Asphalt Mixture Essentials

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Asphalt Testing Solutions & Engineering
Objectives

- Materials of an Asphalt Mixture
  - Asphalt Binder
  - Aggregates
  - Recycled Materials
- Asphalt Mixtures
- Addressing the Issues
- Asphalt Essentials
Materials of Asphalt Mixtures

**Asphalt Binder**
- Makes up 4 to 7% of the mixture weight
- Acts as the “glue” or “muscle” of the mix
  - Flexibility
  - Durability

**Aggregate**
- Makes up 93 to 96% of the mixture weight
- Acts as the skeleton of the pavement mixture
  - Skid resistance
  - Stability
  - Workability
Materials - Asphalt Binder

What is it?
- a.k.a. Asphalt, Bitumen, Oil, Binder
- Petroleum by-product

Where does it come from?
- Gilsonite
- Tar Sands
- Trinidad Lake Pitch
- Refined Crude Oil
Materials – Asphalt Binder

• Crude is pumped from ground
• Transported to refinery
• Undergoes Fractional distillation
  • Crude is heated to drive off the volatiles or lighter products
  • First atmospheric and then under vacuum (prevents cracking)
• What is left over after vacuum distillation is used as a feedstock for asphalt

Asphalt is manufactured from crude oil
Materials – Asphalt Binder

Pavements see many temperatures and loads

Heavy Trucks
Materials – Asphalt Binder

Grading system based on climate

**PG 67-22**

- Performance Grade
- Average 7-day max pavement design temp
- Min pavement design temp
**Performance Grades**

<table>
<thead>
<tr>
<th>Max. Design Temp.</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>
</table>

### Original

- **≥ 230 °C**
  - Flash Point

- **≤ 3 Pa-s @ 135 °C**
  - Rotational Viscosity

- **≥ 1.00 kPa**
  - DSR G*/sin δ (Dynamic Shear Rheometer)
    - 46
    - 52
    - 58
    - 64
    - 70
    - 76
    - 82

### (Rolling Thin Film Oven) RTFO, Mass Change < 1.00%

- **≥ 2.20 kPa**
  - DSR G*/sin δ (Dynamic Shear Rheometer)
    - 46
    - 52
    - 58
    - 64
    - 70
    - 76
    - 82

### (Pressure Aging Vessel) PAV

- **20 hours, 2.10 MPa**
  - DSR G*/sin δ (Dynamic Shear Rheometer)
    - 90
    - 90
    - 100
    - 100
    - 100(110)
    - 100(110)
    - 100(110)

- **≤ 5000 kPa**
  - DSR G*/sin δ (Dynamic Shear Rheometer)
    - 10  7  4  25  22  19  16  13  10  7  25  22  19  16  13  31  28  25  22  19  37  34  31  28  40  37  34  31  28

- **S ≤ 300 MPa m ≥ 0.300**
  - BBR S (creep stiffness) & m-value (Bending Beam Rheometer)
    - -24  -30  -36  0  -6  -12  -18  -24  -30  -36  -6  -12  -18  -24  -30  0  -6  -12  -18  -24  0  -6  -12  -18  -24

**If BBR m-value ≥ 0.300 and creep stiffness is between 300 and 600, the Direct Tension failure strain requirement can be used in lieu of the creep stiffness requirement.**

- **ε₁ ≥ 1.00%**
  - DTT (Direct Tension Tester)
    - -24  -30  -36  0  -6  -12  -18  -24  -30  -36  -6  -12  -18  -24  -30  0  -6  -12  -18  -24  0  -6  -12  -18  -24
Materials – Asphalt Binder

Certificate of Analysis (COA)

- Document issued by Liquid Supplier that confirms that the product meets the noted specification.
STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

ASPHALT MIX DESIGN - SP 17-15140A (TL-C)

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Name</th>
<th>Production Facility</th>
<th>Plan/Mine</th>
<th>Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>334- CRUS-ED</td>
<td>Crushed RAP Stockpiles</td>
<td>C-12</td>
<td>Duval Asphalt Products, Inc.</td>
<td>0216</td>
<td></td>
</tr>
<tr>
<td>C52</td>
<td>5.18 Stone</td>
<td>Aggregate USA</td>
<td></td>
<td>GA175</td>
<td></td>
</tr>
</tbody>
</table>

