MARTCP

Training/ Qualification Program

Hot Mix Asphalt

Plant Technician

Level I

Hot Mix Asphalt Volumetric Properties

Page 9-1

1

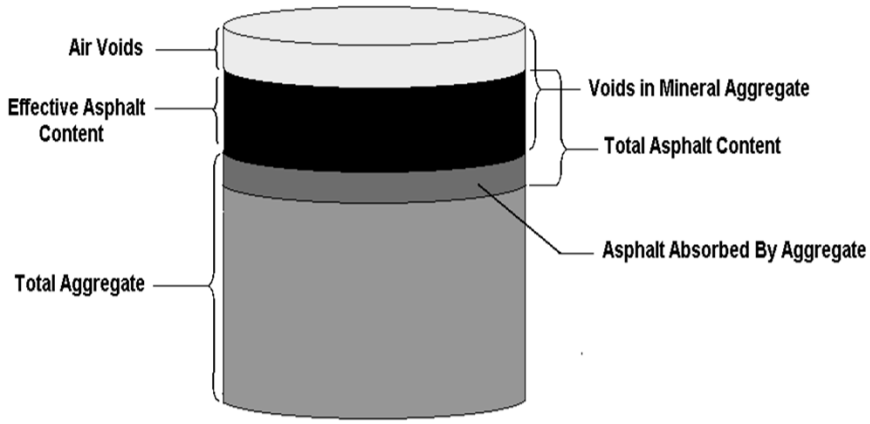
Overview

- Volumetric Relationships
- Volumetric Abbreviations & Definitions
- Volumetric Calculations Using Formulas
- Test Procedures and examples of Calculations

2

Components of a compacted HMA sample

These components are used for calculating volumetric properties.



4

Volumetric Abbreviations & Definitions

Gmb = (B)ulk (G)ravity of (M)ix

Gmm = (M)aximum Specific (G)ravity of (M)ix

Va = (A)ir (V)oids

or

VTM = (V)oids in (T)otal (M)ix

Page 9-3

5

Volumetric Abbreviations & Definitions

VMA = (V)oids in (M)ineral (A)ggregate

VFA = (V)oids (F)illed with (A)sphalt

Gmb = (B)ulk (G)ravity of (M)ix

Ps = (P)ercent (S)tone

Gsb = (B)ulk (G)ravity of (S)tone

VTM = (V)oids in (T)otal (M)ix

$P_{0.075}$ = (P)ercent passing #200 (0.075) sieve

Pbe = (P)ercent (E)ffective (B)inder

Page 9-4

6

Volumetric Abbreviations & Definitions

Gmm = (M)aximum Specific (G)ravity of (M)ix

Ps = (P)ercent (S)tone

Pb = (P)ercent (B)inder

Pbe = (P)ercent (E)ffective (B)inder

Gb = Specific (G)ravity of (B)inder

Gsb = (B)ulk (G)ravity of (S)tone

Gse = (E)ffective (G)ravity of (S)tone

Page 9-5

7

Volumetric Calculations Using Formulas

T 166 **T 209**

Gmb = A / (B - C) **Gmm = A / (A - C)**

A = mass or weight of dry sample

B = mass or weight of SSD sample

C = mass or weight of sample under water

R 35

$$\text{VTM or Va} = 100 \times \left(1 - \frac{Gmb}{Gmm}\right)$$

Page 9-3

8

Volumetric Calculations Using Formulas

$$\text{VMA} = \left(1 - \frac{Gmb \times Ps}{Gsb}\right) \times 100$$

$$\text{VFA} = \left(\frac{VMA - VTM}{VMA}\right) \times 100$$

Dust to Binder Ratio = $P_{0.075}$ / Pbe

Page 9-4

9

Volumetric Calculations Using Formulas

$$Gse = \frac{100 - Pb}{\frac{100}{Gmm} - \frac{Pb}{Gb}}$$

$$Pbe = -(PsxGb)\left(\frac{Gse - Gsb}{Gse \times Gsb}\right) + Pb$$

Page 9-5

10

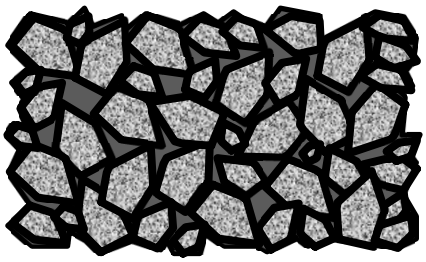
Test Procedures

- **T-166** Bulk Specific Gravity of Compacted HMA (Gmb)
- **T-209** Maximum Specific Gravity
- **T-308** Asphalt content by Ignition oven
- **T-11** Wash Gradation

