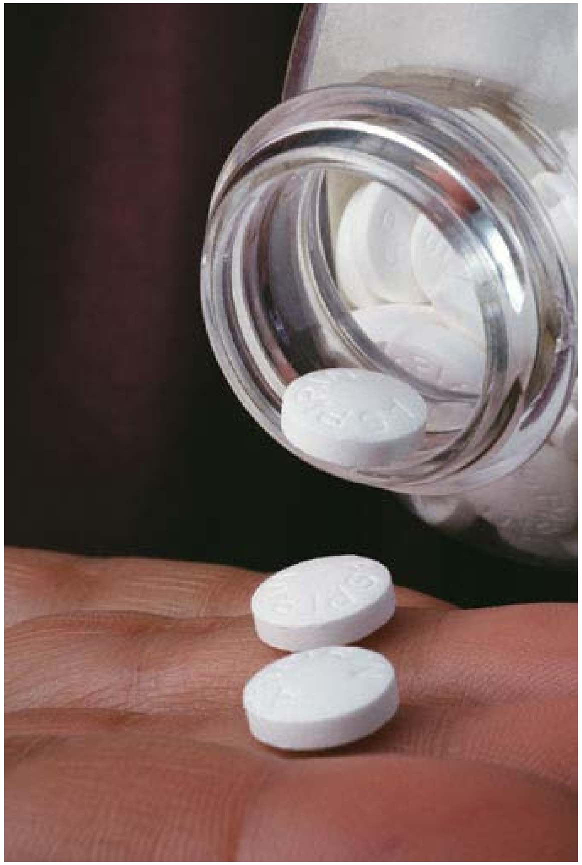
Tilcon NY, Inc.

P401 Specification and Development of Job Mix Formula

We Got an Airport Job !



Who is the Resident Project Representative (RPR) and what version of the specification is in use.

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KNOWLEDGEABLE PARTNERS and RESOURCES

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

- NAPA
- State Asphalt Pavement Associations
- National Center for Asphalt Technology
- Association of General Contractors
- FHWA Expert Task Groups & NCHRP project panels
- Transportation Research Board

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Well-equipped to tackle your Airport Project ?

P401 Specification

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Standard Specifications for Construction of Airports

Date: 12/21/2018
Initiated By: AAS-100

AC No: 150/5370-10H
Change:

1 **Purpose.**
The standard specifications contained in this advisory circular (AC) relate to materials and methods used for construction on airports. Items covered in this AC include general provisions, earthwork, flexible base courses, rigid base courses, flexible surface courses, rigid pavement, fencing, drainage, turf, and lighting installation.

2 **Cancellation.**
This AC cancels AC 150/5370-10G, *Standards for Specifying Construction of Airports*, dated July 21, 2014.

- FAA Specifications
  - Advisory Circulars
  - https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5370-10H
  - Review 10 H Changes
  - ***Caution- be sure to look at specification for "version"***

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Summary of Changes AC 150/5370-10H

- Engineer SHALL choose prevalent mix design method (SUPERPAVE)
- Aggregate requirements for Clay lumps and Flat and Elongated, and Plasticity Index
- Binder-Elastic Recovery increase
- TSR limits increase
- Stability and Flow removed; replaced with APA or Hamburg for design
- Gradation bands changed
- Silo storage time limits have increased
- Option to place 2nd test strip removed
- Small projects < 3K test strip, PWL not required
- VMA Action and Suspension limits narrowed
- PWL double sided density removed

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- FAA- “Owner Representatives” *(H Spec defines this individual as Resident Project Representative or RPR)*
- Percent Within Limits (PWL)
  - Air Voids
  - Mat Density
  - Joint Density
  - Stability and Flow *(H spec removed and replaced with APA/Hamburg in design, could be in older AC)*
  - Ride Quality
  - **Quality Assurance**
  - **QC Test requirements**
  - **No Dispute resolution- QA Test results prevail**
    - Additional Cores for Mat calculation

"Advisory" Circular

- RPR/Consultant Engineer
  - "Options"
    - Quantity Exceptions
      - H-No PWL < 3000 tons
    - RAP
    - ***SUPERPAVE* - *H spec clear that SUPERPAVE SHALL be used if "prevalent"***

Job Mix Formula - Critical first step

12/21/2018 AC 150/5370-10H

Table 1. Asphalt Design Criteria

Test Property	Value	Test Method
Number of blows or gyrations	[75]	
Air voids (%)	3.5	ASTM D3203
Percent voids in mineral aggregate (VMA), minimum	See Table 2	ASTM D6995
Tensile Strength Ratio (TSR)[1]	not less than [80] at a saturation of 70-80%	ASTM D4867
Asphalt Pavement Analyzer (APA)[2]	Less than 10 mm @ 4000 passes	AASHTO T340 at 250 psi hose pressure at 64°C test temperature

[1] Test specimens for TSR shall be compacted at 7 ± 1.0 % air voids. In areas subject to freeze-thaw, use freeze-thaw conditioning in lieu of moisture conditioning per ASTM D4867.

[2] AASHTO T340 at 100 psi hose pressure at 64°C test temperature may be used in the interim. If this method is used the required Value shall be less than 5 mm @ 8000 passes

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75 blows or gyrations shall be specified for airports serving aircraft greater than 60,000 pounds. 50 blows or gyrations may be specified for airports serving aircraft 60,000 pounds or less.

The APA procedure has shown that mixes that meet the requirements above perform well under aircraft loading. The APA is preferred on airport pavement projects serving aircraft greater than 60,000 pounds. If APA is not available in an area, compacted mix design samples may be sent to a laboratory that has an APA or the Hamburg wheel test (AASHTO T 324) 10mm @ 20,000 passes may be used with FAA approval.

Specify a TSR of not less than 85 in areas with aggregate that have a history of stripping.

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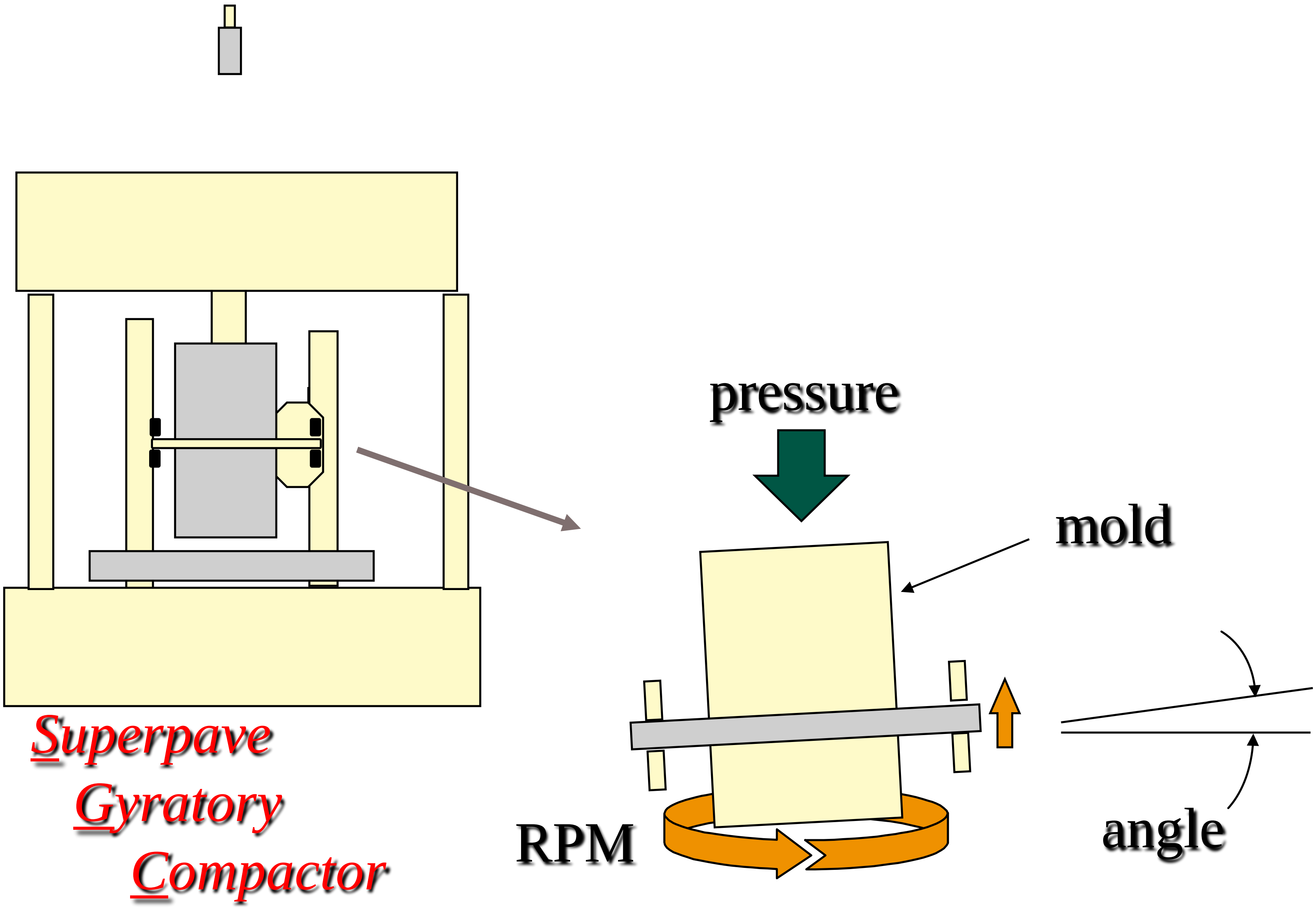
SUPERPAVE

- SUPERPAVE the Industry standard
  - Initial Projects were let statewide in 1996
  - 100% SUPERPAVE Implementation on projects ***let*** in 1999

Gyratory Compactor

- Gyrations are a function of Mix ESAL's
  - MORE ESAL's- More gyrations
    - LESS ASPHALT (Rutting)
- Simulate the effect of traffic after over the "life cycle"


pressure
mold
angle
RPM
Superpave
Gyratory
Compactor

SUPERPAVE Features

- Sample size
  - 115 mm +/- 5 mm
  - Typically 4600 grams
- Number of Specimens
  - Asphalt Institute MS-2, 7th edition recommends minimum of 2 replicate samples
- Ndesign
  - 75 gyrations > 60,000 lbs
  - 50 gyrations < 60,000 lbs

