HMA TESTING EQUIPMENT AND METHODS

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Acceptance Testing Requirements

OUTLINE

- PREPARING FOR TESTING
- SAMPLING
- DETERMINING COMPOSITION OF MIXTURE
- VOLUMETRIC TESTING
- TEST RESULTS AND RELATIONSHIPS

Acceptance Testing Requirements

<u>Pre-Production Meeting is KEY</u>

- Sampling Method
- Asphalt Content Procedure
- Method for Measuring In-Place Density
- Contractor Lab Use?
- Dispute Resolution Lab
- Special Provision for HMA Acceptance

***QC Lab and QA Lab Should be Present**

Acceptance Testing Requirements

<u>MIX DESIGN for Targets</u>

- Aggregate Gradation
- <u>Aggregate Source</u>
- Asphalt Content
- Volumetrics
- In-place Density

HMA Sampling

STARTS OR ENDS WITH SAMPLING

- A number of sampling methods.
- Splitting sample to proper size.
- A sample must be representative of material being produced!
- Sample Certified

Acurate **Repeatable**

- **Too Coarse – Result in Lower AC content**
- **Too Fine – Result in Higher AC Content**
- **Also Affect TMD**

LEVEL 1: Composition of the Mixture

The **Asphalt Content** is probably the most important component in the HMA

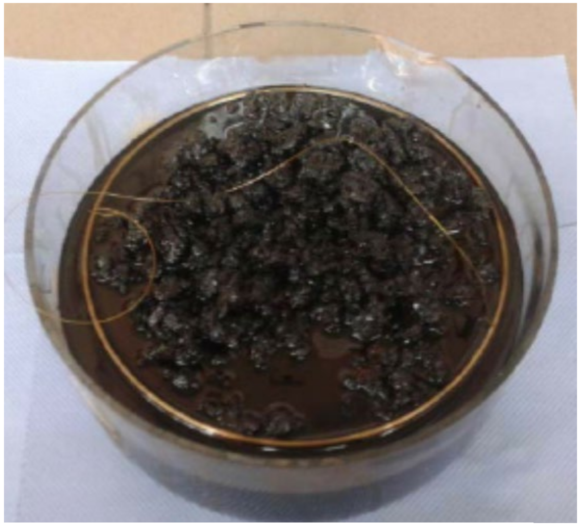
- **Solvent Extraction Method.** A sample of asphalt mixture is placed in a solvent and the asphalt is removed from the aggregate. This allows the amount of asphalt to be determined. **Hazardous Solvents**.

- **Ignition Extraction Method.** This test determines the asphalt content by burning out the asphalt allowing the amount to be determined. **Need Correction Factors!**

* Back calculation not allowed for LAP projects.

LEVEL 1: Composition of the Mixture

Solvent Extraction Method.



Vacuum Extraction

LEVEL 1: Composition of the Mixture

Ignition Extraction Method.

- Correction Factors!
- Ignition Temperatures!
- 1,000 Deg F

LEVEL 1: Composition of the Mixture

Determined from the aggregate blend once the binder has been removed from either the Solvent Wash or Ignition Oven

- **Gradation**
- **Crushed content**

LEVEL 1: Composition of the Mixture

SPECIAL PROVISION: ACCEPTANCE OF HMA MIXTURES ON LOCAL AGENCY PROJECTS

Table 1: Uniformity Tolerance Limits for HMA Mixtures

Parameter			Top and Leveling Course		Base Course	
Number	Description		Range 1 (a)	Range 2	Range 1 (a)	Range 2
1	% Binder Content		-0.30 to +0.40	±0.50	-0.30 to +0.40	±0.50
2	% Passing	# 8 and Larger Sieves	±5.0	±8.0	±7.0	±9.0
		# 30 Sieve	±4.0	±6.0	±6.0	±9.0
		# 200 Sieve	±1.0	±2.0	±2.0	±3.0
3	Crushed Particle Content (b)		Below 10%	Below 15%	Below 10%	Below 15%

a. This range allows for normal mixture and testing variations. The mixture must be proportioned to test as closely as possible to the Job-Mix-Formula (JMF).
b. Deviation from JMF.