11

T-166 Bulk Specific Gravity of Compacted HMA **(Gmb)**

- **Asphalt mixed with aggregate and compacted into sample**



Page 9-6

12

T-166 Bulk Specific Gravity of Compacted HMA **(Gmb)**

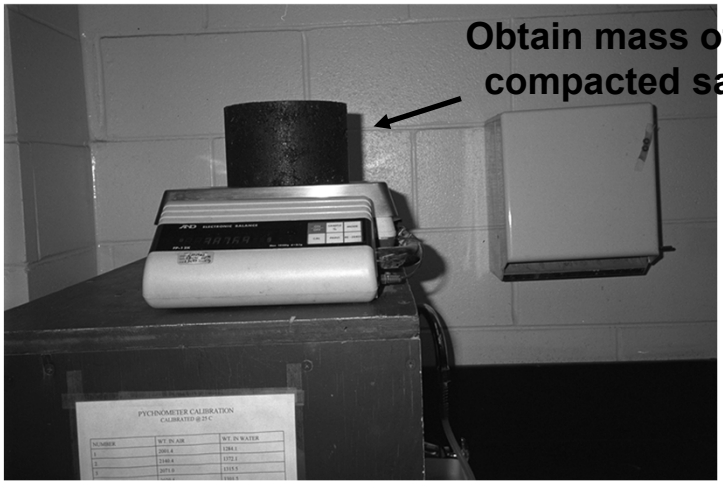
Testing Procedure

- **Compaction of sample**
- **Mass of dry sample**
- **Mass under water**
- **Mass saturated surface dry (SSD)**

Page 9-6

13

T 166 Testing



14

T 166 Testing

15

Calculations

T 166

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

Where:

A = mass of dry sample

B = mass of SSD sample

C = mass of sample under water

Page 9-7

16

T 166 Example, So if we had: (WS 1A)

A / (B - C) plug in the numbers:

A = mass of dry sample 5001.5

B = mass SSD sample 5011.5

C = mass of sample under water 2950.5

5001.5 / (5011.5 - 2950.5) = 2.427

Gmb = 2.427

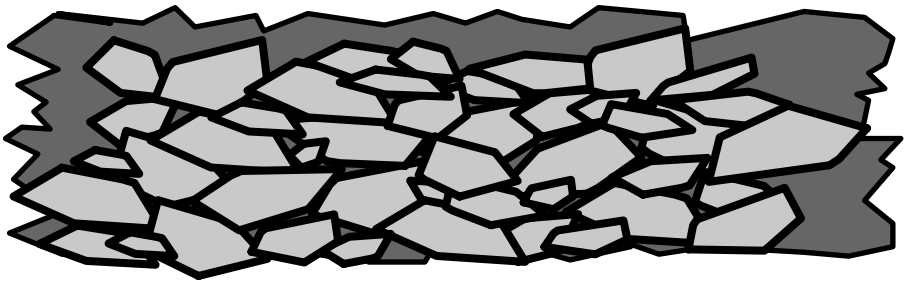
Page 9-7

17

T-209 Maximum Specific Gravity

(Gmm)

- Loose (uncompacted) mixture



Page 9-8

18

T-209 Maximum Specific Gravity

(Gmm)

