HMA - The Last 50 Years in Indiana
HMA - The Last 50 Years in Indiana

- Materials
- Mix Design
- Sampling
- Testing
- Equipment
- Problems
- Quality Control
- Quality Assurance
Materials - Aggregates

- Certified Sources - 191
  - Stone - 80
  - Sand & Gravel - 50
  - Sand Only - 36
  - Sand, Gr., & St. - 15
  - Slag - 9
  - Recycled - 1
Materials - Stone

- Limestone - all mixtures
- Dolomites - friction resistant surface mixtures
- Sandstone - high ESAL friction resistant mixtures
Materials - Stone

- Limestone - Ledge and Production Testing
Materials - Friction Resistance

Dolomite - 10.3% Magnesium (1980s)
Materials - Sandstone

HMA Surface & SMA Surface
Polish Resistant Aggregates
British Polishing Wheel
Polish Resistant Aggregates

- 2 year evaluation with comparison to test section
ITM 221 - Acceptance Procedures for HMA Surface Mixture Coarse Aggregate for ESAL $\geq 10,000,000$

- Circular Track Polishing Machine
- Circular Track Meter
- Dynamic Friction Tester
Maximizing the Use of Local Aggregates

- 20% of Highly Polishing Aggregate
Abrasión - Stone Matrix Asphalt (SMA)

- Gravel Sources - 11
- Stone Sources - 27/41 Benches
Materials - Gravel

- Sand & Gravel - 50
- Sand Only - 36
- Sand, Gr., & St. - 15
Materials - Blast Furnace Slag

- Variable Specific Gravity
- Surface Area and Absorption
- High Friction Resistant Aggregate
Materials – Blast Furnace Slag

- Leachate – calcium sulfide
- pH and rock color chart requirements
Materials - Steel Furnace Slag

- Limited to aggregate shoulders, HMA or SMA surface, dumped riprap, and snow and ice abrasives
- Expansion - unaged calcium oxide and magnesium oxide
- Autoclave Test - ITM 219
Materials - Fine Aggregate

Natural Sand - angularity and clay content
Materials - Fine Aggregate

- Florida Bearing Value -- add 0-20% stone sand to obtain a FBV of 30 for surface mixtures
## Materials - Fine Aggregate

<table>
<thead>
<tr>
<th>FINE AGGREGATE ANGULARITY</th>
<th>TRAFFIC ESAL</th>
<th>DEPTH FROM SURFACE</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 300,000</td>
<td>≤ 4 in.</td>
<td>&gt; 4 in.</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>300,000 to &lt; 3,000,000</td>
<td>40</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3,000,000 to &lt; 10,000,000</td>
<td>45</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10,000,000 to &lt; 30,000,000</td>
<td>45</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥ 30,000,000</td>
<td>45</td>
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</table>
## CLAY CONTENT

<table>
<thead>
<tr>
<th>TRAFFIC ESAL</th>
<th>SAND EQUIVALENT, MINIMUM</th>
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<tbody>
<tr>
<td>&lt; 300,000</td>
<td>40</td>
</tr>
<tr>
<td>300,000 to &lt; 3,000,000</td>
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<tr>
<td>10,000,000 to &lt; 30,000,000</td>
<td>45</td>
</tr>
<tr>
<td>≥ 30,000,000</td>
<td>50</td>
</tr>
</tbody>
</table>
Materials - Aggregate Acceptance

- “Yellow card” system
- Approved each stockpile
- Held up contracts if failing

- Certified Aggregate Producer Program (CAPP)
- Statistical evaluation of coarse aggregates
- Made Producer responsible for consistency of aggregate gradation
- Ship on demand
Control Charts

Specification Limit

Control Limits (2σ)

Specification Limit
Materials - Aggregates (CAPP)

- Stockpiling
CAPP - Sampling Techniques

- Midstream Sampling
CAPP - Sampling Techniques

- Midstream Sampling
CAPP - Midstream Sampling
CAPP - Midstream Sampling
Blended Aggregate Sampling
Blended Aggregate Sampling
CAPP - Gradation Control
CAPP - Testing

Gradation

- Start of Production - 1/1000t for 5000t with max of 2/day
- Normal Production - 1/2000t
- Load-Out – 1/8000t
Decant Each load-out sample
CAPP - Testing