Total Binder Content 5.5 %
Gmb @ Ndes 2,386
Gmm 2,485

Ignition Oven Corr. Factor 0.00
Gmm Corr. Factor -0.002
Mixing Temp. 305 °F (Plant)
Compaction Temp. 305 °F (Roadway)
Spread Rate @ 1" 108 lb/yd²
P-200/Pbe 1.2

Binder from Recycled Materials 2.44 %
PG 52-28 to be added 3.06 %
Additives

Effective Date 1/17/2017
Expiration Date 1/17/2020
Materials - Asphalt Binder

Modified or Engineered Binders

- Polymers
- Chemical Additives
- Ground Tire Rubber
- Softening Agents
Materials - Aggregate

Sedimentary - Sandstone

Igneous - Granite

Metamorphic - Quartzite
Materials - Aggregate

**Physical**
- Specific Gravity & Absorption
- Angularity
- Particle Shape
- Sand Equivalent
- Methylene Blue
- Deleterious Materials
- Gradation

**Mechanical**
- Hardness
- Soundness
- Polish Susceptibility

- Chemical
- Surface Charge
Materials - Aggregate

- Cubical
- Angular
- “Good” Surface Texture
- Resist breakdown
- Withstand environmental conditions
- Clean
- Surface Chemistry
Materials – Aggregate

- Aggregate Sources used in asphalt
- Aggregate Suppliers will provide Certified Test Report

- Aggregate mines
- Aggregate terminals
Materials - Aggregates

- Oolitic Limestone
- Granite
Designation: C641 – 17

Standard Test Method for Iron Staining Materials in Lightweight Concrete Aggregates

This standard is issued under the fixed designation C641; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers the testing of lightweight concrete aggregates to evaluate the potential degree of staining from iron compounds.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound values given in parentheses are provided for information only.

1.3 This standard does not purport to address the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.4 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

C702/C702M Practice for Reducing Materials to Testing Size
D75/D75M Practice for Sampling
E11 Specification for Woven Wire Cloth Sieves
E832 Specification for Laboratory Filter Papers

3. Terminology

3.1 Definitions:
3.1.1 For definitions of terms used in this test method, refer to Terminology C125.

4. Significance and Use

4.1 This test method evaluates the potential degree of staining attributable to the presence of iron compounds in a lightweight aggregate sample primarily by means of a visual classification method. Such compounds may or may not produce stains on the surface of the concrete in which the aggregate is incorporated.
Materials – Recycled Materials
Materials – Recycled Materials

Recycled Asphalt Pavement (Milled Material)
# Materials – Recycled Materials

## Table 334-2
Asphalt Binder Grade for Mixes Contains RAP

<table>
<thead>
<tr>
<th>Percent RAP</th>
<th>Asphalt Binder Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 15</td>
<td>PG 67-22</td>
</tr>
<tr>
<td>16 – 30</td>
<td>PG 58-22</td>
</tr>
<tr>
<td>&gt;30</td>
<td>PG 52-28</td>
</tr>
</tbody>
</table>

The bituminous material specification requirements are outlined in Section 916.
Asphalt Mixtures

Select Materials
- Binder
- Aggregates

Design Aggregate Structure

Design Asphalt Binder Content

Evaluate Moisture Sensitivity
Asphalt Mixtures

• Goal
  • Design mixtures having a **strong aggregate skeleton** for rut resistance
  • Enough (but not too much) asphalt and **air voids** for durability

• **Volumetric properties** form the basis for **aggregate gradation** and **asphalt binder selection**

• Good laboratory indicator of how mix will perform in the field
## Asphalt Mixtures

### SIEVE SIZE | JOB MIX FORMULA | CONTROL POINTS
--- | --- | ---
3/4" (19.0mm) | 100 | 100
1/2" (12.5mm) | 100 | 100
3/8" (9.5mm) | 99 | 89 – 100
No. 4 (4.75mm) | 74 | – 89
No. 8 (2.36mm) | 55 | 32 – 67
No. 16 (1.18mm) | 44 | 
No. 30 (600µm) | 37 | 
No. 50 (300µm) | 30 | 
No. 100 (150µm) | 14 | 
No. 200 (75µm) | 5.8 | 2 - 10