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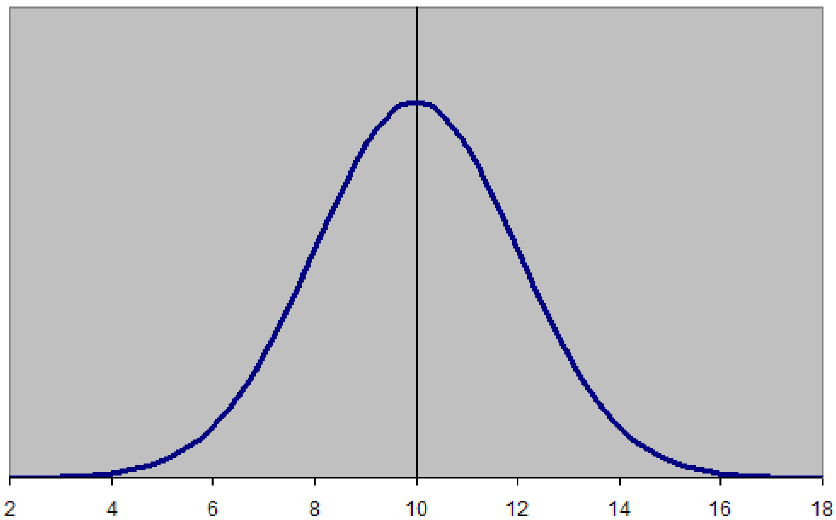
Percent Within Limits (PWL)- Mean

- Mean (or average) is the principal measure of a distribution of measurements

$$\overline{X} = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + X_3 + \ldots X_n}{n}$$

- The mean coincides with the midpoint of a Normal Distribution

$\overline{X}$



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Mean Example

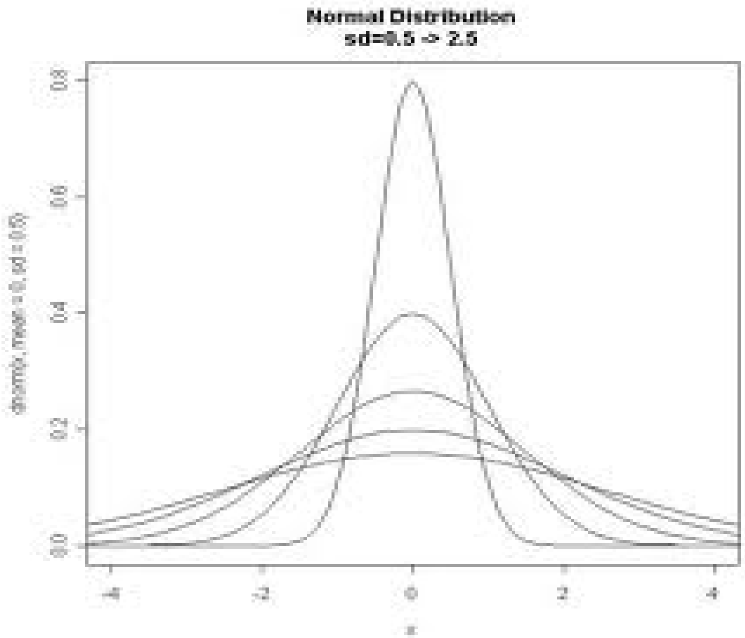
Data Point	Set A	Set B
1	10	1
2	8	6
3	9	7
4	7	6
5	6	7
6	9	6
7	3	7
8	7	6
9	2	6
10	1	10
Total	62	62
Mean	6.2	6.2

Deviation

Data Point	Set A	Deviation	Set B	Deviation
1	10	3.8	1	-4.2
2	8	1.8	6	-0.2
3	9	2.8	7	0.8
4	7	0.8	6	-0.2
5	6	-0.2	7	0.8
6	9	2.8	6	-0.2
7	3	-3.2	7	0.8
8	7	0.8	6	-0.2
9	2	2.8	6	-0.2
10	1	-4.2	10	3.8
Total	62		62	
Mean	6.2		6.2	

Standard Deviation

- Standard Deviation is a measure of the Variability of a set of values which is represented by the square root of the Variance
- Standard Deviation is a statistic that tells you how tightly all the various examples are clustered around the mean in a set of data



$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}}$$

Standard Deviation

Data Point	Set A	Deviation	Deviation^2	Set B	Deviation	Deviation^2
1	10	3.8	14.44	1	-4.2	17.64
2	8	1.8	3.24	6	-0.2	0.04
3	9	2.8	7.84	7	0.8	0.64
4	7	0.8	0.64	6	-0.2	0.04
5	6	-0.2	0.04	7	0.8	0.64
6	9	2.8	7.84	6	-0.2	0.04
7	3	-3.2	10.24	7	0.8	0.64
8	7	0.8	0.64	6	-0.2	0.04
9	2	2.8	7.84	6	-0.2	0.04
10	1	-4.2	17.64	10	3.8	14.44
Total			89.6			43.6
Variance			9.96			4.84
Std Dev			3.16			2.20

What is PWL?

- Percent within Limits
  - Normal distribution to predict % of material in-spec or out of specification

LSL = JMF – Lower Tolerance

USL = JMF + Upper Tolerance

$$Q_l = \frac{\bar{x} - LSL}{s} \qquad Q_u = \frac{USL - \bar{x}}{s}$$

TPWL = (LPWL+UPWL) – 100

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Critical Considerations in development of JMF, Production and Construction – CONSISTENCY!

- Plant
  - Batch vs. Drum
  - Cold feed bins
- Production capabilities
- Proportional balance of aggregates in JMF
- Aggregate properties
- Aggregate Variability
- Gradation/Segregation
- Volumetric Control in Production
- Stockpile Management
- Aggregate Moisture
- Silo Management
- Paver
- Paving Speed
- Rollers
- MTV
- People
- Etc.

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Mix Design

- P 401 hot mix asphalt design used during airport construction
- Mix Design Methodology:
  - Asphalt Institute MS-2, Mix Design Methods- 7th Edition *(Best Source)*

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Summary of FAA Mix Design

1. Aggregates properties are tested (soundness, abrasion, crush count, liquid limit, plasticity index, sand equivalence) and must be acceptable in accordance with requirements
2. Aggregate blends are developed that fall within the **general** limits established, blends are plotted on a power 0.45 curve
3. Batches of the proposed aggregate blend are prepared, minimum of 2 specimens are used for each asphalt content for bulk analysis to develop a minimum of 4 separate asphalt contents

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Summary of FAA Mix Design

4. Minimum of 4 asphalt contents will be prepared, each differing by 0.5%, with the intention of bridging the optimum asphalt content
5. Bulk specific gravity and maximum theoretical specific gravities are measured for each asphalt content, volumetric properties are derived through calculation. Optimum asphalt content is chosen based on air void target (3.5%) All other volumetric properties shall be met at that optimum

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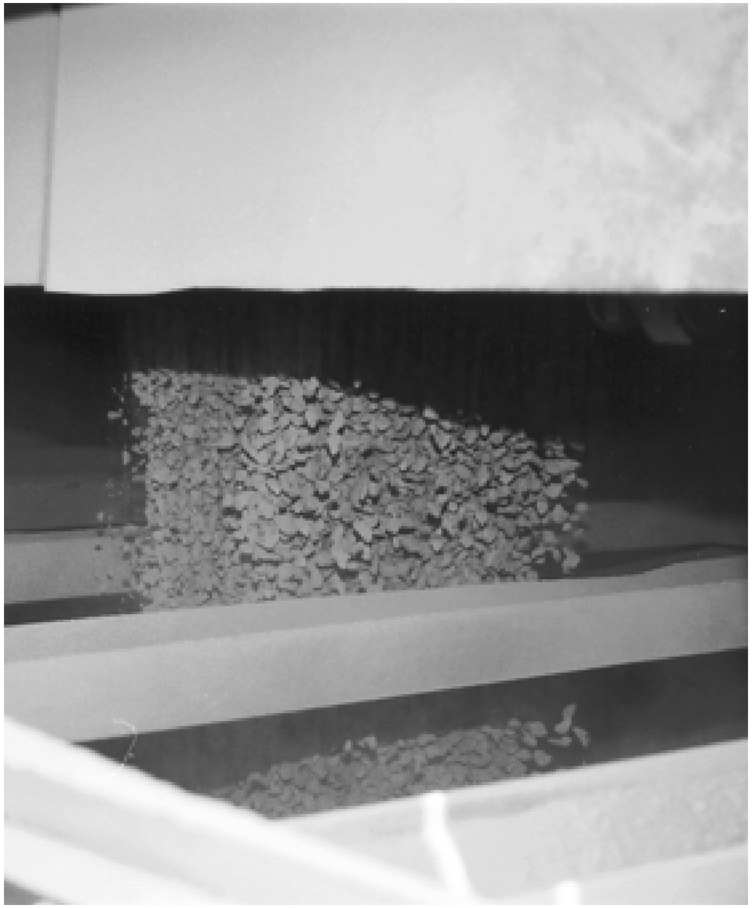
Summary of FAA Mix Design

7. Volumetric property measurements are plotted against asphalt content
8. Optimum asphalt content is chosen from plots and verified with additional batches
9. TSR testing is performed at the optimum asphalt content
10. Asphalt Pavement Analyzer or Hamburg testing completed at optimum to evaluate rutting potential of mixture

Preliminary Procedures

- Determine aggregate properties
- JMF is developed using either plant bins or stockpiles (hot bins are highly recommended at a batch plant)



P401 Specification Coarse Aggregate

- LA Abrasion
  - 40% Maximum
- Soundness
  - 5 cycle Sodium = 12% Loss
  - 5 cycle Magnesium = 18% Loss
- Clay lumps and friable
  - < 0.3% *(H change from 1%)*
- Crush Faces
  - > 60K = 75/85
  - < 60K = 50/65
- Flat and Elongated
  - 5:1 = 8%
  - 3:1 = 20% *(H change removes 3:1)*

Source Properties

- LA Abrasion
  - Indicates an aggregate's ability to withstand breakdown during handling, mixing and placement (compaction)
- AASHTO T96
- "Impacts"
  - Coarse grained Granite/Gneiss
    - Brittle in LA though perform well in field
  - Carbonates/Shale
    - Perform well in LA but degrade in field when wet

