Asphalt Mixture Design – An Overview

Professor John Read
General Manager – Technology (Bitumen/Asphalt & Sulphur)
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OUTLINE

▪ Introduction

▪ Mixture Design Practices in:
  ▪ Europe
  ▪ Asia
  ▪ Africa (South Africa)
  ▪ Australasia
  ▪ South America

▪ To Conclude
ASPHALT MIXTURE DESIGN
METHODS OF ASPHALT MIXTURE DESIGN

- Recipe
- Empirical testing,
- Analytical computations,
- Volumetric method,
- Performance related testing, and
- Fundamental testing.
Attaining a Balance is the key
Mainstay is using the Marshall method for specimen preparation

Several elements of specimen preparation and performance characterization have evolved to becoming the accepted practices in many countries, notably:

- the French Gyratory Compactor (for SGC)
- the Hamburg Wheel Tracking Test (for all wheel tracking tests)
- The ITSM, ITFT and RLAT

Also the concepts of Performance based asphalt mixture design were followed in Europe earlier than elsewhere in the world notably the French method of asphalt mixture design.
<table>
<thead>
<tr>
<th></th>
<th>Wearing Courses</th>
<th>Binder Courses</th>
<th>Base Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Asphalt Mix</strong></td>
<td>SMA (5 types)</td>
<td>PA (3 types)</td>
<td>MA (6 types)</td>
</tr>
<tr>
<td><strong>Typical Grading</strong></td>
<td>0/5, 0/8, 0/11</td>
<td>0/8, 0/11, 0/16</td>
<td>0/5, 0/8, 0/11</td>
</tr>
<tr>
<td><strong>Bitumen Content M.-%</strong></td>
<td>6.6 - 7.4</td>
<td>5.5 - 6.5</td>
<td>6.8 - 7.5</td>
</tr>
<tr>
<td><strong>Bitumen Grade</strong></td>
<td>PMB 25/55-55</td>
<td>PMB 40/100-65</td>
<td>PMB 10/40-65</td>
</tr>
<tr>
<td><strong>Void content (Marshall) Vol.-%</strong></td>
<td>1.5 - 3.0</td>
<td>24 - 28</td>
<td>0</td>
</tr>
<tr>
<td><strong>Minimum layer thickness cm</strong></td>
<td>2 - 4</td>
<td>4.5 - 6</td>
<td>2 – 4</td>
</tr>
<tr>
<td><strong>Recycling?</strong></td>
<td>RAP &lt; 20 %</td>
<td>no RAP</td>
<td>RAP</td>
</tr>
</tbody>
</table>

**Typical Marshall designs with slight deviations in neighboring countries, e.g.:**

- Austria, Switzerland: Base courses with hard binders (Bitumen 10/20, PMB 25/55-65)
- Poland: base and binder courses with Bitumen 20/30
GERMAN METHOD OF FORMULATING AN ASPHALT MIXTURE

- Marshall Test: 3 binder contents or more, Marshall Flow and Stability to determine optimum binder content – EN 12697-34:

- Water sensitivity:
  - I.T.S.R. method – EN 12697-12/A

- Resistance to permanent load – EN 12697-22:
  - Hamburg Wheel Tracker, water, 50°C
  - Wheel Tracker – Small model, air, 60°C
FRENCH METHOD OF FORMULATING AN ASPHALT MIXTURE

• A performance based approach utilizing:
  • Volumetric method,
  • Performance related testing, and
  • Fundamental testing.

• Hierarchial mixture design
  • Several levels of mixture characterization

• Application of Gyratory compactor for specimen preparation

• Formulated the HiMA mixtures incorporating harder binders in higher percentages
LEVEL 1:
- Workability assessment with the Gyratory Compactor – EN 12697-31
- Duriez – water sensitivity – EN 12697-12/B

LEVEL 2:
- LCPC Wheel Tracker – Large Model
  EN 12697-22

LEVEL 3:
- 2PB-TR Stiffness modulus, 15°C, 10 Hz
  EN 12697-26/A

LEVEL 4:
- 2PB-TR Fatigue test, 10°C, 25 Hz
  EN 12697-24/A
ENGLISH METHOD OF FORMULATING AN ASPHALT MIXTURE

- Water sensitivity:
  - I.T.S.R. method – EN 12697-12/ A

- Resistance to permanent load:
  - Wheel Tracker – Small model, air, 60 °C
    EN 12697-22

- Stiffness modulus
  - Indirect Tensile Stiffness Modulus (IT-CY),
    124 ms, 5 or 7 µm – EN 12697-26/ C

- Fatigue:
  - Indirect Tensile Fatigue Test (ITFT)
    EN 12697-24/ E
  - Or: 2PB-TR Fatigue test, 10°C, 25 Hz
    EN 12697-24/ A
EXAMPLE OF PERFORMANCE TEST: WHEEL TRACKING TEST

Preparation:

Tests:

Large Model Wheel Tracker

Small Model Wheel Tracker

Hamburg Wheel Tracker
EXAMPLE OF PERFORMANCE TEST: MODULUS + FATIGUE

2PB-TR

NAT – ITFT + ITSM
Asphaltic mixes for paving applications

Figure 4

- Graded stones
- Sand
- Filler
- Bitumen

Open-graded bitumen macadam
Asphaltic concrete
Hot rolled asphalt
Gussasphalt
Mastic asphalt
Asia Pacific Region

