Asphalt 104:
An Introduction to Hot Mix Asphalt Materials

-Part II-

Mix Design

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The MIX
The MIX

- Rocks
The MIX

- Rocks
- Asphalt
The MIX

- Rocks
- Asphalt
The MIX

- Rocks
- Asphalt
- Air
The MIX

- Rocks: About 86%
- Asphalt
- Air
The MIX

- Rocks
- Asphalt
- Air

About 86%
The MIX

- Rocks: About 86%
- Asphalt: About 10%
- Air: None
The MIX

- Rocks: About 86%
- Asphalt: About 10%
- Air
The MIX

- Rocks: About 86%
- Asphalt: About 10%
- Air: 4%
The MIX

- Rocks: About 86%
- Asphalt: About 10%
- Air: 4%
Purpose of Mixture Design
To Build Better Roads
Better Asphalt Roads are:
Better Asphalt Roads are:

A Combination of an Asphalt Binder

And Crushed Rocks
These Individual Rock Sizes **Will Not** Make a Good Asphalt Mix Alone

but

A Combination **Might**
What Combination Works?

Coarse

Intermediate

Fines
What Combination Works?

Coarse  Intermediate  Fines

33.3%  33.3%  33.3%
Maximum Density for Aggregates

- Goode and Lufsey, Bureau of Public Roads
Maximum Density for Aggregates

- Goode and Lufsey, Bureau of Public Roads

\[ p = 100 \left( \frac{d}{D} \right)^{0.45} \]
Maximum Density for Aggregates

- Goode and Lufsey, Bureau of Public Roads

\[ p = 100 \left( \frac{d}{D} \right)^{0.45} \]

- \( p \) = percent material passing a given sieve \( d \)
- \( D \) = Maximum aggregate size
Aggregate Gradation Specs

Sieve Sizes Raised to 0.45 Power

Percent Passing

0.075 0.30 2.36 4.75 9.5 12.5 19.0

Max size Nom max size control points maximum density line

Max size

100

Sieve Sizes Raised to 0.45 Power
What a Mixture Design Does
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
What a Mixture Design Does

• Creates a Strong Pavement – HOW?
  – The Right Volumes of
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of Rocks
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of Rocks
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of \( n \) Rocks: About 86%
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of $n$ Rocks
    - About 86%
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of
    - Rocks
    - Asphalt
    - About 86%
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of
    - Rocks, About 86%
    - Asphalt
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of
    - Rocks: About 86%
    - Asphalt: About 10%
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of
    - Rocks: About 86%
    - Asphalt: About 10%
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  - The Right Volumes of

  - Rocks
    - About 86%

  - Asphalt
    - About 10%

  - Air
What a Mixture Design Does

• Creates a Strong Pavement – HOW?
  – The Right Volumes of

  n Rocks           About 86%
  n Asphalt         About 10%
  n Air             4%
What a Mixture Design Does

- Creates a Strong Pavement – HOW?
  – The Right Volumes of

  - Rocks: About 86%
  - Asphalt: About 10%
  - Air: 4%
Traffic Affects the Air Voids
Traffic Affects the Air Voids

Rocks
Traffic Affects the Air Voids

Rocks 86%
Traffic Affects the Air Voids

Asphalt

Rocks

86%
Traffic Affects the Air Voids

Asphalt: 10%
Rocks: 86%
Traffic Affects the Air Voids

Air: 86%
Asphalt: 10%
Rocks: 10%
Traffic Affects the Air Voids

- Air: 4%
- Asphalt: 10%
- Rocks: 86%
Traffic Affects the Air Voids

- Air: 4%
- Asphalt: 10%
- Rocks: 86%
Traffic Affects the Air Voids

Minivans, Cars

Air: 4%
Asphalt: 10%
Rocks: 86%
Heavier Traffic Squeezes Air Out

- Air: 4%
- Asphalt: 10%
- Rocks: 86%

Minivans, Cars
Heavier Traffic Squeezes Air Out

- Air: 3%
- Asphalt: 10%
- Rocks: 86%

Light Trucks, Vans
Until There is Less, and Less

- Rocks: 86%
- Asphalt: 10%
- Air: 3%

Light Trucks, Vans
Until There is Less, and Less

- Rocks: 86%
- Asphalt: 10%
- Air: 4%
- Minivans, Cars: 10%
- Light Trucks, Vans: 2%
- Semis: 2%

Until there is less, and less.
And Finally.....
And Finally…..

Rutting
Adjust Asphalt and Rocks for Traffic

- Cars: 4% Air, 10% Asphalt, 86% Rocks
- Light Trucks: 4% Air, 9% Asphalt, 87% Rocks
- Semis: 4% Air, 8% Asphalt, 88% Rocks
Simulate Traffic in the Laboratory
Simulate Traffic in the Laboratory

Low Gyrations - Cars
Simulate Traffic in the Laboratory

Low Gyrations - Cars
Simulate Traffic in the Laboratory

Low Gyrations - Cars

Med Gyrations – Lt Trucks
Simulate Traffic in the Laboratory

Low Gyrations - Cars

Med Gyrations – Lt Trucks
Simulate Traffic in the Laboratory

- Low Gyrations - Cars
- Med Gyrations – Lt Trucks
- High Gyrations - Semis
Simulate Traffic in the Laboratory

Low Gyrations - Cars

Med Gyrations – Lt Trucks

High Gyrations - Semis
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ???????
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ???????

![Graph showing the relationship between Air Voids and Asphalt percentage.]

Air Voids, %

Asphalt, %
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ???????

![Graph showing the relationship between asphalt percentage and air voids percentage. The graph includes two lines, one labeled 'Med Traffic-50', illustrating the decrease in air voids as the asphalt percentage increases.]
How Much Asphalt to get 4% Air Voids ?????