Wear-Abrasion (ASTM C 131)

- Measures the resistance to wearing as aggregate is subjected to impact and grinding
- Ensures that aggregate will not wear excessively during shipment and production
- Standard graded aggregate is subjected to impact and grinding by steel spheres inside a hollow steel chamber

Wear-Abrasion (ASTM C 131)

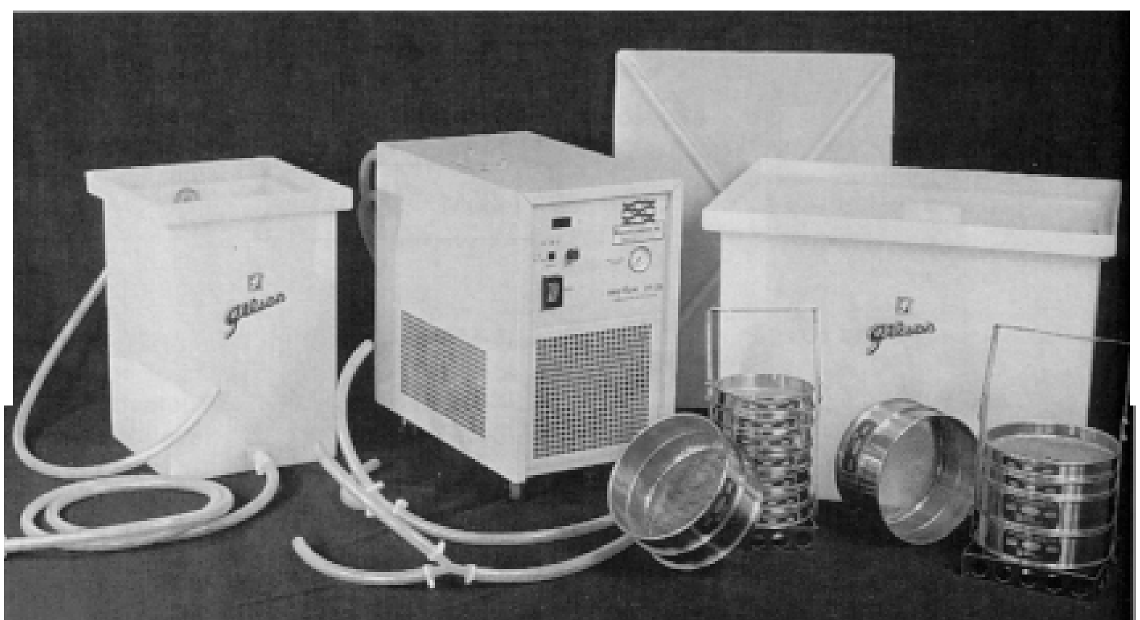
- This loss is measured over the 1.7 mm (#12) sieve
- 40% wear for surface courses
- *H Specification removes allowance for locally performing aggregates exceeding LA limit of 40%*

Soundness (ASTM C 88)

- The soundness test subjects aggregate particles to alternating cycles of soaking in a salt solution (either sodium or magnesium sulfate) and drying in an oven regulated at 110±5˚C (230±9˚F)
- Salts permeate the voids of the aggregate during soaking and expand during drying, simulating the expansive pressures of water

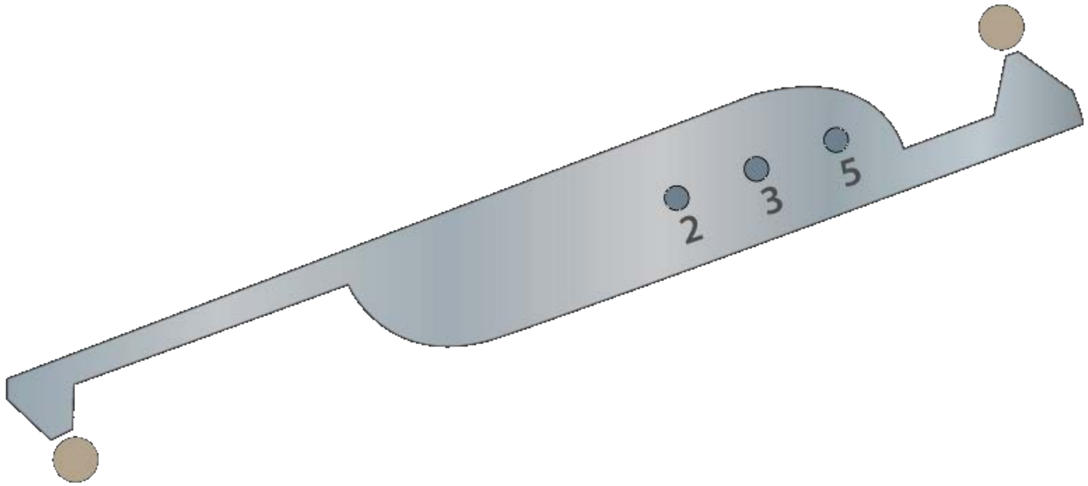
Soundness (ASTM C 88)

- The soundness value is also a measure of loss of particles after the sample has been subjected to a specified number of soaking and drying cycles
- Specification stipulates the maximum loss as 12% for sodium sulfate tests and 18% for magnesium sulfate tests



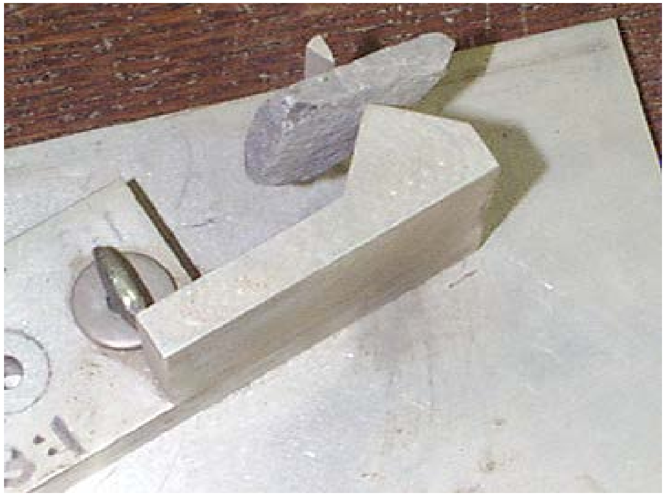
Flat & Elongated (ASTM D 4791)

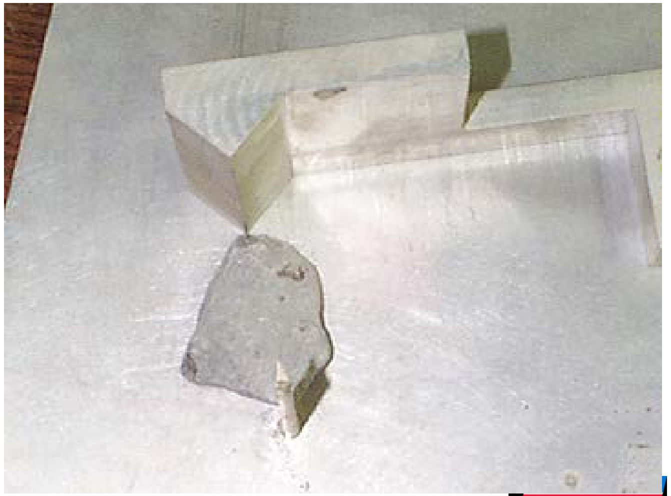
- Flat and elongated particles in an aggregate are measured using a proportional caliper device set to the appropriate ratios required by the agency
- Flat AND elongated test: length to thickness is compared



Flat & Elongated (ASTM D 4791)

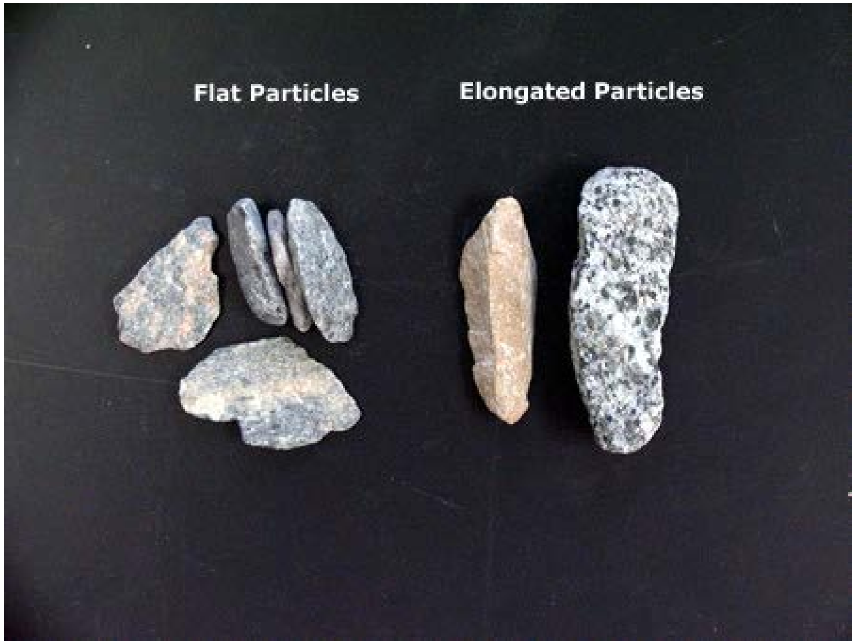
- Flat & Elongated (ASTM D 4791)
  - Flat or elongated particles in an HMA mixture may degrade more quickly than non flat or elongated particles, thereby reducing the durability of the pavement
  - Specification limits the amount of these particles in the coarse aggregate to no more than 8% at a 5:1 ratio. H specification removes option to evaluate F & E at 3:1





Flat and Elongated Particles

- Generally believed higher F & E detrimental to pavement performance- difficulty with compaction
- ASTM D 4791
  - Highly variable at low ratios (< 5:1) F & E which could mask the relationship to actual pavement performance



Crushed Pieces aka Coarse Aggregate Angularity

- In order to produce pavements that are resistant to deformation, it helps to use angular aggregate particles
- Angular aggregates tend to interlock and resist deformation after repeated loading
- The crushed pieces requirement in the specification is meant to ensure the aggregate angularity is maintained

