Asphalt Mix Design

AAPA training
Asphalt Mix Design

Outline of presentation

- Selection of mix type and component materials
- Combining and proportioning of aggregates
- Mixing conditioning and compaction of samples
- Volumetric characteristics
- Mechanical testing
- Design of specialised mixes

Reference:
- AUSTROADS: Guide to Pavement Technology - Part 4B: Asphalt
Mix Design Process

Select mix type

Select components

Adjust or reselect components and/or proportions

Determine proportions of aggregates to meet target grading

Determine binder content(s) for tests

Mix and compact specimens

Determine volumetrics

Mechanical tests

Production trial

Test

Additional tests

Unsatisfactory

Recipe only

Volumetrics only

JOB MIX
Selection of Mix Type

- Selecting mix type sets parameters for:
  - Aggregate quality, shape and grading
  - Filler requirements
  - Binder type and range of binder content
  - Volumetric requirements (voids, etc.)

- Design can be a compromise between:
  - Stiffness and rutting resistance for heavy traffic applications using coarse gradings, stiff binders, etc.
  - Durability for light traffic (soft binders, low air voids, high binder contents, etc.)
Recipe Criteria for Asphalt Mix Design

• Used
  – Where characteristics of mix not readily defined or optimised by conventional tests
  – For simple mixes and minor applications

• Examples include:
  – Grading limits in open graded asphalt
  – Binder content for above mix types
  – Setting binder type or additives to achieve particular attributes
  – Cold mixes
Volumetric properties

- Bulk density
- Maximum density
- Voids in mineral aggregate (VMA)
- Air voids
- Absorbed binder
- Effective binder content
- Voids filled with binder
- Binder film thickness
Constituents of Compacted Asphalt

- Voids in Mineral Aggregate
- Voids Filled with Binder
- Aggregate Volume (Effective Density)
- Air Voids
- Effective Binder Content
- Absorbed Binder
- Total Binder Volume
- Volume of Mix Excluding Air Voids (Maximum Density)
- Total Volume of Compacted Asphalt (Bulk Density)
VMA, Air voids and Effective Bitumen

- Air void
- Absorbed bitumen
- Water permeable porosity, not filled with bitumen
- Aggregate volume (particle density on a dry basis)
- Aggregate volume (effective density)
- Aggregate volume (apparent particle density)
- Effective bitumen binder
- Volume of water permeable porosity (water absorption)
Dense Graded Asphalt

- Dense graded asphalt mixes use a continuous grading to facilitate packing of aggregate particles to achieve:
  - flexibility
  - durability
  - structural stiffness
  - deformation resistance
  - low permeability.

- Fuller equation \( P = (d/D)^n \)
  
  Where:
  - \( P \) = percentage passing each sieve
  - \( d \) = size of sieve opening
  - \( D \) = maximum size of aggregate
  - \( n \) = grading exponent
Dense Graded Asphalt

TYPICAL GRADING CURVE FOR 14 mm MIX

Grading envelope for light traffic mixes

Grading envelope for heavy duty mixes

n = 0.45 maximum density curve

Percentage passing

Sieve size (mm)
Mechanical Testing

- Fundamental tests for stiffness and deformation resistance, and fatigue:
  - repeated load indirect tensile test
  - repeated flexural bending

- Simulative tests for deformation resistance and other properties:
  - wheel tracking test
  - moisture sensitivity

- Empirical tests:
  - Marshall test
Austroads Mix Design Procedure

Level 1
- Select materials and grading
- Compact trial mixes at 4 or 5 binder contents in Gyropac
- Evaluate plots of voids, density and VMA vs bitumen content

Level 2
- Check % film index for durability*
- Mix specimens at design bitumen content
- Compact for appropriate cycles
- Measure modulus
- Measure creep
- Moisture sensitivity if required
- Compact slab
- Fatigue test if required

Level 3
- Mix specimens at design bitumen content
- Gyropac for 250 cycles*
- Voids > spec. minimum
- Compact wheel track slabs
- Report wheel tracking rate
- End Level 3

End Level 1

* testing normally carried out in Level 1
Compaction of Laboratory Mixes

- Gyratory compaction
- Marshall compaction
- Preparation of slabs and large samples
Gyratory Compaction
Principle of Gyratory Compaction
Gyratory Compaction

- Light traffic: 50 cycles
- Medium traffic: 80 cycles
- Heavy traffic: 120 cycles
- “Refusal Density”: 250 cycles
Asphalt Stiffness

• Stiffness is response to load and will vary with:
  – temperature
  – rate of loading (traffic speed)

• Stiffness may be increased by:
  – decreasing the binder content
  – increasing the angularity of the aggregate
  – adjusting the filler content
  – using a harder binder.

• Stiffness may be estimated from:
  – Shell Nomographs
  – Resilient modulus test
  – Fatigue test
Indirect Tensile Test
Deformation

- Worst conditions for rutting are:
  - High temperatures
  - Heavily loaded vehicles
  - Channelised traffic
  - Slow moving vehicles

- Deformation resistance is controlled by
  - Aggregate grading and shape
  - Binder content
  - Appropriate field compaction

- Deformation resistance is measured by
  - Wheel tracking test
Fatigue

- Fatigue is caused by repeated bending and tensile stress
- Fatigue life may be determined:
  - From Shell formula
  - Laboratory test
- Laboratory test conditions for fatigue are:
  - Constant stress (constant load)
    - Increasing stiffness increases fatigue life
  - Constant strain (constant deflection)
    - Fatigue life is increased by softer bitumen, higher binder content or polymer modified bitumen
Fatigue Test Apparatus
Marshall Stability and Flow

Continuously increasing load

Max. load (Stability)
Marshall Test Results
Design of Other Mix Types

• Open graded asphalt
• Stone mastic asphalt
• Fine gap graded asphalt

These mixes are generally designed as a combination of targets for grading and binder content together with determination of volumetric properties at defined compaction levels. Mixes may also be subject to mechanical tests where appropriate.
Special Applications

- Recycled asphalt
- Cold mixes
- Polymer modified binders
- Crumb rubber asphalt
- Ultra thin asphalt
References

- AUSTROADS AGPT04B/07 : Guide to Pavement Technology - Part 4B: Asphalt
- AUSTROADS Asphalt Guide
- AUSTROADS Framework for Specifying Asphalt
- AAPA National Asphalt Specification
- AS 2150 Hot Mix Asphalt
- AS 2891 Methods of sampling and testing asphalt
- AUSTROADS Manual of Test Methods