sand in relation to total sand
- Develop Tough Stone Skeleton
ND QC/QA Introduction to Asphalt

Chapter 3

Typical Superpave (Gyratory) Mixes

<table>
<thead>
<tr>
<th>Percent Passing</th>
<th>100</th>
<th>100</th>
<th>90</th>
<th>72</th>
<th>65</th>
<th>48</th>
<th>36</th>
<th>22</th>
<th>15</th>
<th>9</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size, mm, Raised to 0.45 Power</td>
<td>.075</td>
<td>.3</td>
<td>2.36</td>
<td>6.75</td>
<td>19</td>
<td>25</td>
<td>48</td>
<td>72</td>
<td>90</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Aggregate Size Definitions

- **Nominal Maximum** Aggregate Size
  - One size larger than the first sieve to retain more than 10%

- **Maximum** Aggregate Size
  - One size larger than nominal maximum size

- Both definitions are based on the standard ASTM sieve nest

Superpave Size Designations

<table>
<thead>
<tr>
<th>Superpave Designation</th>
<th>Nom Max Size, mm</th>
<th>Max Size, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 mm</td>
<td>37.5</td>
<td>50.0</td>
</tr>
<tr>
<td>25.0 mm</td>
<td>25.0</td>
<td>37.5</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>19.0</td>
<td>25.0</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>12.5</td>
<td>19.0</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>9.5</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Aggregate Properties

The suitability of an aggregate for use in asphalt construction depends on the following:

- Maximum particle Size
- Specific Gravity
- Toughness
- Absorption (Affinity for asphalt binder)
- Moisture Susceptibility
- Gradation (Particle size distribution)
- Cleanliness or clay content
- Particle shape and surface texture

Aggregate Properties

- **Cleanliness**
  - Limits must be placed on the amount of foreign or deleterious substances in the aggregate
  - Vegetation
  - Shale
  - Soft particles
  - Clay lumps
  - Clay coatings on coarse aggregates

Chapter 3
Aggregate Properties

- Toughness
  - An estimate of the crushing and/or abrasion aggregates experience during transportation, mixing, placement, and/or service loads
  - Surface -vs- lower layer toughness requirements
  - Influence of type of traffic to be using the pavement
  - Availability of local materials
  - Measured by the Los Angeles Abrasion Test (ASTM 131 or C53/ AASHTO T 96)

Los Angeles Abrasion Loss

AASHTO T 96 *
Or ASTM C131
- Maximum Loss:
  - Asphalt Institute
    - 45%
  - McLeod
    - <26 for high traffic
    - <35 for medium to low traffic

Aggregate Properties

- Surface texture
  - Rough surface increases mixture strength
  - Smooth surfaces produce “sliding effect”
  - Asphalt binders will typically adhere better to a rough textured surface
  - Surface texture will influence workability of the mixture

Aggregate Properties

- Particle shape
  - Also influences workability and compaction
  - Particle interlock, which produces higher mix strength, is higher with cubical shapes and lower for rounded particles
  - Percent crushing requirements (coarse/fine)

Aggregate Properties

- Affinity for asphalt
  - Hydrophobic -vs- hydrophilic
  - Stripping
    - Separation of the asphalt from the surface of the aggregate through the action of water
    - Liquid anti-strip additive
    - Hydrated lime

Aggregate Properties

- Absorption
  - Porosity of aggregate causes absorption of both water and asphalt binder
  - Additional amounts of asphalt binder needed
  - Additional drying time for mixing
  - Slag and other synthetic materials tend to be more absorptive than natural aggregates

Chapter 3
Superpave Aggregate Criteria

Aggregate Properties

- Consensus Properties
  - coarse aggr angularity
  - fine aggr angularity
  - flat, elongated particles
  - clay content
- Source Properties
  - toughness
  - soundness
  - deleterious materials

Coarse Aggregate Angularity

- Measured on + 4.75 mm material
- Based on Fractured Faces
  - fractured surface larger than 25% of aspect ratio
- Use Standard DOT Procedures
- Requirements Depend on
  - position within pavement
  - traffic level

Flat, Elongated Particles

- Measured on + 4.75 mm Material
- Based on Dimensional Ratio of Particles
  - max to min dimension < 5
- Use ASTM D4791
- Requirements Depend on
  - traffic level

Flat, Elongated Particles

- Measured on - 2.36 mm Material
- Based on Air Voids in Loose Sample
- Use NAA Procedure (Method A)
  - weight/volume measurement
- Requirements Depend on
  - position within pavement
  - traffic level

Chapter 3
Fine Aggregate Angularity

Clay Content

- Measured on - 4.75 mm Material
- Based on Sand Equivalent Value
- Use AASHTO T176
- Requirements Depend on traffic level

Sand Equivalent (AASHTO T176)

Selection Based on Economics

Thought Process in Selection of Aggregate
- Proximity to Plant and/or Job-Site and Unit Cost
- Pre-Bid Testing for Viability
- Previous Use of Aggregate- Prior to Superpave
- Previous Use of Aggregate on Superpave Project
- Competitors Use of Given Aggregate Sources on Superpave Project

Questions?