Cubical Aggregate

Rounded Aggregate

Crushed Pieces

- Requirements for crushed pieces in coarse aggregate are dependent upon anticipated loading of pavement

Percentage of Fractured Particles	For pavements designed for aircraft gross weights of 60,000 pounds (27200 kg) or more: Minimum 75% by weight of particles with at least two fractured faces and 85% with at least one fractured face[1]	ASTM D5821
	For pavements designed for aircraft gross weights less than 60,000 pounds (27200 kg): Minimum 50% by weight of particles with at least two fractured faces and 65% with at least one fractured face[1]	

Coarse Aggregate Angularity

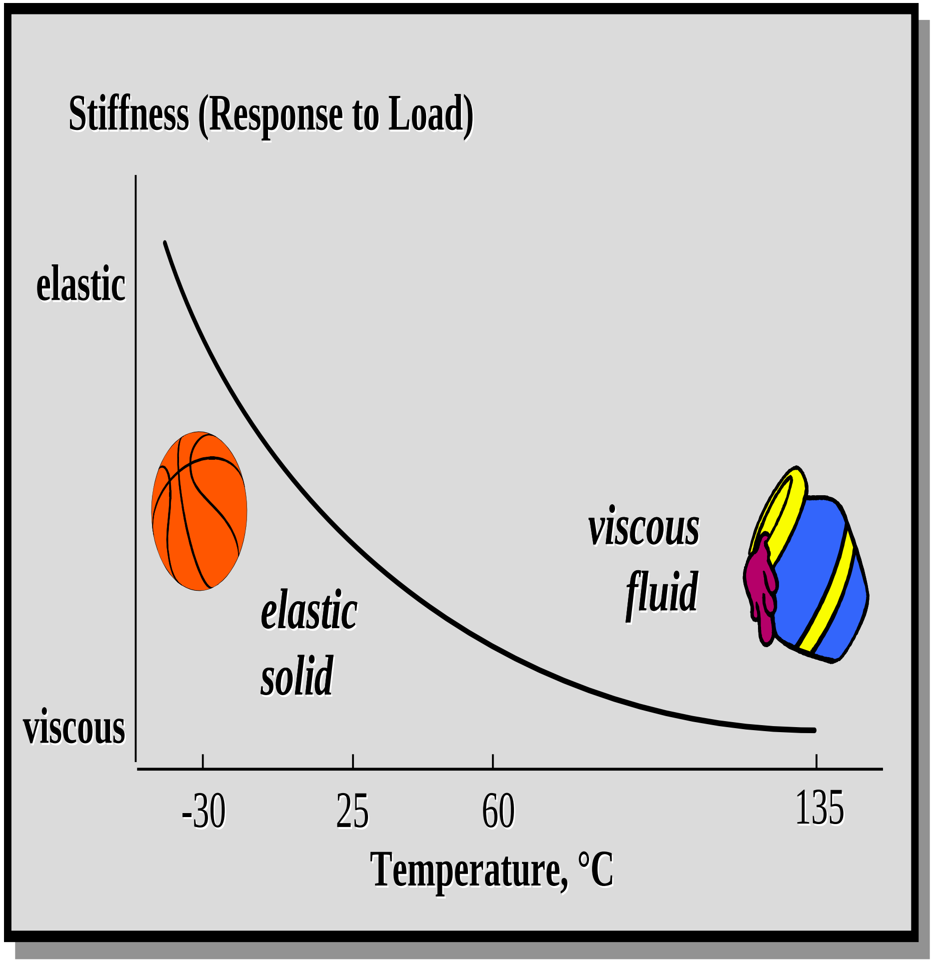
- Coarse Aggregate Angularity
  - "Fractured Faces"
  - Identified as a very important indicator of pavement performance
    - Aggregate "interlock" and internal friction
- ASTM D5821
  - Highly subjective visual examination- gravel

P401 Fine Aggregate

- No more than 15% natural sand - *(H spec encourages to use the minimum amount to achieve workability if needed)*
- Soundness- C-88, 5 cycles, 10% sodium, 15% mag
- Plasticity < 6 *(H spec reduces this to < 4)*
- Sand equivalent is 45 % *(H spec removes allowance for locally available aggregates with performance history)*

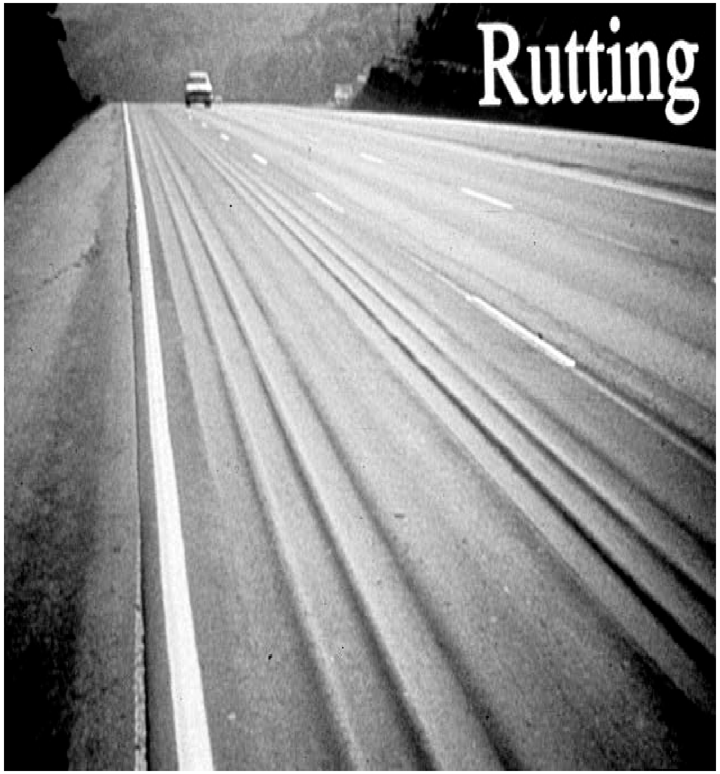
Asphalt Cement (Binder)

- Specifications evolved to characterize asphalt binder's viscosity in the 1960's.
- Viscosity is defined as resistance to flow
  - Asphalt is "temperature viscous"
    - Temperature of the material affects it stiffness (or resistance to flow)



Binder Tests

- Need to further characterize asphalt binder due to widespread pavement failures (permanent deformation)
  - Radial tires
  - Increased truck traffic
    - Higher tire pressures
  - Changes in refining process



Superpave Binder

- Rolling Thin Film Oven Test
- Pressure Aging Vessel
- Direct Tension Tester
- Dynamic Shear Rheometer
- Bending Beam Rheometer

Direct Tension Bath and Load Frame

Binder

Superpave Binder specification grading based on pavement climatic conditions from FHWA Long Term Pavement Program (LTPP)

PG 64-22

Performance Grade

Average max pavement design temp in Celsius

Min pavement design temp in Celsius

Binder

- PG System
- Grade bumping based on aircraft weight
  - < 12,500lbs Standard
  - <100,000lbs - 1 grade
  - > 100,000lbs -2 grade
- "Plus" specifications
  - Elastic recovery to ensure that material polymer modified (70%). **H SPEC increases to 75%**
- Highly polymerized materials can be difficult to use at reasonable temperatures

MSCR Binder

- MSCR
  - Multiple Stress Creep Recovery
  - AASHTO TP 70
- DSR
  - High and intermediate temperature grading
- NEW Grading for asphalt
- PG Grading appropriate for grading, followed by "letter" designation

- Changes to AASHTO M320, Table 1
  - PG 64S-22
    - Standard traffic loading
  - PG 64H-22
    - Heavy traffic loading
  - PG 64V-22
    - Very heavy traffic loading
  - PG 64E-22
    - Extremely heavy traffic loading

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PG Binder - 10H

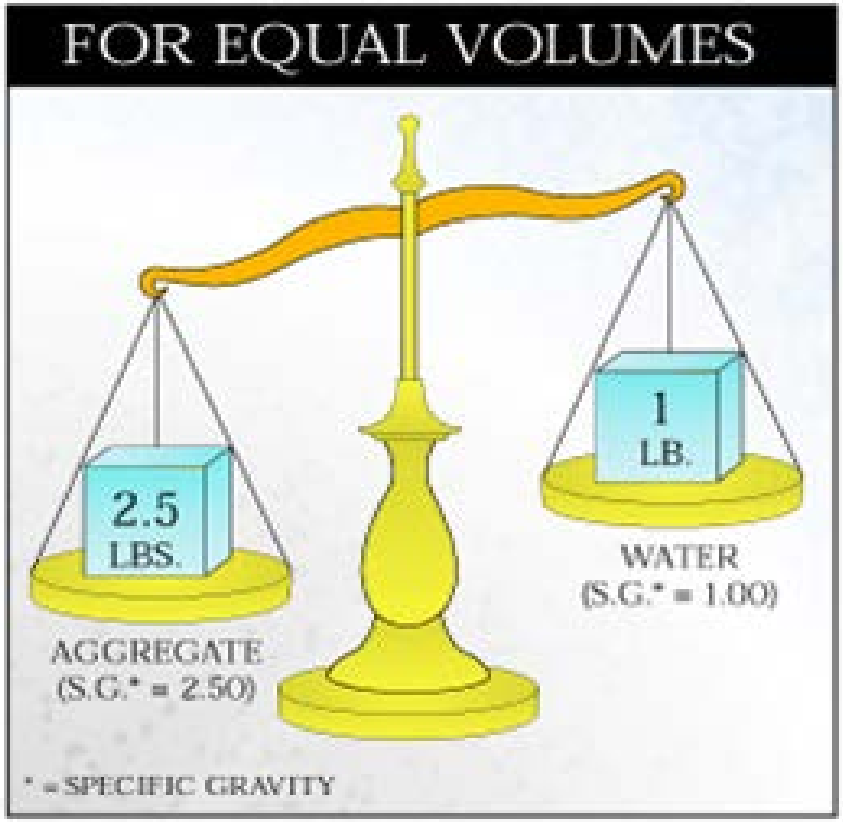
- Elastic Recovery minimum for ***polymer modified PG Binder increased to 75%***
- Typical 64E22, or 76-22 will likely not meet this requirement without additional polymer
- You will need to communicate this requirement to your binder supplier
- Manage storage so as not to co-mingle even if polymer modified….potential to fail the Elastic Recovery of 75%