Pay Adjustment Parameters: **Binder, Gradation, Crushed Content**

Two consecutive tests (same parameter) to trigger a pay adjustment

*Requires at least **Bit Level One Certification**

LEVEL 1: Composition of the Mixture

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Table 4: Calculating Total Price Adjustment

Cost Adjustment as a Sum of the Two Highest Parameter Penalties		
Number of Parameters Out-of-Specification	Range(s) Outside of Tolerance Limits of Table 1 per Parameter	Total Price Adjustment
One	Range 1	10%
	Range 2	25%
Two	Range 1 & Range 1	20%
	Range 1 & Range 2	35%
	Range 2 & Range 2	50%
Three	Range 1, Range 1 & Range 1	20%
	Range 1, Range 1 & Range 2	35%
	Range 1, Range 2 & Range 2	50%
	Range 2, Range 2 & Range 2	50%

Pay Adjustment Parameters: **Binder and Gradation**

Two consecutive tests (same parameter) to trigger a pay adjustment

LEVEL 2: HMA Volumetrics

Volumetrics are the relationships between **mass** and **volume**

Specific gravity is the ratio of the density of a material to the density of a reference substance

Requires **Bit Level Two Certified** or Bit **QA/QC Technician Certified** to perform testing

LEVEL 2: HMA Volumetrics

Most mix designs are now conducted in accordance with the Superpave procedures and criteria. However, Marshall mix are still common on the local agency and commercial projects. The primary component of these tests is to compact the HMA using some specified compaction effort and determining the volumetric properties.

Marshall

- or -

Superpave

LEVEL 2: HMA Volumetrics

Marshall

<u>Common Marshall Mixes</u>

2C	Base
3C	Leveling
4C	Wearing
13A	Base, Leveling, Wearing
36A	Wearing

- **<u>Impact method</u> of compaction**
- **<u>Load perpendicular</u> to compaction axis**
- **Does <u>not</u> consider <u>shear strength</u>**
- **<u>Standard compaction</u> between mixtures**

LEVEL 2: HMA Volumetrics

Superpave Mixes – 2003

LVSP, #E03, #E1, #E3, #E10, #E30, #E50

Superpave Mixes – 2020 (Mix Reduction)

EL, #EML, #EMH, #EH

- **Compaction Method simulates field**
- **Estimates density at critical service points (ini, des, max)**
- **# Gyrations (compaction) adjusted based on traffic**

Gyratory Compactor

LEVEL 2: HMA Volumetrics

ESAL		2003 Mix	2020 Mix	2003 Ni, Nd, Nm	2020 Ni, Nd, Nm
0.0-0.3	0.0-0.3	LVSP	EL	6, 45, 70	7, 50, 75
0.0-0.3		E03		7, 50, 75	
0.3-1.0	0.3-3.0	E1	EML	7, 76, 117	7, 75, 115
1.0-3.0		E3		7, 86, 134	
3.0-10	3.0-30	E10	EMH	8, 96, 152	8, 100, 160
10-30		E30		8, 109, 174	
30-100	30-100	E50	EH	9, 126, 204	9, 125, 205

4E1

4EMH

Compacted to N - Design

LEVEL 2: HMA Volumetrics

KEY TERMS

- Bulk Specific Gravity **(G_{mb})** of compacted HMA
- Maximum Specific Gravity **(G_{mm})**
- Air Voids **(V_a)**
- Voids in mineral aggregate **(VMA)**
- Voids filled with asphalt **(VFA)**

***Covert Specific Gravity to Density: SG x 62.4**

(Specific weight of water lb/ft^3)

HMA Volumetrics – Air Voids

- Measure of air, Percentage of total volume
- Typically, 3 to 4 percent laboratory compacted
- There are two properties that are used to determine the air voids in the mixture.

Calculated Using:

- **Bulk SG of the Compacted Sample**
- **Theoretical Maximum SG**

$$Air\ Voids = 100 * [\frac{Gmm - Gmb}{Gmm}]$$

HMA Volumetrics – Bulk SG of Mixture

The **first property** that is needed to determine **air voids** in a mixture is the **bulk SG of the compacted mixture**, which is determined by weighing the sample in air and then weighing while submerged in water and calculating the bulk density.