Thank You!
Project Selection and Preparation for Paving

North Dakota Department of Transportation
TTCP
Introduction to Asphalt

**PROJECT SELECTION**

- NDDOT Problem: more needed road repairs than available funding
- Which roadways are selected for work?
- What type of work?
  - routine or preventive maintenance?
  - thin overlay?
  - rehabilitation?
  - reconstruction?
- What level of surface preparation?

---

**Project Selection**

- Consider all of the following when choosing the best alternative:
  - pavement distress type
  - pavement distress amount
  - pavement distress severity
  - pavement smoothness
  - structural adequacy
  - initial cost
  - “life cycle” cost

---

**Pavement Distress**

- Typical surface problems
  - Cracking
  - Potholes
  - Surface deformation
  - Surface defects

---

**Pavement Distress**

- Causes of surface problems
  - Improper thickness design
  - Improper mix design
  - Poor subgrade/base support
  - Traffic higher than expected
  - Lack of maintenance
  - Time and environment

---

**Pavement Distress**

- Solutions
  - Depend on both the type of distress and severity of problem
  - Proper routine maintenance minimizes future problems and reduces cost
  - Distress identification is critical

Chapter 4
**Structural Adequacy**

Is pavement structure adequate to handle future traffic volume and loading?

**Structural analysis** is performed routinely for new construction!

But…should be performed on overlay and rehabilitation projects, too.

How is a structural analysis done?

---

**Thickness Design Methods**

- **AASHTO Thickness Design**
  - Used by most state DOTs
  - Based on structural number concept

- **AASHTO MEP Design Guide**
  - Future design method closing on ratification
  - Based on mechanistic design principles

- **Asphalt Institute**
  - SW-2
  - For pavements on highways, airports, HWL

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**Structural Number Concept**

Hot Mix Asphalt Surface

Hot Mix Asphalt Base

Aggregate Base

Soils / Subgrade

---

**Structural Number Concept**

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Structural Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>.44</td>
</tr>
<tr>
<td>9&quot;</td>
<td>.14</td>
</tr>
<tr>
<td>16&quot;</td>
<td>.11</td>
</tr>
</tbody>
</table>
Structural Number Concept

- Total structural number based on
  - number of equivalent loads over design period
  - subgrade support
- Structural number coefficients based on
  - Materials Type
  - Materials Condition
    » May be reduced for existing pavements with distress

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Coefficient</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot;</td>
<td>0.44</td>
<td>1.76</td>
</tr>
<tr>
<td>9&quot;</td>
<td>0.14</td>
<td>1.26</td>
</tr>
<tr>
<td>16&quot;</td>
<td>0.11</td>
<td>1.76</td>
</tr>
</tbody>
</table>

Structural Analysis

- Factors to consider in a structural analysis
  - traffic loading
    » present
    » future
    » total over design life (ESALs)
  - existing pavement condition
  - soils type and support values

Mechanistic Design

High Strain = Short Life
Low Strain = Long Life

Which Mix Types?

- Mix Types Based On
  - design thickness requirements
  - traffic
  - function
  - economics
- Mix Types Include
  - fine- and coarse-graded dense, OGFC, SMA
  - nominal maximum sizes

Pavement Layer Definitions

- Surface Layer
  - considerations: friction, smoothness, permeability, durability, stability, noise, drainage
- Intermediate Layer
  - also referred to as Binder Course
  - resist permanent deformation and distribute loads
- Base Course
  - HMA or Aggregate
- Leveling Course
  - to correct profile prior to HMA overlay
## Mixture Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense-Graded</td>
<td>- coarse and fine</td>
</tr>
<tr>
<td>Gap Graded</td>
<td>- Stone Matrix Asphalt (SMA)</td>
</tr>
<tr>
<td>Open Graded</td>
<td>- Open Graded Friction Course (OGFC)</td>
</tr>
</tbody>
</table>