As Traffic Increases

- Low Traffic-35
- Med Traffic-50
- Hi Traffic-75

Air Voids, %

Asphalt, %
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ???????

As Traffic Increases

Air Voids, %

Asphalt, %

4.5  5.0  5.5  6.0  6.5

Low Traffic-35
Med Traffic-50
Hi Traffic-75

5.0  5.3
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ????????

As Traffic Increases

Asphalt, %

Air Voids, %

Low Traffic-35
Med Traffic-50
Hi Traffic-75

4.5
5.0
5.5
6.0
6.5

5.0
5.3
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ???????

As Traffic Increases

Asphalt, %

Air Voids, %

Low Traffic-35
Med Traffic-50
Hi Traffic-75

4.5  5.0  5.5  6.0  6.5
The Key to Mixture Design

How Much Asphalt to get 4% Air Voids ???????

As Traffic Increases

- Low Traffic-35
- Med Traffic-50
- Hi Traffic-75

Air Voids, %

Asphalt, %

Decreases
We Must Know Traffic To Know Asphalt %
We Must Know Traffic To Know Asphalt %

Let’s Design for Residential Street with 100 cars per day
We Must Know Traffic To Know Asphalt %

Let’s Design for Residential Street with 100 cars per day
We Must Know Traffic To Know Asphalt %

Let’s Design for Residential Street with 100 cars per day
We Must Know Traffic To Know Asphalt %

Let’s Design for Residential Street with 100 cars per day
We Must Know Traffic To Know Asphalt %

Let’s Design for Residential Street with 100 cars per day
Would this Design Work on I-25??????

Air Voids, %

Asphalt, %

Low Traffic-35
Would this Design Work on I-25??????

Air Voids, %

Asphalt, %

Low Traffic-35

Hi Traffic-75

5.7
Would this Design Work on I-25??????

NO!
1.8% Air Voids Is Too Low
Would this Design Work on I-25??????

NO!  
1.8% Air Voids Is Too Low

Air Voids, %

Asphalt, %

Decrease AC%
Superpave Mix Design
Superpave Mix Design

- Gyratory Compactor Simulates Traffic Better Than Hammer
Superpave Mix Design

- Gyratory Compactor Simulates Traffic Better Than Hammer
Superpave Mix Design

- Gyratory Compactor Simulates Traffic Better Than Hammer
- Volumetric Analysis (Voids)
Superpave Mix Design

- Gyratory Compactor Simulates Traffic Better Than Hammer
- Volumetric Analysis (Voids)
Superpave Mix Design

- Gyratory Compactor Simulates Traffic Better Than Hammer
- Volumetric Analysis (Voids)
- Adjusts AC% to Traffic and Climate
Volumetric Analysis
Volumetric Analysis

• Air Voids
Volumetric Analysis

- Air Voids
- VMA (Voids in Mineral Aggregate)
Volumetric Analysis

- Air Voids
- VMA (Voids in Mineral Aggregate)
- VMA Filled with AC%
Volumetric Analysis

- Air Voids
- VMA (Voids in Mineral Aggregate)
- VMA Filled with AC%
- Absorption
VMA Concept
VMA Concept

- Durability – Enough Binder… Not Too Much
VMA Concept

- Durability – Enough Binder... Not Too Much

About 86% Rocks
VMA Concept

- Durability – Enough Binder… Not Too Much

- Rocks
  - About 86%

- Asphalt
  - About 10%
VMA Concept

- Durability – Enough Binder… Not Too Much

\[ \text{VMA} = \text{Effective Asphalt} + \text{Air} \]

- Rocks: About 86%
- Asphalt: About 10%
- Air: 4%

Voids are Just Full Enough
If VMA Too Low
If VMA Too Low

- Durability Suffers...Not Enough Coating

\[ \text{Voids are Not Full Enough} \]

\[ \text{VMA} = \text{Effective Asphalt} + \text{Air} \]

- Rocks: About 88%
- Asphalt: About 8%
- Air: 4%
If VMA Too High
If VMA Too High

- Stability Suffers...Too Much Coating

Voids are Too Full of Asphalt

\[ \text{VMA} = \text{Effective Asphalt} + \text{Air} \]
Select Asphalt and Aggregates

Aggregates

1. Coarse Aggregate Angularity (fractured faces)
2. Fine Aggregate Angularity
3. Flat and Elongated Particles
4. Clay Content (sand equivalent)
5. Toughness (LA Abrasion)
6. Soundness
7. Deleterious Stuff
8. Gradation
Evaluate Compaction

Air Voids, %

Low          Med          High

N_{init}     N_{des}     N_{max}

11           3           2

Compaction
Stability

Rubber
Allows Lateral Movement
Optimum AC%
Optimum AC%
Optimum AC%
Optimum AC%
Optimum AC% 

% Voids
Stability, %

4.5  5.0  5.5  6.0

5.3

minimum

% Voids: 25, 35, 45
Stability, %: 4.5, 5.0, 5.5, 6.0

minimum

5.3
Verify 5.3% AC
Verify 5.3% AC

- VMA OK?
Verify 5.3% AC

• VMA OK?
Verify 5.3% AC

- VMA OK?
- VFA OK?
Verify 5.3% AC

- VMA OK?
- VFA OK?
Verify 5.3% AC

- VMA OK?
- VFA OK?
- Stability OK?
Verify 5.3% AC

- VMA OK?
- VFA OK?
- Stability OK?
Verify 5.3% AC

- VMA OK?
- VFA OK?
- Stability OK?
- Moisture Sensitivity OK?
Let’s Pave!
Let’s Pave!
Questions...