Testing (G_{mb})

- Compact Sample (Gyratory or Marshall)
- Mass of dry sample
- Mass under water
- Mass saturated surface dry

HMA Volumetrics – Bulk SG of Mixture

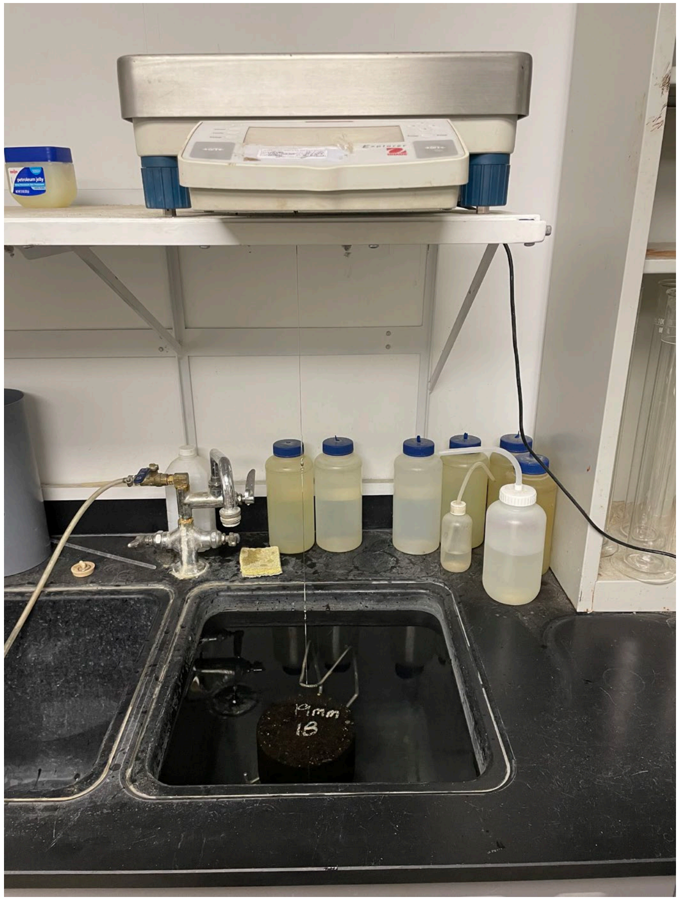
- Compact Sample (Gyratory or Marshall)
- **Mass of dry sample**
- Mass under water
- Mass saturated surface dry

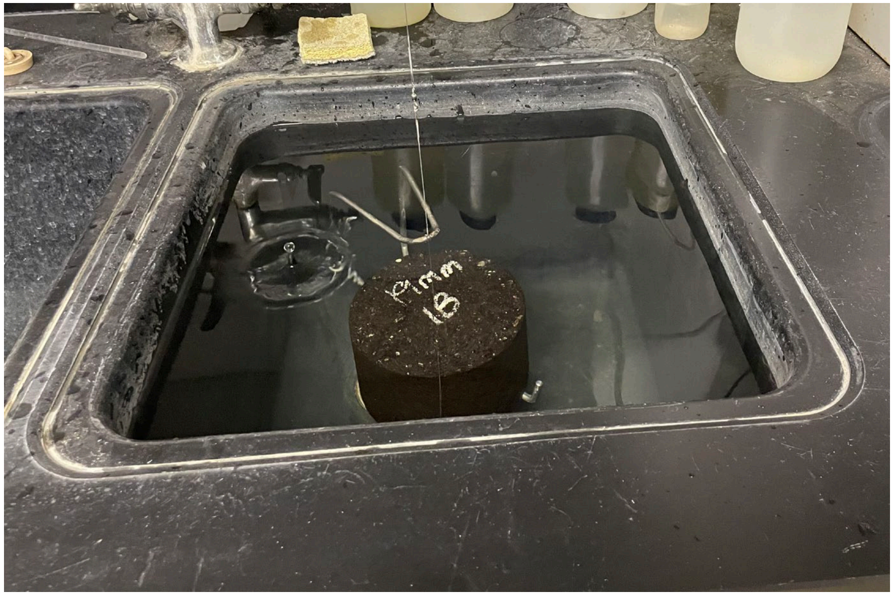
4,857.6 g

HMA Volumetrics – Bulk SG of Mixture

- Compact Sample (Gyratory or Marshall)
- Mass of dry sample
- **Mass under water**
- Mass saturated surface dry