![Sieve Size Distribution Graph](image_url)
Asphalt Mixtures

Fine versus Coarse versus Porous Mixtures
Asphalt Mixtures

Basketball court at Celebration Dream Center paved by Duval Asphalt Products in 2018

www.wolfpaving.com/blog
Asphalt Mixtures

ASBA 2019
Asphalt Mixtures

- Select Materials
  - Binder
  - Aggregates

- Design Aggregate Structure

- Design Asphalt Binder Content

- Evaluate Moisture Sensitivity
Asphalt Mixtures

Tests the potential for a mixture to be damaged by the presence of moisture

\[
\text{TSR} = \frac{\text{Wet Tensile Strength (average)}}{\text{Dry Tensile Strength (average)}} \times 100 \geq 80\% 
\]
Select Materials
- Binder
- Aggregates

Design Aggregate Structure

Design Asphalt Binder Content

Evaluate Moisture Sensitivity
Asphalt Mixtures

• Modifiers
  • Fillers (Hydrated Lime, Portland Cement, Dust)
  • Fibers (Polyester, Polyolefin / Aramid, Cellulose, Mineral)
  • Recycled Materials (Recycled Asphalt Shingles, Tires, Glass, printer cartridges)

• Performance Driven

Asphalt Mixtures – Performance

• Smooth Surface & Structurally Sound

• Mixture
  • Stability – flow of mixture at unsupported edges
  • Stripping / Durability – not enough or loss of asphalt and/or aggregate
  • Cracking – Brittle, aged
  • Bleeding – excess asphalt, run-off, fat-spots
  • Compaction – high air voids → excess or trapped water – blistering; iron spots
Asphalt Mixtures

FDOT Asphalt Mixtures
- Superpave Asphalt Concrete (334)
  - Structural asphalt mixtures
  - SP-9.5,
- Asphalt Concrete Friction Courses (337)
  - FC-9.5, FC-12.5, FC-5 (OGFC)
- Superpave Asphalt Base (234)
  - B-12.5
- Asphalt Treated Permeable Base (ATPB) (287)
  - Used under PCC pavements

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<td>No. 100 (150µm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 200 (75µm)</td>
<td>2 - 10</td>
<td></td>
</tr>
</tbody>
</table>
# Asphalt Mixture

<table>
<thead>
<tr>
<th>Design Types</th>
<th>SI</th>
<th>12.5mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SIII</td>
<td>9.5mm</td>
</tr>
</tbody>
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## Asphalt Binder

<table>
<thead>
<tr>
<th></th>
<th>AC-20</th>
<th>PG 64-22</th>
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<tr>
<td></td>
<td>AC-30</td>
<td>PG 67-22</td>
</tr>
</tbody>
</table>
Addressing the Issues

**STABILITY**
- Consolidation
- Shoving / Lateral Movement

**DURABILITY**
- Raveling
- Loss of cohesion / adhesion

Shoving Photo Courtesy of Pavement Interactive – Pavement Distresses (https://www.pavementinteractive.org)
Addressing the Issues

Patching
• Still a defect
• Joints
• Roughness

Addressing the Issues

BLEEDING
Excess asphalt

Bleeding Photos Courtesy of Pavement Interactive – Pavement Distresses (https://www.pavementinteractive.org)
Addressing the Issues

Coarse Sand

Removing Excess


https://tracklessvehicles.com/Products/Concrete-Asphalt/Infrared-Asphalt-Heater

Caterpillar Motor Grader

Infrared Heat-Planer
Addressing the Issues

Trapped Water
- Bleeding or Flushing (Water)
- Pumping (Water and Fines)
- Blistering of asphalt & coatings
- Pyrite formation

→ Compaction
→ High Water Table
→ Poor Drainage

→ Water evaporation / Vapor Pressure
→ High Iron Content in Aggregate
Acrylic surface coating containing rust inhibitor

Addressing the Issues

✓ Depression / Rutting
✓ Stripping / Raveling / Potholes
✓ Bleeding
✓ Water Bleeding and Pumping

➢ Patching

• Alligator (Fatigue) Cracking
• Block Cracking
• Corrugation and Shoving
• Joint Reflection Cracking
• Longitudinal Cracking
• Polished Aggregate
• Slippage Cracking
• Transverse (Thermal) Cracking
Asphalt Mixtures – Essentials

• Mix Design
  • Type of Mix
  • Recycled Material
  • Type of Binder
  • Modifier

• Testing
  • Asphalt Content / Gradation

• Paperwork
  • Certificates of Analysis
  • Bill of Ladings
  • Certified Test Reports
Questions?

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