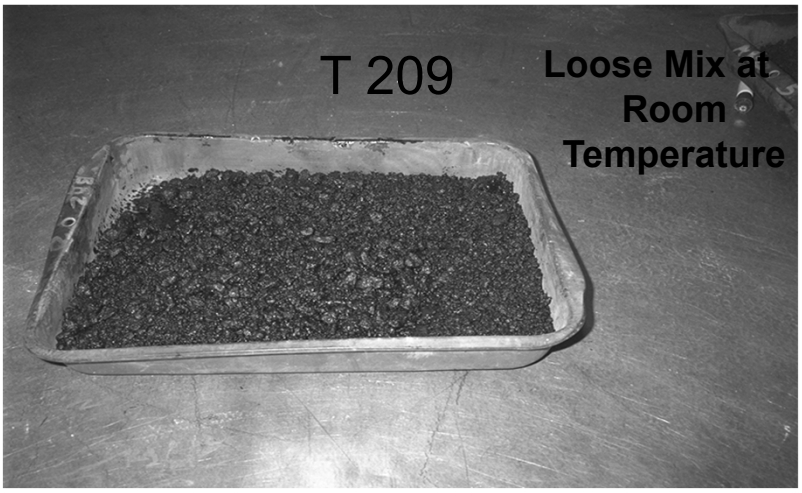
Testing Procedure

- Mass in air
- Apply vacuum
- Mass under water

Page 9-8

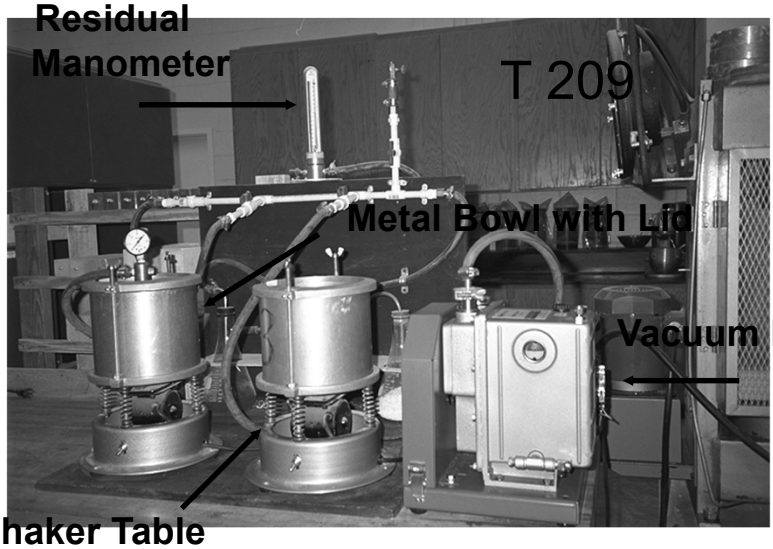
19

Testing



20

Testing



21

Calculations

T 209

$G_{mm} = A / (A - C)$

Where:

A = mass of dry sample

C = mass of sample under water

Page 9-9

22

T 209 Example, So if we had: (WS 2A)

A / (A - C) plug in the numbers:

A = mass of dry sample 2400.0

C = mass of sample under water 1449.8

2400.0 / (2400.0 - 1449.8) = 2.526

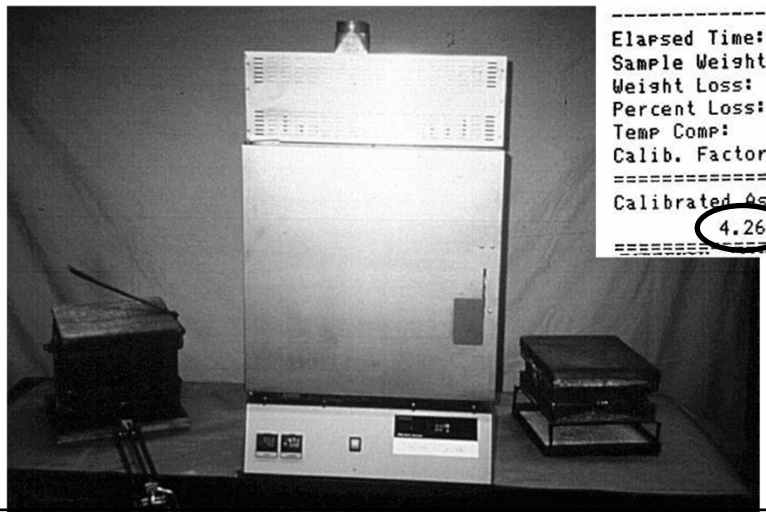
Gmm = 2.526

Page 9-9

23

T-308 Asphalt content by Ignition oven

Pb, is the percent of asphalt or binder in the sample.

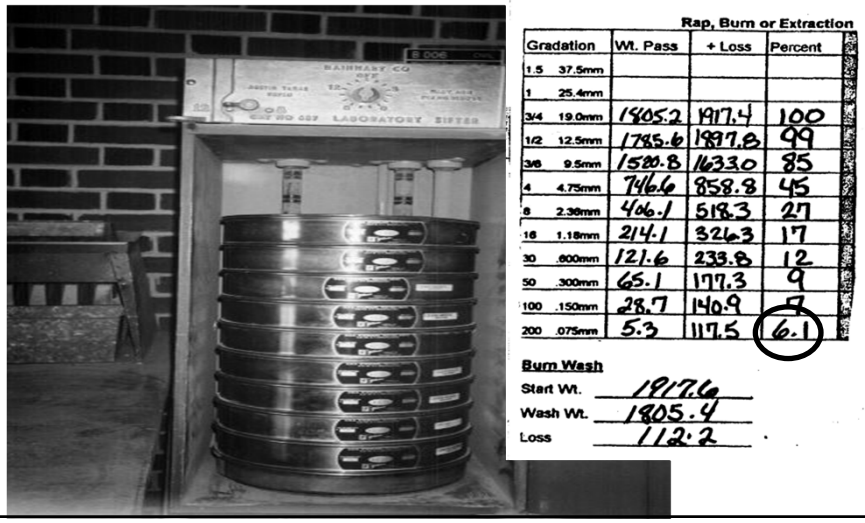


```
----------------------
Elapsed Time: 41:11
Sample Weight: 2012g
Weight Loss:   96.9g
Percent Loss:  4.81%
Temp Comp:     0.14%
Calib. Factor: 0.41%
======================
Calibrated Asphalt Ctnt
        4.26%
======================
```