Specific Gravity

- All matter has weight (mass) and occupies space (volume)
- Volumetrics are the relationships between mass and volume
- Density = MASS/VOLUME

Specific Gravity

- Specific Gravity or "Relative Density" relates mass to volume
- Ratio of the solid unit weight of a substance relative to the weight of de-aired, water at room temperature displaced by that object
  - Based on principles of buoyancy discovered by Archimedes in his "Eureka" moment



Voids in Mineral Aggregate (VMA)

Table 2. Aggregate - Asphalt Pavements

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation 1	Gradation 2	Gradation 3[1]
1 inch (25.0 mm)	100	--	--
3/4 inch (19.0 mm)	90-100	100	--
1/2 inch (12.5 mm)	68-88	90-100	100
3/8 inch (9.5 mm)	60-82	72-88	90-100
No. 4 (4.75 mm)	45-67	53-73	58-78
No. 8 (2.36 mm)	32-54	38-60	40-60
No. 16 (1.18 mm)	22-44	26-48	28-48
No. 30 (600 µm)	15-35	18-38	18-38
No. 50 (300 µm)	9-25	11-27	11-27
No. 100 (150 µm)	6-18	6-18	6-18
No. 200 (75 µm)	3-6	3-6	3-6
Minimum Voids in Mineral Aggregate (VMA)	14.0	15.0	16.0
Asphalt percent by total weight of mixture:			
Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	6.5-9.5	7.0-10.5
Recommended Minimum Construction Lift Thickness	3 inch	2 inch	1 1/2 inch

[1] Gradation 3 is intended for leveling courses. FAA approval is required for use in other locations.

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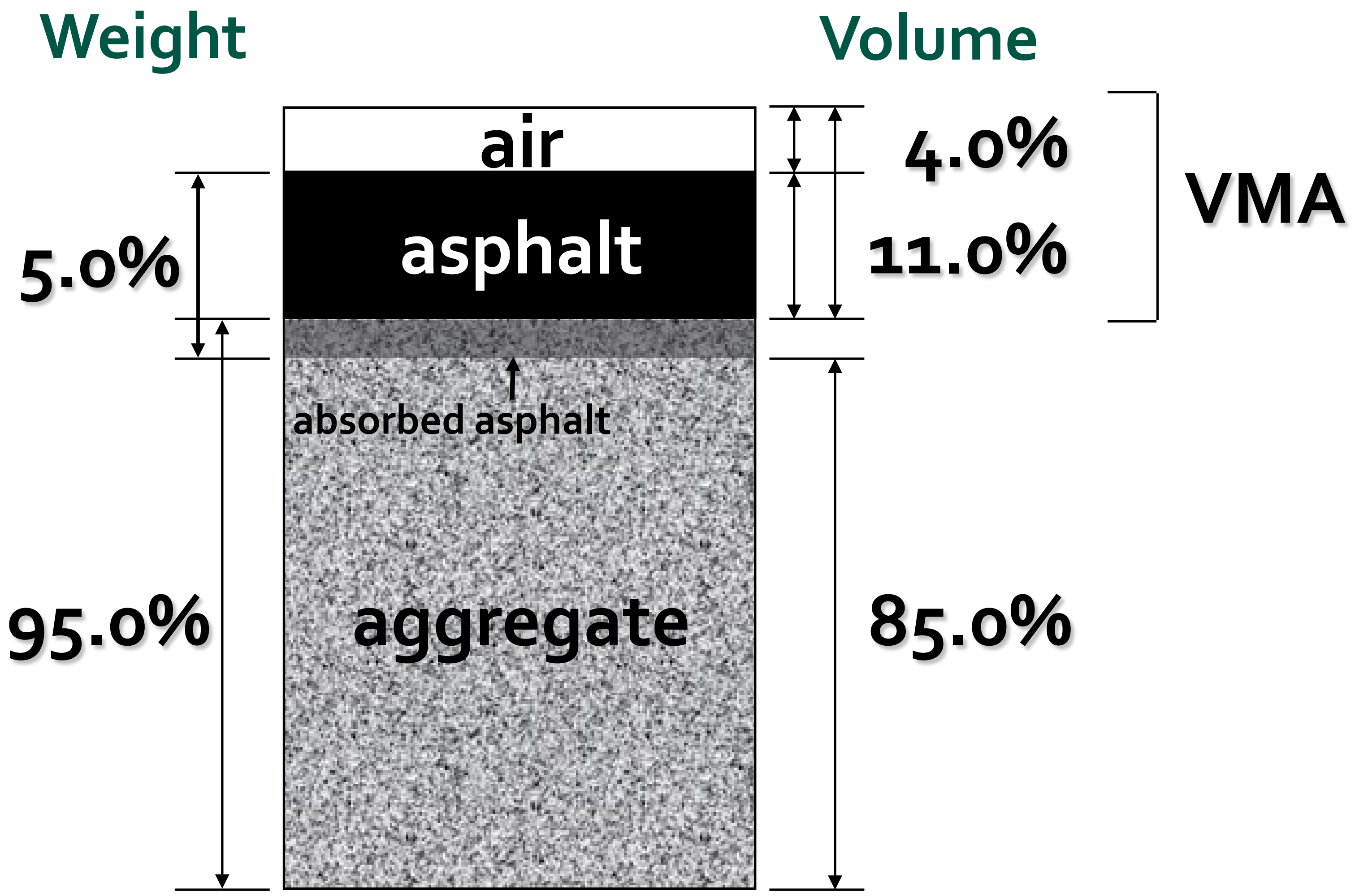
Production VMA tolerances changed in 10H. Action limit is -0.5%, and Suspension is -1.0%.
It is recommended to design well above minimum

Volumetrics



Specific Gravity

- Specific Gravity of component materials in mix must be precisely defined because they are used in all calculations converting mass to volume

Specific Gravity of Coarse Aggregates (ASTM C 127)

- Specific gravity of coarse aggregate is performed in the lab on samples that have soaked for 24±4 hours in water at room temperature
- Of particular interest to the HMA designer is the measurement of the stone's bulk specific gravity, G_{sb}

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Specific Gravity of Fine Aggregates (ASTM C 128)

- The specific gravity of the fine aggregate needs to be determined as well
- This method uses a glass pycnometer of a known volume to determine the water displaced by the sample

Combined Bulk Specific Gravity

- The bulk gravities of the combined aggregates in the mixture have a significant effect on the overall density of the mixture
- The combined bulk gravity of all constituents, based on their percentage in the blend, is used to calculate VMA (Voids in Mineral Aggregate)

$$G_{sb} = \frac{(P_1 + P_2 + P_3)}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \frac{P_3}{G_3}}$$

G_{sb} = Bulk specific gravity of combined aggregate

P_i = Percent by mass of each aggregate in blend

G_i = G_{sb} of each aggregate in the blend

Best Practices

- Particle shape- cubical is desired but we need to work with what is locally available. Some F and E helps VMA
- Gsb- critical for all aggregates. Increase frequency as variability increases.
- Be sure to have adequate supply of aggregate on hand for mix design. Going back for more could impact results
- Awareness of all properties and impact
- Visual inspection imperative in identifying a change

Selection of Gradation P401 Gradation Bands

AC 10 G

Table 3. Aggregate - HMA Pavements

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation 1	Gradation 2	Gradation 3
1 inch (25 mm)	100	--	--
3/4 inch (19 mm)	76-98	100	--
1/2 inch (12 mm)	66-86	79-99	100
3/8 inch (9 mm)	57-77	68-88	79-99
No. 4 (4.75 mm)	40-60	48-68	58-78
No. 8 (2.36 mm)	26-46	33-53	39-59
No. 16 (1.18 mm)	17-37	20-40	26-46
No. 30 (0.600 mm)	11-27	14-30	19-35
No. 50 (0.300 mm)	7-19	9-21	12-24
No. 100 (0.150 mm)	6-16	6-16	7-17
No. 200 (0.075 mm)	3-6	3-6	3-6
Asphalt percent:			
Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	6.5-9.5	7.0-10.5

AC 10 H

Table 2. Aggregate - Asphalt Pavements

Sieve Size	Percentage by Weight Passing Sieves		
	Gradation 1	Gradation 2	Gradation 3[1]
1 inch (25.0 mm)	100	--	--
3/4 inch (19.0 mm)	90-100	100	--
1/2 inch (12.5 mm)	68-88	90-100	100
3/8 inch (9.5 mm)	60-82	72-88	90-100
No. 4 (4.75 mm)	45-67	53-73	58-78
No. 8 (2.36 mm)	32-54	38-60	40-60
No. 16 (1.18 mm)	22-44	26-48	28-48
No. 30 (600 µm)	15-35	18-38	18-38
No. 50 (300 µm)	9-25	11-27	11-27
No. 100 (150 µm)	6-18	6-18	6-18
No. 200 (75 µm)	3-6	3-6	3-6
Minimum Voids in Mineral Aggregate (VMA)	14.0	15.0	16.0
Asphalt percent by total weight of mixture:			
Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	5.0-7.5	6.5-9.5	7.0-10.5
Recommended Minimum Construction Lift Thickness	3 inch	2 inch	1 1/2 inch

[1] Gradation 3 is intended for leveling courses. FAA approval is required for use in other locations.