## Types of Gradations

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniformly graded</td>
<td>- Few points of contact</td>
</tr>
<tr>
<td></td>
<td>- Poor interlock (shape dependent)</td>
</tr>
<tr>
<td></td>
<td>- High permeability</td>
</tr>
<tr>
<td>Well graded</td>
<td>- Good interlock</td>
</tr>
<tr>
<td></td>
<td>- Low permeability</td>
</tr>
<tr>
<td>Gap graded</td>
<td>- Only limited sizes</td>
</tr>
<tr>
<td></td>
<td>- Good interlock</td>
</tr>
<tr>
<td></td>
<td>- Low permeability</td>
</tr>
</tbody>
</table>

### Dense Graded Mixes

- Even Distribution of Aggregate Particle Sizes
- Majority of ND HMA Mixes
- Nominal Maximum Size Definition
  - One Sieve Size Larger Than First Sieve to Retain >10%

### Layer Thickness

Determined by NMPS

Never less than 3 x NMPS !!

## PREPARATION FOR PAVING

The performance of a hot mix asphalt pavement is directly related to the condition of the surface on which it is constructed.
### Surface Preparation

- Various categories of surface preparation
  - Subgrade for full depth asphalt
  - Granular base for deep strength asphalt
  - Existing asphalt pavement overlay
  - Existing pcc pavement overlay

#### Asphalt overlay

- Primary purposes
  - Correct surface irregularities
  - Add structural capacity

#### Surface Preparation

- Extent of preparation needed is a function of the condition of the existing surface
  - Failed areas removed and replaced
  - Patch potholes
  - Clean and fill cracks
  - Repair ruts

#### Surface Preparation

- Attempting to bridge with thin overlay is not wise
  - Failed areas should be removed
  - Cut back to sound pavement
  - Vertical sides - tack edges and bottom of excavation
  - Excavate down to firm base/soil
  - Correct drainage problems
  - Replace removed materials - COMPACTION!
  - Greater than 4” - replace in lifts

#### Surface Preparation

- Crack filling
  - Block or alligator cracks - remove and replace
  - Fill cracks wider than 3/8”
  - Can use router
  - Clean cracks of debris - air blowing
  - Fill cracks with ASTM D3405 material
  - Level of filler slightly below surface

#### Surface Preparation

- Tack coat
  - Ensures bond between existing surface and overlay
  - Slippage can occur without bond
  - Surface must be clean
  - Applied to faces of curbs, gutters, cold joints, structures
  - Apply to warm surface - 80°F
  - Overlay placed after tack “breaks”

---

Chapter 4
**Tack coat (cont.)**
- Typically asphalt emulsion is used
  » CSS-1, 1h or SS-1, 1h
  » Dilute emulsion 1:1 with water
  » Apply 0.05 to 0.15 gal/yd² dilute emulsion
  » Residual of 0.02 to 0.05 gal/yd²
  » Too much vs. too little
  » Temperature 70°F - 160°F

\[(\text{Rate}/2) \times 0.65\]

**Cold milling**
- Also called cold planing
- Used in place of leveling course
  » Removes high points in surface
- Mills 6 in. to 13 ft.
- Automatic grade and slope controls
- Produces RAP for HMA recycling
- Increases surface texture

**Cold milling (cont.)**
- Reduces structural capacity
- Repair uncovered problems
- Surface is typically dusty
  » Clean with broom and/or flush with water
- More tack may be required
  » 0.15 to 0.25 gal/yd² dilute emulsion
  » 0.05 to 0.08 gal/yd² residual asphalt

**pcc pavement overlay**
- Full depth replacement of distressed slabs
  » Asphalt or pcc patch
  » Correct problems in base/subgrade
- Spalled joints repaired partial depth
  » Use pcc for patching
- Stabilize rocking slabs
- Replace joint sealer as required
- Clean and tack surface
- Crack & Seat, Rubblizing, Saw & Seal, Crack Relief Layer

**Rarely gets due consideration**
- It is often time consuming and labor intensive
- Asphalt layers cover up the potential problems
- THE PROBLEMS WE DO NOT TAKE CARE OF TODAY WILL NOT GO AWAY
  » Often the problems get worse
  » They are more costly to fix the second time

Questions ???
Basic Purpose Of HMA Plants

To produce a quality hot asphalt mixture that contains the desired proportions of asphalt and aggregate.

BASIC FUNCTIONS:
Drying, Heating, Mixing

Basic Operations are the Same

- Storage and handling of the materials
- Aggregate proportioning and feeding
- Drying and heating of the aggregate
- Control and collection of dust
- Proportion and mix asphalt with aggregate
- Store and dispense finished HMA

Storage and handling of the materials

The 3 A’s

- Aggregate
- Asphalt
- Air
Aggregate Storage and Handling

Aggregate storage operations must address:

- Segregation
- Degradation
- Contamination

Care must be taken when charging the plant directly from the crusher or active stockpile.