24

T-11 Wash Gradation

$P_{0.075}$, Percent passing the minus 200 Screen



Rap, Burn or Extraction

Gradation	Wt. Pass	+ Loss	Percent
1.5 37.5mm			
1 25.4mm			
3/4 19.0mm	1805.2	1917.4	100
1/2 12.5mm	1785.6	1897.8	99
3/8 9.5mm	1580.8	1633.0	85
4 4.75mm	746.6	858.8	45
8 2.36mm	406.1	518.3	27
16 1.18mm	214.1	326.3	17
30 .600mm	121.6	233.8	12
50 .300mm	65.1	177.3	9
100 .150mm	28.7	140.9	7
200 .075mm	5.3	117.5	6.1

Burn Wash

Start Wt. 1917.6

Wash Wt. 1805.4

Loss 112.2

25

Now you can calculate volumetric properties……...

- VTM or Va, Voids in total mix
- VMA, Voids in mineral aggregate
- VFA, Voids filled with asphalt
- $P_{0.075}$ / Pbe, Dust to Effective Binder

Page 9-10

26

You can also calculate these volumetric properties……...

- Pbe, Percent Effective Binder
- Gse, Effective gravity of stone

Page 9-10

27

Percent Air Voids (VTM)

(AASHTO R 35)

- **Calculated using both specific gravities**

VTM or Va = 100 (1 - (Gmb / Gmm))

Gmb = Bulk Gravity of compacted material

Gmm = Gravity of loose material

Page 9-11

28

Example Calculations

(WS 3A)

- **Voids in total mix (VTM or Va)**

G_{mb} = 2.426

G_{mm} = 2.527

100 (1 - (2.426 / 2.527)) = 4.0 %

VTM = 4.0 %

Page 9-11

29

Voids in Mineral Aggregate

AASHTO R 35

$$\textbf{VMA} = 100\left(1 - \frac{Gmb\ P_s}{Gsb}\right)$$

Gmb = Bulk gravity of compacted sample

Ps = Percent Aggregate (100-AC) /100

Gsb = Bulk gravity of aggregate

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

Page 9-12

30

Example Calculations

(WS 4A)

Given that :

Gmb = 2.426

Ps = .95 (100 – 5.0 AC)/100

Gsb = 2.703

$$\textbf{VMA} = 100 \times \left(1 - \frac{2.426 \times .95}{2.703}\right) = 14.7$$

Page 9-12

31

Voids Filled with Asphalt

AASHTO R35

$$VFA = 100 \times \left(\frac{VMA - Va}{VMA} \right)$$

VMA = voids in mineral aggregate

Va = voids in total mix

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

Page 9-13

32

Example calculations

(WS 5A)

Given that:

VMA = 14.7

Va = 4.0

$$VFA = 100 \times \left(\frac{14.7 - 4.0}{14.7} \right) = 72.8$$

Page 9-13

33

Dust to binder ratio

AASHTO R35

$$P_{0.075} / P_{be} = \frac{P_{0.075}}{P_{be}}$$

$P_{0.075}$ = Percent passing the minus 200 screen

Pbe = Effective asphalt content

The percent of fines to effective asphalt.