Deleterious
1/week for each size
CAPP - Testing

Crushed Content 1/week for each size
CAPP - Testing

Additional Tests

FA Specific Gravity

CA Specific Gravity
Additional Tests -- FAA
- CAPP training - 1994
- ≈ 900 Technicians
- Currently 387 Certified Technicians
Materials - Recycled/Waste Materials

- Air Cooled Blast Furnace Slag
- Ground Granulated Blast Furnace Slag
- Glass
- New Waste Asphalt Shingles
- Reclaimed Asphalt Shingles
- Reclaimed Asphalt Pavement
- Rubber
- Steel Slag
- Wet Bottom Boiler Slag
Materials - Reclaimed Asphalt Pavement
Materials - Reclaimed Asphalt Pavement

- RAP - Heat Transfer Method
- 50% RAP
Materials - Recycled/Waste Materials

- Many Sizes of RAP
- Binder Replacement
Materials - Recycled/Waste Materials

- Reclaimed Asphalt Shingles (RAS)
- Pre-consumer – 1980s
- Asbestos – Processing
- Available Quantity
Materials - Recycled/ Waste Materials

- Post Consumer Shingles
- Deleterious - AASHTO MP 15
- IDEM Legitimate Use Letter
Materials - Rubber

- Wet and Dry Process - 1980s
Materials - Rubber

- **Dry-Process** - added rubber to pugmill
- **Wet Process** - rubber added to asphalt at plant *
Materials - Rubber

- Pyrolysis Plant
- Carbon Black
Materials - Porcelain
Materials - Asphalt

Petroleum Asphalt Flow Chart

- Oil Well
- Field Storage
- Pumping Station
- Tube Heater
- Distillation Tower
- Storage
- Condensers and Coolers
- Refinery
- Residual Material
- Refinery
- Air Blown Asphalts
- Still
- Emulsion
- Emulsified Asphalt
- Slow Curing Cutback Asphalts
- Medium Curing Cutback Asphalts
- Rapid Curing Cutback Asphalts
- Blended
- Process Unit
- Gasoline
- Light Solvents
- Kerosene
- Light Burner Oil
- Diesel Oil
- Lubricating Oils
- Asphalt Cements
- Residual Fuel Oil
- Petroleum
Materials - Asphalt

- Penetration Grades - AP-3, AP-5
- Viscosity Grades - AC-20, AC-40
- PG Grades - PG 58-28, PG 64-22, PG 64-28, PG 70-22, PG 76-22
Materials - Asphalt

- **Penetration** - Used to control the consistency of asphalts at 77 °F
Materials - Asphalt

- Viscosity
- Replace the empirical penetration test with a scientific test
- Measures the consistency at 140°F which better approximates the pavement surface temperature
Asphalt - Performance Graded

HIGHEST MONTHLY MEAN MAXIMUM

LOWEST ANTICIPATED TEMPERATURE
Performance Graded Binders

PG 52-28

- Performance Grade
- Average 7-day max pavement design temp
- Min pavement design temp
Performance Graded Binders

- Dynamic Rheometer
- Direct Tension
- Bending Beam
Performance Graded Binders

- Dynamic Shear Rheometer
  - Evaluates binders at upper and intermediate temperatures where rutting and fatigue cracking occur
Performance Graded Binders

- Bending Beam
  - Measures low temperature stiffness which relates to thermal cracking
Performance Graded Binders

- Direct Tension
  - Used to estimate the low temperature failure properties of the binder
Asphalt - Quality Control

- Asphalt Supplier Certification (ASC) Program (39 sources - 28 fully & 11 partially approved)
  - Materials testing - AASHTO M 320
  - Quality Control Plan
  - Participation in AASHTO AMRL equipment inspection and proficiency sample program
ASC Program

- Supplies a shipping report for each load certifying the PG binder has been manufactured according to the ASC program
- Supplies a Type A certification for PG 58-28 and PG 64-22
- Furnishes instructions with each PG binder on the proper storage and handling of the material
Acceptance is based on samples taken at the plant except for PG 58-28 and PG 64-22
**In-Line Blending**