Asphalt Storage and Handling

- Storage tanks must be heated
- Large enough to minimize disruption
- Vertical mixing tanks for PMA
- Multiple tanks for multiple grades
- Sampling Valves
- Tanks should be calibrated to allow for content determination

Permanent plant asphalt storage

50,000 gal. portable plant storage tank

Think Safety!
Cold Feed Aggregate Proportioning

The purpose of the cold feed system is to accurately and uniformly combine the various aggregate stockpiles into a composite blend that meets the mix design specifications.

Variable Speed DC motors on feed belts

Gathering / Collector Belt

All aggregate feed bins are adjusted and monitored from the control shack.

Collector belt delivers proportioned aggregate to scalping screen.

Basic Elements of a Batch Plant

Batch Tower
Hot Elevator
Aggregate Cold Feed
Pugmill Mixer
Counter Flow Dryer

Batch Plants
Screen Deck

Aggregates are individually weighed from the Hot Bins

1. The discharge gate of an aggregate bin is opened and the aggregate drops into the weigh box.
2. When the scale reading reaches a preset weight, the discharge gate is closed.
3. The discharge gate of the next aggregate bin is opened.
4. When the scale reading reaches a preset weight, the discharge gate is closed.
5. These steps are repeated for the remaining aggregate bins and the mineral binder.

Hot bin feed % is different than the cold feed bin %

Pug Mill

The exact weight of asphalt is added to each batch

TRUCK BEING LOADED FROM A DIRECTLY FROM A BATCH PLANT
All batching activities are automatically controlled.

**Drum Plants**

Drum Plants do not have a batch tower.

- RAP Entry point
- Aggregate Cold Feed
- Parallel Flow Dryer
- HMA
- Burner

Maintaining a uniform veil of aggregate in the drum is essential in obtaining efficient heat transfer.

**Veil pattern is very critical**

**Drum Plant Silo System**

**HMA Delivery**

- Paver pulls up to meet the truck – DON'T BUMP THE PAYER!
- Charge the hopper before it's empty
Break the load before opening tailgate

Paving Equipment

Paving Machine Components
- Tractor unit
- Screed
- Electronic grade controls

Tractor and Screed Units

Forces Acting on Screed

Chapter 5
Automatic Screed Controls

- Electronic adjustment to screed height using sensing and reference system
- Sensor detects elevation changes, adjusts height of tow point
- Slope (transverse) controls

Paving Operations

- Maintain uniform resistance to face of screed!
  - Keep paver in motion 75% of the time
  - Keep augers turning 85% of the time
- Coordinate mixture delivery, paver speed and compaction operations

Compaction

The process of compressing a material into a smaller volume while maintaining the same mass.

Compaction

- Essential to good performance!
- Need to compact to desirable air voids level
  - conventional dense-grade mixtures: 4-8%
  - gap-grade mixtures: 3-6%
- Compaction can only be achieved if:
  - mixture is confined
  - mixture is hot (workable)

Compaction Equipment

- Screed unit on paver
  - weight of screed
  - tamping/vibratory unit
- Rollers
  - vibratory steel-wheeled
  - static steel-wheeled
  - pneumatic
Static Steel-Wheeled Rollers

- 10-14 ton rollers normally used for HMA compaction
  - Commonly use vibratory rollers operated in static mode
- Lighter rollers used for finish rolling
- Drums must be smooth and clean
- For initial compaction, drive wheel must face paver

“Three-Wheel” Static Roller

Pneumatic-Tired Rollers

- Reorients particles through kneading action
- Load/tire: 1050 – 6730 #/tire depending on model/ballast
- Tire pressures:
  - ~70 psi (cold) for compaction
  - ~50 psi (cold) for finish rolling
- Tires must be hot to avoid pickup
- Not used for open-graded mixes or SMA

Dynapac CP 132
- 5-13 tons
- 69 inch width

Dynapac CP 271
- 12-30 tons
- 93” width

Pneumatic as Breakdown Roller

Vibratory Rollers
Amplitude & Frequency

- Time between blows
- Amplitude

Impacts per Foot of Travel
Vibratory Rollers

<table>
<thead>
<tr>
<th>VPM</th>
<th>2 mph</th>
<th>2.5 mph</th>
<th>3 mph</th>
<th>3.5 mph</th>
<th>4 mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>11.4</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2500</td>
<td>14.2</td>
<td>11.4</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3000</td>
<td>17.0</td>
<td>13.6</td>
<td>11.4</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3500</td>
<td>19.9</td>
<td>15.9</td>
<td>13.3</td>
<td>11.4</td>
<td>10.0</td>
</tr>
<tr>
<td>4000</td>
<td>22.7</td>
<td>18.2</td>
<td>15.2</td>
<td>13.0</td>
<td>11.4</td>
</tr>
</tbody>
</table>

Rolling Pattern

- Speed & lap pattern for each roller
- No. of passes for each roller
- Min. temperature by which each roller must complete pattern

**IMPORTANT:**
Paver speed must not exceed that of the compaction operation!!!

In Conclusion

One word sums up what it takes to build a quality asphalt pavement ……

**Uniformity !!!**

Thank You!