2,854.8 g





HMA Volumetrics – Bulk SG of Mixture

- Compact Sample (Gyratory or Marshall)
- Mass of dry sample
- Mass under water
- **Mass saturated surface dry**

4,858.3 g

HMA Volumetrics – Bulk SG of Mixture

$$G_{mb} = \frac{A}{(B-C)}$$

$$2.425 = \frac{4{,}857.6}{(4{,}858.3-2{,}854.8)}$$

$2.425 \times 62.4 = 151.32\ lb/ft^3$

Where:

A = mass of dry sample

B = mass of SSD sample

C = mass of sample under water

HMA Volumetrics – Maximum SG of Mixture

The **second property** that is needed to determine the **air voids** in a mixture is the **theoretical maximum SG**, which is the SG at which there would be no air voids.

Testing (G_{mm})

- Mass in air
- Mass under water

HMA Volumetrics – Maximum SG of Mixture

- **Mass of dry sample**
- Mass under water

2,178.2 g

Loose Dry Mixture at Room Temperature

HMA Volumetrics – Maximum SG of Mixture

- Mass in air
- **Mass under water**

1,305.7 g

- **Metal Bowl**
- **Shaker Table**
- **Vacuum Pump**

HMA Volumetrics – Maximum SG of Mixture

Theoretical Maximum Density

$$G_{mm} = \frac{A}{(A-C)} \qquad 2.497 = \frac{2{,}178.2}{(2{,}178.2-1{,}305.7)}$$

2.497 * 62.4 = 155.8 lb/ft^3

Where:

A = mass of dry sample

C = mass of sample under water

HMA Volumetrics – Air Voids

Now that we have calculated:

- **Bulk SG of the Compacted Sample (G_{mb})**
- **Theoretical Maximum SG (G_{mm})**

$$Air\ Voids = 100 * [\frac{G_{mm} - Gmb}{G_{mm}}]$$

$$2.88 = 100 * [\frac{2.497 - 2.425}{2.497}]$$

Deviation 0.12, Target 3%

HMA Volumetrics - VMA

- VMA is a measure of the **voids in between the mineral aggregate particles in a compacted mixture**.
- Determined by? **G_{mb}, %AC, G_{sb}**
- When the VMA is too low, enough asphalt can not be added to produce a durable mixture. So setting a minimum VMA is an approach that is used to **ensure that adequate asphalt is added** to the mixture.

$$VMA = 100 - \frac{G_{mb} * \%\, Aggregate}{G_{sb}}$$

$$14.69 = 100 - \frac{2.425 * (100 - 5.75)}{2.679}$$

VMA is an indication of film thickness on the surface of the aggregate

HMA Volumetrics - VFA

Another mixture property that is important is the **amount of the VMA that is filled with asphalt.**

The voids filled should be high enough so that the mixture is not permeable to air and water and not so high that bleeding and rutting occur under traffic.

$$VFA = 100\ x\ \frac{VMA - \%\ Air\ Voids}{VMA}$$

$$80.39 = 100\ x\ \frac{14.69 - 2.88}{14.69}$$

VFA is the percent of VMA that is filled with asphalt binder

HMA Volumetrics - LAP PILOT

SPECIAL PROVISION: VOLUMETRIC SINGLE TEST ACCEPTANCE OF HMA MIXTURES ON LOCAL AGENCY PROJECTS

- **SINGLE TEST ACCEPTANCE (STA)**
- **STA SAMPLES LESS THAN 1,000 TONS**
- **VI UP TO 500 TONS PER MIXTURE TYPE PER PROJECT**
- Pay Adjustment Parameters: **Density, Air Voids, Binder, & VMA**

HMA Volumetrics - LAP PILOT

SPECIAL PROVISION: VOLUMETRIC SINGLE TEST ACCEPTANCE OF HMA MIXTURES ON LOCAL AGENCY PROJECTS

Table 1: HMA Quality Index Parameters Specification Limits

Quality Index Parameter	Specification Limits
Air Voids, %	Target Air Voids ± 0.50
Vma	Target Vma ± 0.60
	Vma Targets
13A and LVSP	15.00
2C and 2E	2C - 12.00, 2E - 13.00
3C and 3E	14.00
4C and 4E	15.00
36A and 5E	16.00
Binder Content	Target ± 0.30

$$OSPF = (30 \times PF_{D}) + (40 \times PF_{AV}) + (20 \times PF_{BINDER}) + (10 \times PF_{VMA})$$

STA sample Payment Adjustment = (100-OSPF)/100 x (Contract Unit Price) x (STA sample Quantity).