- SBR polymer latex
- PG-58-28 $\rightarrow$ PG 64-28
- PG 64-22 $\rightarrow$ PG 70-22
Mixtures - Kentucky Rock Asphalt (Kyrock)
Mixtures - Kentucky Rock Asphalt (Kyrock)
Mixtures

- Dense Graded - standard
- Open Graded - drainage layers & surface mixtures
- Sand Surface - high friction resistant
- Stone Matrix Asphalt - rut resistant surface
- Kneading Compactor - applies pressure to the specimen through hydraulically operated tamper foot
- **Stabilometer** - ability to resist shear forces applied by wheel loads
Mix Designs - Hveem

- Cohesiometer – measured the tensile property of the mixture that was related to a minimum level to prevent raveling of surface mixes
Developed as method that could be taken to the field for quality control purposes
Mix Designs - Marshall

- Started in 1984 as a mix design and quality control procedure
Mix Designs - Superpave (1990s)

- Gyratory compactor - orients the aggregate particles in a way similar to that observed in the field
- Number of gyrations are varied to simulate anticipated traffic
- Mixtures designed at 4.0% air voids
- Seven manufacturers & 12 models approved
Mix Design - Superpave
Mix Design - Superpave

RIETH-RILEY CONSTRUCTION CO., INC.
.45 POWER SIEVE ANALYSIS

Mix Design - Superpave

Upper Specification  ▲  Lower Specification  → BLEND PLOT  — Maximum Density Line

Percent (%) Passing

Sieve Size

0 10 20 30 40 50 60 70 80 90 100

75μm 300μm 1.18mm 2.36mm 4.75mm 9.5mm 12.5mm 19mm 25mm 37.5mm 50mm

77
HMA - Plant Sampling

Truck Sampling - Dense Graded, Open Graded & Sand Mix
Core Sampling - Density
Plate Sampling

- Final Place of Material
- Requires good coordination of plant, trucks and paving crew to obtain uniform mixture
Plate Sampling
Plate Sampling
Plate Sampling
Plate Sampling
Plate Sampling

- Backup Sample for Gyratory Specimens
- Sample for Gyratory Specimens
- 2 ft (0.6 m)
- Backup Sample for MSG and Binder Content
- Random Location MSG and Binder Content Sample
- Increasing Station
HMA - Testing

- Gradation
- Asphalt Content
- Air Voids
- VMA
- Density
- Smoothness
Testing - Gradation
HMA - Asphalt Content

- Centrifuge Extractor
  - Asphalt content with fines recovery
  - Recovery of asphalt for further testing
Vacuum Extractor
- Asphalt content with fines recovery
- Biodegradable solvents - film on aggregate
HMA - Asphalt Content

- Ignition Oven
  - Total asphalt content
  - High Mg aggregates
HMA - Air Voids

- Bulk Specific Gravity
- Maximum Specific Gravity - weighing in water
HMA - Density

- Nuclear Gauge - nondestructive
- Cores
HMA - Equipment
HMA- Plants

- Continuous
- Batch
- Parallel - flow
- Counter - flow
Continuous - Mix Plants
Batch Plants
Parallel-Flow Drum Plant

Mixture exposed to dryer burner - emissions
Counter-Flow Plants

Improve the heat transfer process inside the drum and reduce plant emissions
Double Barrel Plants

Protects the RAP from high-temperature exhaust gases and reduces visible emissions
Warm Mix Asphalt - 54 plants

- Water Injection -- < 0.1% moisture in mix
- 250 - 260° F - reduces emissions
- Approximately 14% reduction in fuel
- Improves coating
- Mixture cools slower - longer haul distances
Surge Bins

- Allows continuous flow of mix to contract
- Length of storage - hardening of asphalt and draindown
Dust Collectors

Cyclone

Valve

Wet Scrubber

Outlet

Liquid Inlets

Wall Mounted Sprays May Be Center Pipe

Gas Inlet

Drain
Baghouse

Allowed return of fines to mixture
Baghouse Fines

- Uniform return of the fines
- Calibration of fines vs rate of return
Cold Feed Bins

Cold bins

Cold feed gates
Asphalt Storage
Mass Flow Meters
Trucks
Trucks - Anti Adhesive Agents