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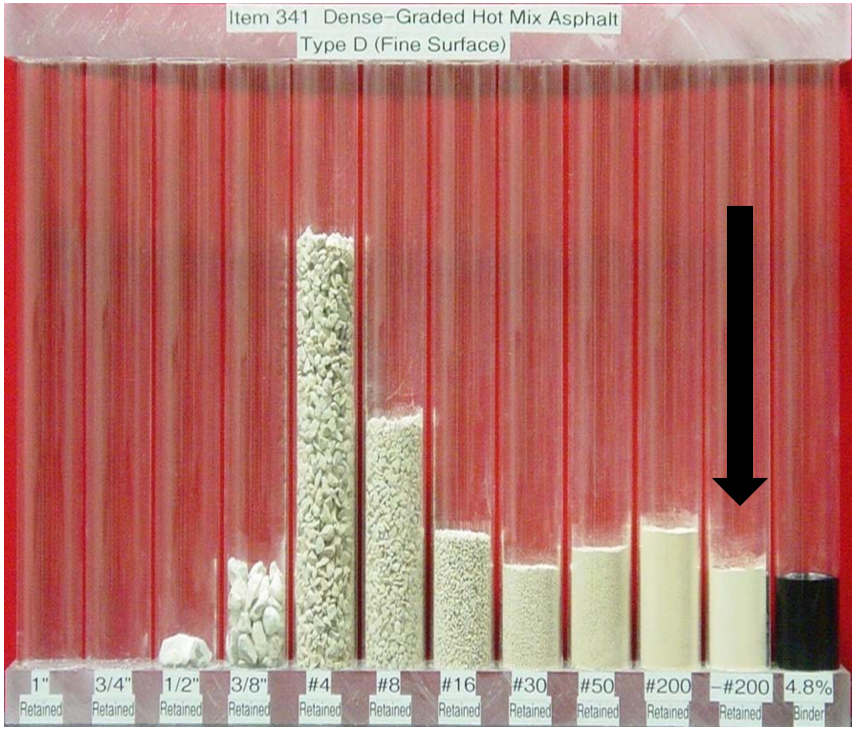
Gradation

- Combined aggregate gradation impacts mixture stiffness, mix stability, durability, permeability, workability, fatigue resistance, frictional resistance and resistance to moisture damage

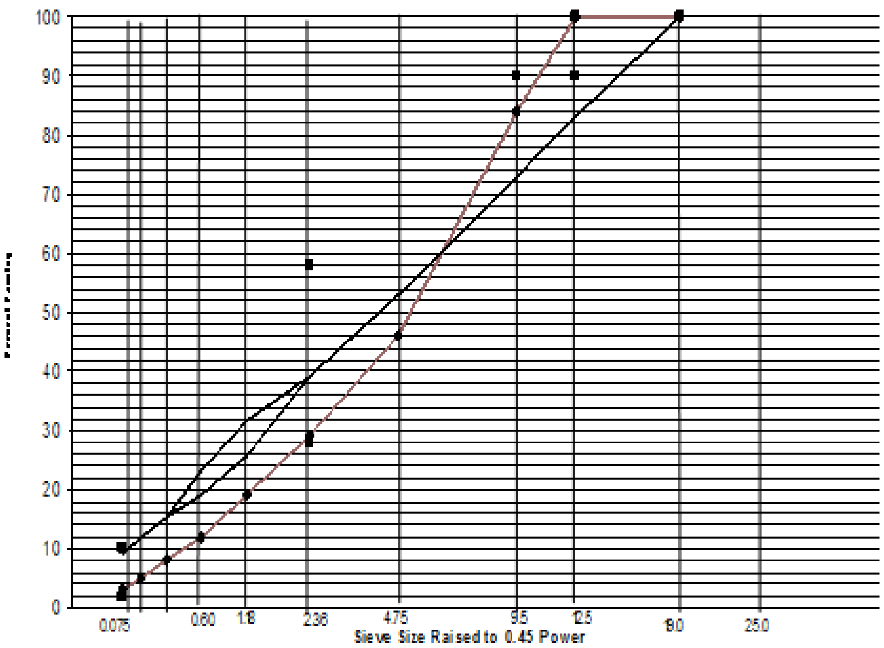
Gradation

- Ideal gradation provides adequate space for minimum amount of asphalt binder and air voids, while ensuring adequate stability
- #200 / 0.075 µm



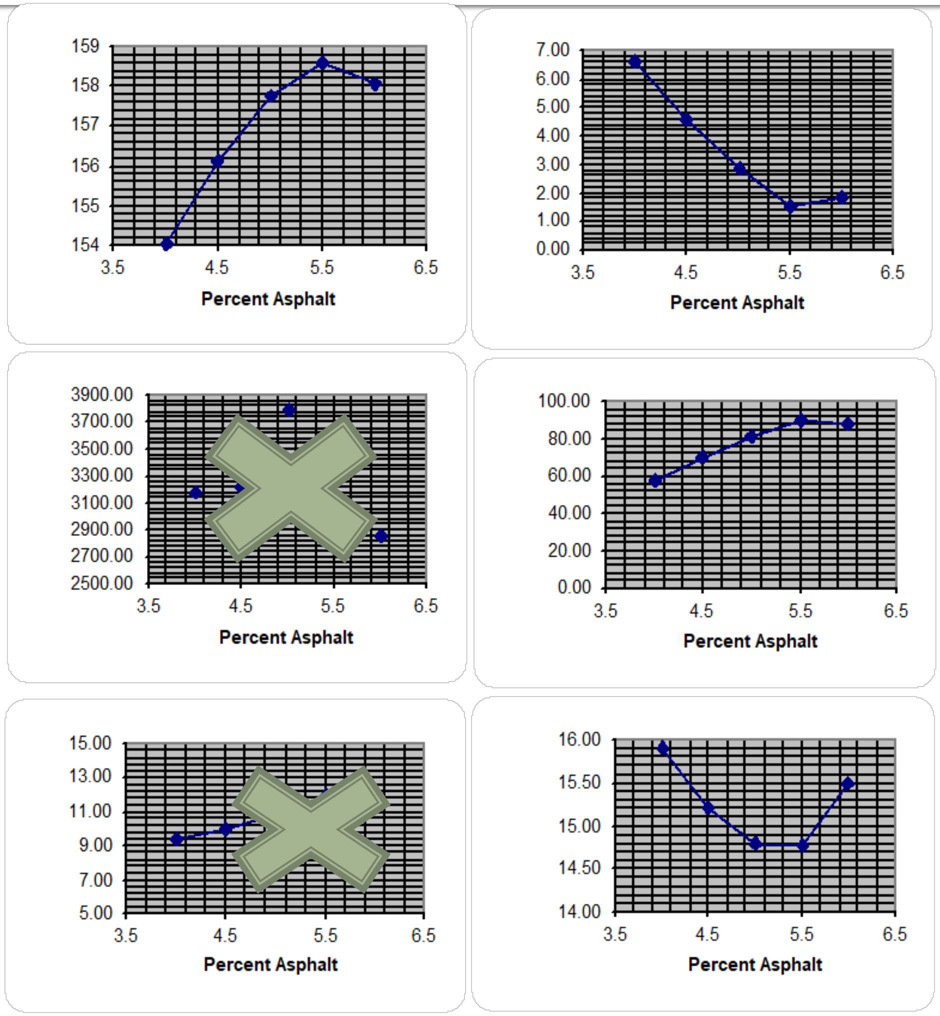
Gradation

- 0.45 Power Chart
- Incremental sieves double in size from fine to coarse along x-axis (intermediate fractions have been added as sieves sizes get larger)
- Maximum density line determined from sieve size raised to 0.45 power
  - Densest packing of materials (Nijboer, 1961)



Gradation is selected- Volumetric Mix Design

- Test results on each of the blends are plotted graphically to show physical properties
- Optimum asphalt content is selected from graphical representations of test data
- Mix properties plotted against asphalt content as part of volumetric mix design method



Mixing Equipment

- Pans, metal, flat bottom for the heating of test specimens
- Oven and hot plate for heating asphalt and aggregate to required temperatures

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Mixing Equipment

- Mixing bucket will be required for larger SUPERPAVE specimens
- Scoop, for batching aggregates

Mixing Equipment

- Container for heating asphalt (hopper with control valve recommended)
- Thermometers, armored glass, or metal stem (50 to 450˚ F with sensitivity of 5.0˚ F) for determining temperature of aggregate, asphalt, and asphalt mixture
- Balance, 10Kg capacity, sensitive to 0.5g for weighing aggregates and asphalt

SUPERPAVE Gyratory Compactor and molds

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Aggregate Batching

- Each particle size for each aggregate constituent is placed into each batch
- The size of the batches (around 4800 g) is intended (when mixed with the liquid binder) to produce bulk specimens that are 115 mm ±5 mm in height after compaction

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Aggregate Batching

- Prepare at least 3 (2 bulk samples and 1 split rice) for each asphalt content
- Aggregates in batches shall be dried to constant mass at 221 to 230˚F (105 to 110˚C) and separated by dry-sieving into the desired fractions
- Aggregate batches consist of the proposed blend of aggregates to be used in the HMA

Material Heating

- Aggregate is placed into an oven regulated 50˚F (20˚C) higher than the mixing temperature indicated by COA of binder supplier
- Liquid binder should be heated to the mixing temperature (not more than 1 hour prior to mixing) and covered
- Mixing should not begin until the aggregate and liquid binder have stabilized at the appropriate temperature
- Take care not to overheat liquid
- Use proper PPE when handling hot liquid asphalt in the laboratory

Mixing & Compaction Temperatures

- Mixing and compaction temperatures determined by the temperature viscosity chart
- Mixing temperature is defined as that range of temperatures that produces a viscosity of 0.17±0.02 kPa (170±20 centistokes) in the liquid binder (asphalt cement)
- Compaction temperature is defined as that range of temperatures that produces a viscosity of 0.28±0.03 kPa (280±30 centistokes) in the liquid binder (asphalt cement)

Mixing HMA

- Keep all materials up to temperature as much as possible
- Keep bucket and all mixing/compacting equipment to temperature in oven
- Charge heated bucket with aggregates, dry mix thoroughly

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Mixing HMA

- Form a crater in the dry aggregate
- Weigh out the appropriate mass of liquid binder (asphalt cement) into the batch in accordance with accumulated batch weights
- Mix HMA with mechanical mixer
- Mix HMA so that liquid binder coverage is uniform, with minimal loss of heat

Compacting Specimens

- Charge the specimen mold with the mixture

Compacting Specimens

- Determine the temperature of the sample, it should be within the compaction temperature range
- If the specimen is cold, it shall be discarded; reheating is not allowed

Compacting Specimens

- When compaction is completed, remove specimen from apparatus, remove protection disks, and allow it to cool

Compacting Specimens

- Cool long enough so that when it is extruded with the specimen extruder no deformation will result

Test Procedure

- Each compacted specimen is evaluated for air voids
- Two maximum theoretical specific gravity samples are prepared and tested at each asphalt content
- Maximum Specific gravity required to calculate the void level of the bulk specimen

Bulk Specific Gravity (G_{mb}) ASTM D 2726

- Care should be taken to avoid distortion of specimen when removing from mold
- Specimens shall be free of foreign materials prior to testing
- Determine the mass of the specimen after it has been standing in air at room temperature for at least one hour, designate as mass A