Questions ???

Chapter 5
QUALITY CONTROL/QUALITY ASSURANCE

QC/QA in Pavement Construction

ACCEPTANCE (COMPLIANCE) CRITERIA

Common factors used for acceptance of materials and finished pavements

ACCEPTANCE CRITERIA

- Depends on type of specifications used
  - Method - Recipe
    - Spells out equipment, materials, methods, etc.
  - End result
    - Stresses testing not inspection
  - Quality Assurance
    - Statistically based contractor testing
  - Performance based
    - Emphasizes performance not construction
  - Warranties

TRADITIONAL ACCEPTANCE CRITERIA

- Materials
  - Asphalt binder properties
  - Aggregate gradation
  - Aggregate properties
  - Asphalt content
  - Pavement density
  - Pavement smoothness

QUALITY ASSURANCE PROGRAM

- Required on all Federal-aid highway construction projects on the NHS (23 CFR 637).
- Implementation to begin by 1997.

THE SEVEN ELEMENTS OF A QA PROGRAM
QUALITY ASSURANCE PROGRAM
The core elements of a QA program include:
- Contractor QC
- Agency Acceptance
- Agency Independent Assurance
- Specifications
- Dispute resolution
- Laboratory accreditation and qualification
- Personnel qualification and certification

QUALITY CONTROL

Definition
The system used by a contractor to monitor, assess, and adjust processes to ensure that the final product meets the specified level of quality

CONTRACTOR RESPONSIBILITY FOR QUALITY CONTROL
Under a proper QA program, responsibility for QC is assigned to the contractor

SCOPE OF QC ACTIVITIES
- QC Key Activities:
  - Materials production and transportation
  - Field placement processes
- QC Processes:
  - Sampling and testing
  - Inspection
  - Material storage and stockpiling

AGENCY RESPONSIBILITY FOR ACCEPTANCE
- All Acceptance decisions must be made by the agency
- Contractor QC data may be included in the final Acceptance determination

SCOPE OF ACCEPTANCE ACTIVITIES
Primary Acceptance activities include:
- Monitoring the contractor’s QC activity
- Acceptance sampling and testing
- Agency inspection
  Evaluating product quality
ND QC/QA FOR HOT MIX ASPHALT (HMA)

- Standard Specification Section 430
- Superpave Mix Design & Control Method
- Six Traffic Levels: FAA 40 – 45
- Commercial Grade Asphalt Added

- Special Provision for Marshall Design & Control Method
  - Marshall Hammer Specimen
  - Four Traffic Levels: Class 27, 29, 31 & 33

QC/QA TESTING ALLOWS INCREASED TESTING TO ASSURE PERFORMANCE PROPERTIES ARE MET.

THE KEY TO SUCCESSFUL TESTING IS -

- Random sampling
  - Any portion of the population has equal chance of being selected
  - Bias is introduced when judgment is used
  - Attempts to include “good and bad” samples
  - Use random number tables

NDDOT TABLE OF RANDOM NUMBERS

<table>
<thead>
<tr>
<th>Random Numbers</th>
<th>Utilized in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate and Mixture Sampling</td>
<td></td>
</tr>
<tr>
<td>Core Locations for Density Testing</td>
<td></td>
</tr>
</tbody>
</table>

PURE RANDOM SAMPLING

LOT = Days Paving

Random Sampling

Samples generally spread throughout the area (population) to be sampled
5 Samples (Sublots) per Lot
Chapter 6

**PURE RANDOM SAMPLING**

Clipped samples are also possible and undesirable

**ND QC/QA USES STRATIFIED RANDOM SAMPLING**

**QC/QA**

- Goals/Success
  - Improve Pavement Quality ~ Improve Pavement Performance
  - “You Get What You Measure”
    - Aggregate – Physical Descriptor & Qualitative Requirements
    - Asphalt Binder – Performance Graded Specifications
    - Mixture – Stability & Durability
    - Pavement – Ride Quality, Density & Uniformity

QUESTIONS?