- Approved List
- Truck Beds raised after application of non-foaming agents
Trucks - Anti Adhesive Agents
- Faster operation - Driver remains in truck
- Amount of anti-adhesive agent is controlled
Rollers - Three Wheel

- 300 lb/ in on rear wheels
- Tandem meeting this requirement could be used
Contact Pressure of 50 to 90 psi
Tire temperature - picking up
Tandem Rollers

- Minimum of 10 ton weight
Rollers

Single Drum Vibratory on Soil
Rollers

- Single Drum Vibratory on HMA
- \( \approx 1500 \) vpm
- > 10 passes to achieve density
- Dual Drum Vibratory
- More compaction and wider drums
- $\geq 2000$ vpm
Vibratory Rollers - Frequency

Low Frequency

High Frequency

Impact Spacing

FREQUENCY

DIRECTION OF TRAVEL
Vibratory Rollers - Amplitude

Amplitude

Higher

Lower
2000 vpm @ 2 ½ mph = 1 in. spacing of drum impact
Vibratory Rollers - Test Strip

Graph showing the relationship between density and number of passes. The graph indicates that as the number of passes increases, the density also increases, reaching a peak at a certain point and then leveling off.
### Approved Equipment List - Vibratory Rollers

<table>
<thead>
<tr>
<th>Man.</th>
<th>Model</th>
<th>Base Material</th>
<th>Amplitude</th>
<th>Number Of Passes (100-170)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>vib</td>
</tr>
<tr>
<td>Bomag</td>
<td>BW-202</td>
<td>asphalt</td>
<td>low</td>
<td>3</td>
</tr>
<tr>
<td>Case</td>
<td>752</td>
<td>asphalt</td>
<td>low</td>
<td>4</td>
</tr>
<tr>
<td>Tampo</td>
<td>RS-166</td>
<td>concrete</td>
<td>med</td>
<td>2</td>
</tr>
</tbody>
</table>
Oscillatory Rollers

Reduce impact on pipes and adjacent buildings in metropolitan areas
Density – Intelligent Compaction (IC)

- GPS radio and receiver unit on roller
- On-board documentation system
  - Stiffness values
  - Number of passes
  - Location of roller passes
  - Pavement surface temperature
  - Roller speed
  - Vibration frequencies
  - Amplitudes of roller drums
Problems - Rutting

- Number of Trucks
- Allowable load limits
QC/ QA Specifications - 1984

- **Quality Control (QC) - Contractor Process**
  - Control of producing quality mixture
- **Quality Assurance (QA) - Acceptance by statistical means, with random sampling**
Mix Designs - Marshall

- Mixtures were designed at 6.0% air voids
- Larger percentage of coarse aggregate
Materials - Gravel

- Crushed Count - 1960s
- Base mixtures - 50%
- Binder mixtures - 50%
- Surface mixtures - 85%
## Materials - Gravel

### Coarse Aggregate Angularity

<table>
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<tr>
<th>Traffic, ESAL</th>
<th>Depth From Surface</th>
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<tr>
<td></td>
<td>( \leq 4 \text{ in.} )</td>
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<td>(&lt; 300,000)</td>
<td>55</td>
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<tr>
<td>300,000 to (&lt; 3,000,000)</td>
<td>75</td>
</tr>
<tr>
<td>3,000,000 to (&lt; 10,000,000)</td>
<td>85/80*</td>
</tr>
<tr>
<td>10,000,000 to (&lt; 30,000,000)</td>
<td>95/90*</td>
</tr>
<tr>
<td>( \geq 30,000,000)</td>
<td>100/100*</td>
</tr>
</tbody>
</table>

*Denotes two faced crush requirements.*
Baghouse Fines

- Bins - low level indicator
- No return of Fines
- Adjust volumetric properties
Problems - Segregation
Materials - Aggregates (CAPP)

Reduce segregation of aggregates with stockpiling procedures
CAPP - Loading Trucks

Three drops in truck and working across face of stockpile
Surge Bins

- Discharge when mix falls below top of cone
  - Mix segregation
  - Alarm system
Trucks - Loading

Incorrect

Correct
Trucks - 3 Drops

Front

Back

Middle
Loading Trucks

Rear Axle Overload
Material Transfer Vehicles

Transfer mix to paver - where trucks could not unload easily
Material Transfer Vehicles