- Marshall method of mixture design as per Manual Series #2 (Asphalt Institute) for modified and conventional binder mixtures
- Cross check for Refusal Density using PRD Test (BS 598) or additional number of blows – up to 200 blows per face
- Local (country wise) specifications for mixture volumetric limits
- Performance evaluation not common for specifications but used in specific projects.
  - Example: TSR and Wheel Tracking
Indian subcontinent

India

- Marshall method of mixture design as per Manual Series #2 (Asphalt Institute) for modified and conventional binder mixtures
  - Modified Marshall Method for mixtures with NMAS > 25 mm.
- Cross check for Refusal Density using additional number of blows – 200/300 per face
- Indian Roads Congress (IRC) provides specifications for use for mixture volumetric limits
- No performance characterization for selection of mixtures

Pakistan

Marshall method of mixture design as per Manual Series #2 (Asphalt Institute) for modified and conventional mixtures and no performance characterization
ASPHALT MIXTURE DESIGN IN ASIA

Middle East

- Primarily uses Marshall method of mixture design as per Manual Series #2 (Asphalt Institute)
- Aggregate Gradation using 0.45 Power Curve
- Cross check for Refusal Density using PRD Test (BS 598) or additional number of blows – 400/500/600 per face
- Local (country wise) specifications for mixture volumetric limits
- No performance characterization for selection of mixtures
SOME CASES IN MIDDLE EAST

Muscat Airport, Sultanate of Oman:

- Superpave mixture design
- Performance Characterization by HW TT, TSR, Toughness

Dubai Airport, Dubai, United Arab Emirates:

- Marshall mixture design with cross check using Superpave criteria
- Performance Characterization by HW TT, TSR, SPT

Dubai Road Transportation Authority (RTA)

- Evaluated Bailey’s Method in 2001
SOME CASES IN MIDDLE EAST

State of Qatar

- Allows Superpave method of mixture design for wearing and base course mixtures under QCS 2014
- Performance Tests such as TSR, Dynamic Modulus, Flow Number etc for Superpave mixtures

Kingdom of Saudi Arabia

- Allows Superpave method of mixture design
China

- Marshall method of mixture design as per Manual Series #2 (Asphalt Institute) for modified and conventional binder mixtures
- Superpave method of mixture design as per Manual Series #2 (Asphalt Institute) for modified and conventional binder mixtures

Performance Tests:

- Follow zonation of climates for choice of performance tests and limiting criteria
- Wheel Tracking at 60°C (similar to HW TT)
- TSR (similar to AASHTO T 283)
- Low temperature characterization (bending test)
  - Target failure strains in the range of 2000 – 3000 µs
  - Test done at -10°C±0.5°C and loading rate of 50mm/ min
ASPHALT MIXTURE DESIGN IN AUSTRALASIA

Australia

- Austroads Method
- Based on four key performance requirements:
  - Permanent deformation (surface courses)
  - Fatigue
  - Moisture susceptibility
  - Durability
- Hierarchical mixture design method: Three levels
- Mixture preparation using Gyratory Compactor (Gyropac)
- Mixture Conditioning is required for all levels
ASPHALT MIXTURE DESIGN IN AUSTRALASIA

- Australia
- Levels of Mixture Design

<table>
<thead>
<tr>
<th>Traffic Category</th>
<th>Design Level</th>
<th>Laboratory Compaction (Cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
<td>80</td>
</tr>
<tr>
<td>Heavy</td>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>Very heavy</td>
<td>3</td>
<td>120 + (250)</td>
</tr>
</tbody>
</table>

- Performance Characterization (only for levels 2 and above) using
  - Wheel Tracker
  - 4 PBB apparatus
  - Axial Creep measurements
  - Indirect Tensile Modulus
  - Moisture Sensitivity using TSR
New Zealand

- Follows Austroads Method preferably
- Marshall method is permissible.
  - Gyration compaction allowed for Superpave mixtures and special mixtures
- Considers usage of RAP
Mixture Design guided by the Southern African Bitumen Association (SABITA)

Manual # 24 (July 2005) - Guidance based approach

Aggregate grading using Bailey’s method

Compaction methods:
- Marshall compaction
- Modified Marshall
- Gyratory

Manual # 24 under review
ASPHALT MIXTURE DESIGN IN SOUTH AFRICA

- Hugo Hammer – for Large Aggregate Mixes for BaseS (LAMBS)
  - The compaction hammer, with its unique molded face, is turned 30° after each blow to simulate a kneading action in an attempt to ensure aggregate packing that more closely resembles field packing.

- Kango Hammer – for refusal density

- Performance testing for:
  - Permanent deformation
  - Fatigue
  - Moisture damage (stripping)

Manual # 24 under review
ASPHALT MIXTURE DESIGN IN ARGENTINA AND BRAZIL

- Argentina - Mixture Design using Marshall Method of Mixture Design
  - Argentinian Asphalt Commission developed National Standards to include:
    - Thin HMA design recommendations for wearing courses (max size 12mm, 2005)
    - “Thick” HMA design recommendations for both wearing courses and base layers (max size 19mm and 25mm, 2010)
    - Hot recycling in plant recommendations (2012)

- Brazil - Mixture Design using Marshall Method of Mixture Design
  - Follow DNIT specifications
Asphalt Mixture Design – Key Facets

Attaining a Balance is the key
TO CONCLUDE

- Asphalt Mixture design has evolved over the decades

- Europe has had a tremendous influence in developing specimen compaction methods and performance characterization tests that have become the cornerstone of asphalt pavement technology.

- Newer materials such as modified binders, RAP etc are leading the evolution of thought for asphalt mixture design evolution