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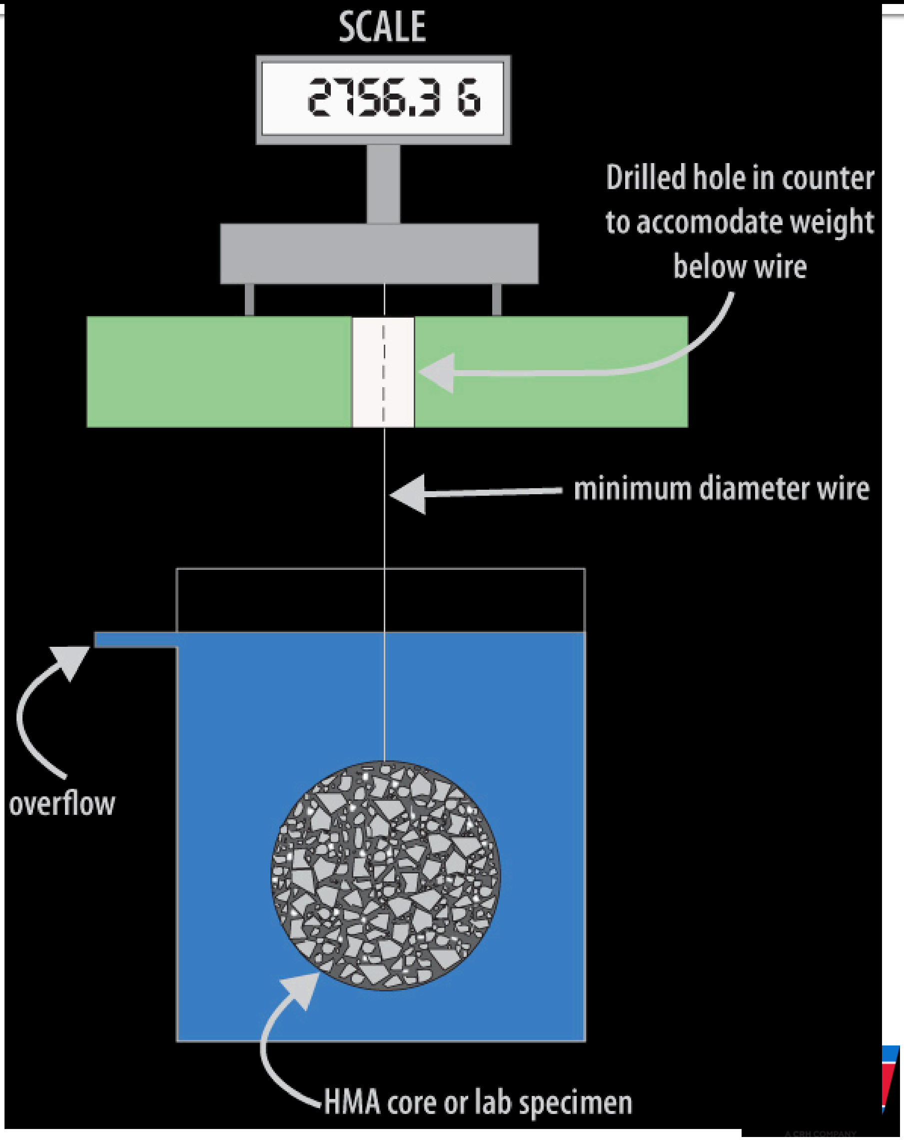
Bulk Specific Gravity (G_{mb}) ASTM D 2726

- Immerse the specimen in a water bath at 77±1.8˚F (25±1˚C) for 3 to 5 minutes
- Maintain proper water level on weigh below apparatus with overflow outlet



Bulk Specific Gravity (G_{mb}) ASTM D 2726

- Record mass of immersed specimen as C mass

Bulk Specific Gravity (G_{mb}) ASTM D 2726

- Remove the specimen from the bath and quickly blot specimen with a damp towel (remove surface moisture of specimen, but leave internal moisture)
- Record mass of SSD (saturated, surface dry) specimen as C
- Bulk specific gravity (G_{mb}) = A/(B–C)
- Report G_{mb} to nearest 0.001

Maximum Theoretical Specific Gravity (ASTM D 2041)

- The maximum theoretical specific gravity is the ratio of the mass of a given volume of separated and cooled hot mix asphalt at 25˚C (77˚F) to the mass of an equal volume of water at the same temperature

Maximum Theoretical Specific Gravity (ASTM D 2041)

- The sample is subjected to a partial vacuum (required to be 3.7 ± 0.3 kPa (25.5 to 30 mm Hg) for 15±2 minutes) in order to remove the air trapped between the particles of the sample

Maximum Theoretical Specific Gravity (ASTM D 2041)

- This mass to volume measurement expresses the density of the mixture as if it had no air voids.
- The maximum Specific Gravity (G_{mm}) is used in conjunction with Bulk Specific Gravity (G_{mb}) to determine Percent Air Voids (P_a) in compacted bituminous materials

Density and Voids Analysis

- Average the bulk specific gravity values (G_{mb}) for all test specimens of a given asphalt content
- Values obviously in error shall not be included in the average (consult test methods for guidance on d2s)
- Determine the unit weight for each average G_{mb} by multiplying the G_{mb} by 62.4 for pcf or 1000 for kg/m^3

Air Void (P_a) Calculation

- Air Voids (P_a) are determined using the following formula:
- $P_a = 100 – [100(G_{mb}/G_{mm})]$

Air Void (P_a) Calculation

- $G_{mb} = 2.334$
- $G_{mm} = 2.416$
- $P_a = 100 - [100(2.334/2.416)]$
- $P_a = 100 - (100 \times 0.9661)$
- $P_a = 100 - 96.61$
- $P_a = 3.39$

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VMA (Voids in Mineral Aggregate) Calculation

- VMA is determined using the following formula:

$$VMA = 100 - [(G_{mb} x P_s)/G_{sb}]$$

VMA (Voids in Mineral Aggregate) Calculation

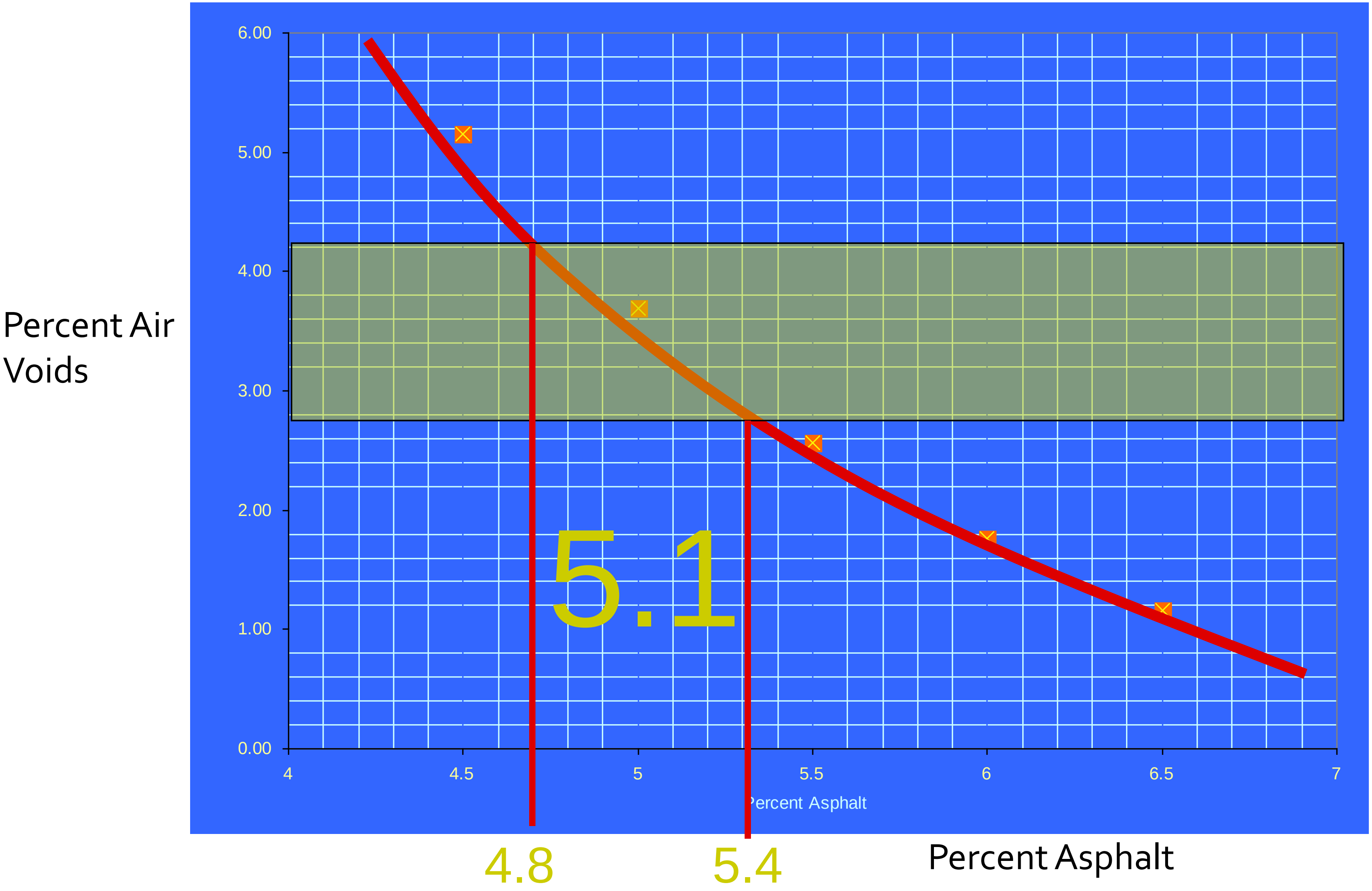
- $G_{mb} = 2.344$
- $P_s = 93.04$
- $G_{sb} = 2.651$
- VMA = 100 - [(2.344 x 93.04)/2.651]
- VMA = 100 - (218.1/2.651)
- VMA = 100 - 82.26
- VMA = 17.74