- Reduced Segregation
- Trucks could unload quickly
- Provided uniform mat temperature
Paver - Segregation
Paver - Segregation

Top-Down Longitudinal Cracking and/or Segregation were found at these locations.
Paver Restrictions

- Blaw-Knox – MMK
- Cedar Rapids – 1989 or later
- Barber Green/
  Caterpillar – Deflector Kit
Pavers - Segregation
Pavers - Segregation

- Raise bed before unloading
- Flood the paver hopper
Pavers - Segregation

Constant Head of Material on Screed
Plate Sampling - Segregation
Certified HMA Producer Program

109 Certified HMA Producers
Quality Control - Plant

- Personnel
- Materials
- Laboratory
- Plant Production
- Sampling
- Testing
- Documentation
- Certified Asphalt Technician Training - 1984
- \(\approx 800\) Technicians
- Currently 227 Certified Technicians
QCP - HMA Laboratory

- Owned by Producer
- HMA Plant
- Other Locations
  - Results furnished in writing to plant within two working days
  - Equipment calibrated
  - Certified Asphalt Technician
  - Qualified Technician
QCP-HMA Plant Production

- Plant site layout
- Plant calibration
- Aggregates
- Binder
- Baghouse fines
- Fibers
- Trucks
- Surge bins
Testing – QCP Requirements

- Aggregates
  - Stockpile
  - Blended Aggregate

- Recycled Materials
  - Binder Content
  - Gradation
  - Moisture Content
  - CAA

- Binder
Testing

- Mixture at HMA Plant
  - Binder Content
  - Gradation (SMA)
  - Moisture Content
  - Temperature
  - Draindown (OG & SMA)
Testing

- Mixture from Pavement
  - Binder Content
  - Gradation (SMA)
  - Moisture Content (Surface Mixture)
  - Bulk Specific Gravity
  - Maximum Specific Gravity
Daily Diary

- Quantity of mixture produced
- Contract number
- When samples taken & tested
- Non-conforming tests and resulting corrective action
- Any significant events or problems
Control Charts

Control Limit

Target Mean

Control Limit
Certified HMA Plants

- Manufactured product
- Improved quality of product
  - React quickly to changes
- Cities/Counties use
Personnel

- QCP Manager – responsible for administration of QCP
- QCP Field Manager – responsible for execution of QCP and liaison to PE. Required to be a Certified HMA Field Supervisor
- Quality Control Technician – responsible for conducting quality control tests and inspection
Quality Control Technician

- Paving operations and joint construction
- QC tests for temperature, density and smoothness
- Pavement samples
MILLING

- Milling Plan – general procedures for asphalt removal
- Equipment – description
- Testing – macrotexture measurement (ITM 812)
- Procedure, frequency, and equipment for measuring the cross slope and longitudinal surface finish
Process Balance

- Plant Production
- Transportation
- Placement
- Compaction
- Corrective Action
Transportation of Mixture

- Truck Bed Cover – when waterproof covers are used
- Unloading – procedures and removal of mixture from truck bed and bed apron
- Transfer Vehicles – type and size and plans for bridge crossing
- Equipment – make, model, etc.
- Paving Plan – general sequence, widths, and depths of paving, and planned date for starting and finishing
- Procedure for construction of longitudinal and transverse joints
- Starting and stopping procedures of paver for transverse joints
Joint Compaction

1st Pass
off the joint

Roller drum

Cold |

Hot

6-8” Creates a confined edge & raised area

2nd Pass
on the joint

Roller drum

Cold |

Hot

6-8” Uses Dynamics to build density “pinch the joint”

- Procedures for compaction of the longitudinal and transverse joints
Materials Sampling and Testing

- Density – procedure for measuring (minimum 1/1000 yd² on mainline and shoulders)
- Procedure for monitoring temperature of mix during compaction to optimize rolling pattern
Materials Sampling and Testing

- Plan for when cores shall be taken and procedure for refilling core holes
Materials Sampling and Testing

- Procedure for measuring smoothness. Annual certification of profilograph shall be included (ITM 912)
Response to Test Results

- Corrective Action in response to mixture, temperature, and density tests
Project Quality Control Plan