Single Test to trigger a pay adjustment

HMA Volumetrics - LAP PILOT

SPECIAL PROVISION: VOLUMETRIC SINGLE TEST ACCEPTANCE OF HMA MIXTURES ON LOCAL AGENCY PROJECTS

Deviation from JMF (± percent)	PF_{AV}
≤ 0.50	1.00
0.51 – 0.60	0.98
0.61 – 0.70	0.96
0.71 – 0.80	0.94
0.81 – 0.90	0.92
0.91 – 1.00	0.90
1.01 – 1.20	0.84
1.21 – 1.40	0.78
1.41 – 1.60	0.72
1.61 – 1.80	0.66
1.81 – 2.00	0.60
> 2.00	RQL

Deviation from JMF (± percent)	PF_{VMA}
≤ 0.60	1.00
0.61 – 1.00	0.90
1.01 – 1.50	0.70
1.51 – 2.00	0.30
> 2.00	RQL

Rejectable Quality Limit

Overall STA Sample Pay Factor

$$OSPF = (30 \times PF_D) + (40 \times PF_{AV}) + (20 \times PF_{BINDER}) + (10 \times PF_{VMA})$$

STA sample Payment Adjustment = (100-OSPF)/100 x (Contract Unit Price) x (STA sample Quantity).

In-Place Density

<u>**Density Testing**</u>

- Destructive Testing: Cut cores from the in-place mixture and measure the bulk density by weighing in air and water. This is the <u>**most accurate test**</u>.

- Non-Destructive Testing: Density Gauge

Relationships

<u>RICE AND BULK SG OF AGGREGATES</u>

- **Theoretical Maximum Specific Gravity** (rice value) **is the key** measurement during both laboratory mix design and quality control procedures.
- **Change in Rice value** may indicate a **change in the Bulk Specific Gravity** of the Aggregate. **<u>Material Substitution!</u>**
- $\mathbf{G_{sb}}$ can have a big affect on volumetric property calculations which are typically **taken from the mix design**. Determining of G_{sb} is **somewhat cumbersome**.
- However, **Effective SG of combined aggregate** can be calculated from QC routine test results including mixture $\mathbf{G_{mm}}$ **and asphalt content.** Monitored during productions.

Relationships

LOW ASPHALT CONTENT

- **Higher Air Voids**
- **Higher TMD**
- **Permeability Increases** - causing susceptible to moisture damage and stripping
- **Reduces film thickness** on the aggregate – accelerated **oxidation** - early aging and loss of roadway life.

Relationships

HIGH ASPHALT CONTENT

- **Lower Air Voids.**
- **Lower TMD.**
- **VMA** will generally **decrease slightly** to a minimum value **then increase** with increasing asphalt contents becoming unstable.
- **Increases VFA** and takes the space for air voids.

Relationships – Gradation and Voids

- **Dense** graded **<u>BUT</u> not too dense**! Need VMA
- Higher fines = lower % air voids compacted
- Aggregate texture & shape affect void content.
- Higher VMA for smaller aggregate mixtures (more void space)
- Smaller crushed aggregate can increase VMA

Relationships

- Percent compaction when **compared to TMD** is = to compacted air voids
- This is different to specification that **compare to Marshall**.
- For local agency project looking for field compaction from **92% to 98% TMD** compaction **(2% to 8% air voids)**

Relationships – TMD and Density

OBTAINING DENSITY MAY BE MOST IMPORTANT TO LONG TERM PERFORMANCE!

Accurate TMD value is Critical for mix that is being placed!

- EX. 143.0 (gauge reading)

  143.0 / **155.4** (JMF) = 92.0

  143.0 / **155.8** (New Rice) = 91.8

Low AC, Higher TMD

QUESTIONS