Preparation of Graphs

- Create a graphical plot for each of the following:
  - Unit weight vs. Asphalt Content
  - Percent air voids vs. Asphalt Content
  - Voids Filled with Binder vs. Asphalt Content
  - Percent VMA vs. Asphalt Content
- For each plot connect the values with a smooth curve that best fits all values

Analysis of Graphs

- Optimum asphalt content is determined as the asphalt content that produces a void level in the HMA at 3.5%
- If the other plotted values do not meet the required criteria, or are marginal, or if the mixture meets parameters but is not workable in the field, the aggregate blend could be revised or a new source of aggregates secured and a new JMF developed



6.00
5.00
4.00
3.00
2.00
1.00
0.00
4
4.5
5
5.5
6
6.5
7
Percent Asphalt
5.1
Percent Air Voids
4.8
5.4
Percent Asphalt

Verification of JMF

- When the selected optimum asphalt content does not coincide with the asphalt content used in the trial specimens, an additional set of specimens shall be prepared
- The optimum asphalt content is added to the specimens and they are tested as described to verify the actual results duplicate those anticipated from the curves

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TSR (Tensile Strength Ratio)

- Once the optimum asphalt content has been determined and verified, samples need to be prepared and tested for moisture sensitivity and the potential for stripping
- These tendencies can be gauged using ASTM D 4867, Standard Test for Effect of Moisture on Asphalt Concrete Paving Mixtures, other wise known as the TSR (Tensile Strength Ratio) test

TSR (Tensile Strength Ratio)

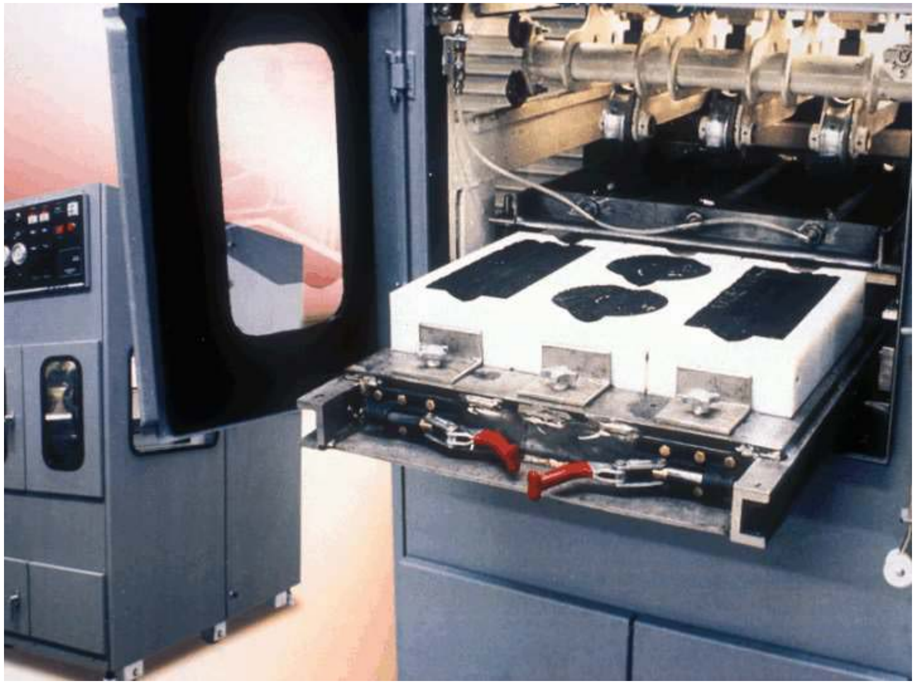
- This procedure subjects samples specially prepared at specific void level, saturated with water under vacuum, and "tortured" with some combination of hot water exposure (140˚F for 24 hrs) and possibly freeze/thaw cycles (see Note 5 in ASTM)

TSR (Tensile Strength Ratio)

- In addition, the surface of the specimens is examined for any evidence of asphalt cement stripping from the surface of the aggregates
- If the mixture fails this procedure, anti-stripping agent needs to be added to the mixture to produce the desired result

Evaluation of optimum point for rut resistance

- Asphalt Pavement Analyzer (APA)
  - AASHTO T340 @ 250 psi
    - < 10 mm of rutting@ 4000 passes
  - AASHTO T340 @ 100 psi
    - < 5 mm of rutting@ 8000 passes
- Hamburg Wheel Test
  - AASHTO T324
    - 10 mm of rutting@ 20,000 passes
    - Hamburg alternate requires FAA approval



Pre-pave Meeting

- Contractor
- Producer
- Owner
- Consultant engineer
- Assurance Testing Laboratory

Pre-test Mix

- Test the mix prior to the first day of Project!
- Work out the bugs!

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Communication

- Game Plan
  - Production goal
  - Density Specification
- Constant monitoring
  - Nuke gauge technician
  - Roller operators
  - Paving foreman
  - Project manager

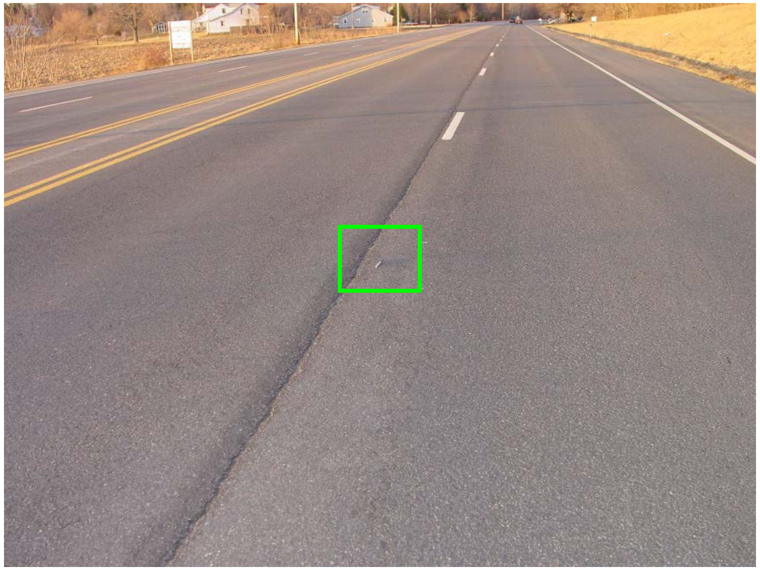
Monitor Assurance Testing

- Partnership
- Consistency
- Sampling
- Calibration
- Test Standards

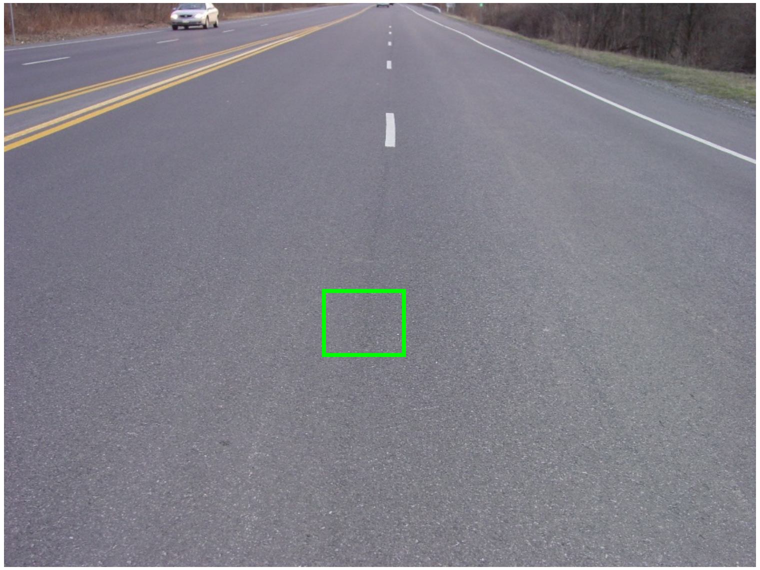
Potential Pitfalls....

- Production Temperature
  - Batch Plant
  - Multiple Customers
- Variation in aggregates
- Dust Control
  - Mechanical Failure
  - Build-up of material in Hot Bin Fines

Bad Joints



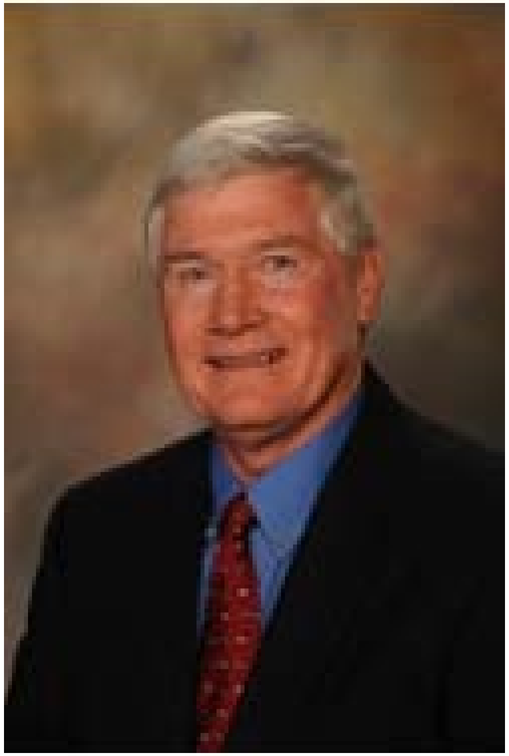
Good Joints



Sufficient Material + Mat Density @ 99% Gmb = 100PWL on Joints

NAPA Ray Brown Airport Award

- The Ray Brown Airport Pavement Award is given to the highest-rated Quality in Construction - Airport Pavement .
- The award is named after Ray Brown, who was the Director of the National Center for Asphalt Technology from 1991 until his retirement in 2007.
- Under his leadership, NCAT became the preeminent organization for asphalt pavement research.



2011 Ray Brown NAPA Award Winner

- TJ Young (Production Manager) and Chris Wright (Project Manager)
- "*We put a core rig right on the job that can run complete core tests for immediate feedback to the paving crew and for correlation to non-destruct density gauges. We feel this is a key strategy"*

Duval Asphalt, Jacksonville, FL
Runway 5-23, Craig Municipal Airport

- Stockpile Management
- Pre-test mix
- Control mix segregation
- Control temperature
- Steady production
- Constant communication between Plant and Field staff

TILCON


TILCON
TILCON
TILCON
SAFETY
INTEGRITY
QUALITY
SCALE 3
SCALE 1