Page 9-14

34

Example calculations

WS 6A

Given that:

$P_{0.075}$ = 6.1

Pbe = 4.26

$$P_{0.075} / Pbe = \frac{6.1}{4.26} = 1.43$$

Page 9-14

35

Effective Asphalt Content

AASHTO R35

$$\textbf{Pbe} = -(P_s \times G_b)\frac{(Gse - Gsb)}{(Gse \times Gsb)} + P_b$$

Pbe = (P)ercent (E)ffective (B)inder

P_s = (P)ercent (S)tone or Aggregate

G_b = Specific (G)ravity of (B)inder

G_{se} = (E)ffective Specific (G)ravity of (S)tone

G_{sb} = (E)ffective Specific (G)ravity of (S)tone

P_b = (P)ercent (B)inder Content

Page 9-15

36

Effective Asphalt Content (WS 7A)

AASHTO R35

P_s = 95.0 (100 – 5.0 AC)

G_b = 1.025 **P_b = 5.0**

G_{se} = 2.760 **G_{sb} = 2.703**

$$\textbf{Pbe} = -(95.0 \times 1.025)\frac{(2.760 - 2.703)}{(2.760 \times 2.703)} + 5.0$$

Pbe = 4.26

37

Effective Asphalt Content

$$Pbe = -(P_s \times G_b)\frac{(Gse - Gsb)}{(Gse \times Gsb)} + P_b$$

AASHTO R35

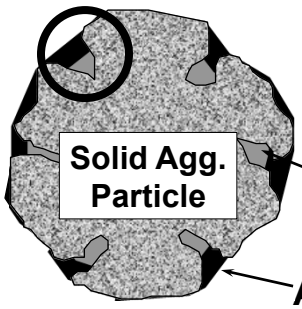
The effective asphalt content is the total asphalt content minus the percent lost to absorption (based on mass of total mix).

Page 9-15

38

Effective Specific Gravity

Surface Voids



$$G_{se} = \frac{\text{Mass, dry}}{\text{Effective Volume}}$$

Vol. of water-perm. voids not filled with asphalt

Absorbed asphalt

Page 9-16

Effective volume = volume of solid aggregate particle + volume of surface voids not filled with asphalt

39

Effective Specific Gravity

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

AASHTO R35

G_{se} is an aggregate property

40

Example Calculations

WS 8A

- **Mixed with 5 % asphalt cement**
- **G_{mm} = 2.535**
- **G_b = 1.03**

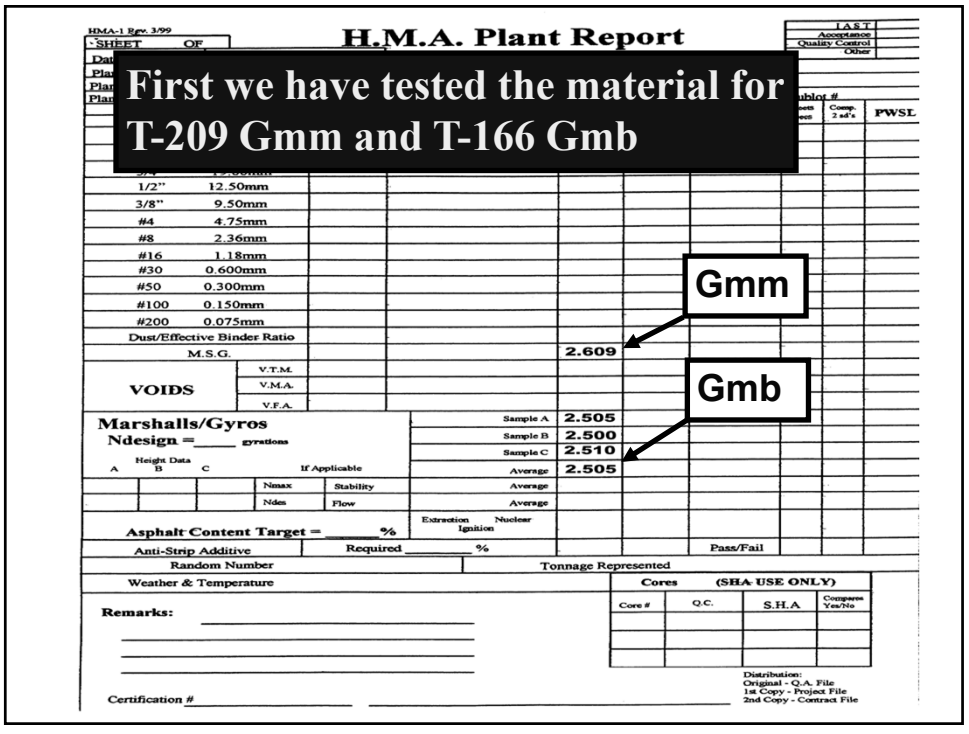
$$G_{se} = \frac{100 - 5}{\frac{100}{2.535} - \frac{5}{1.03}} = 2.746$$

Page 9-16

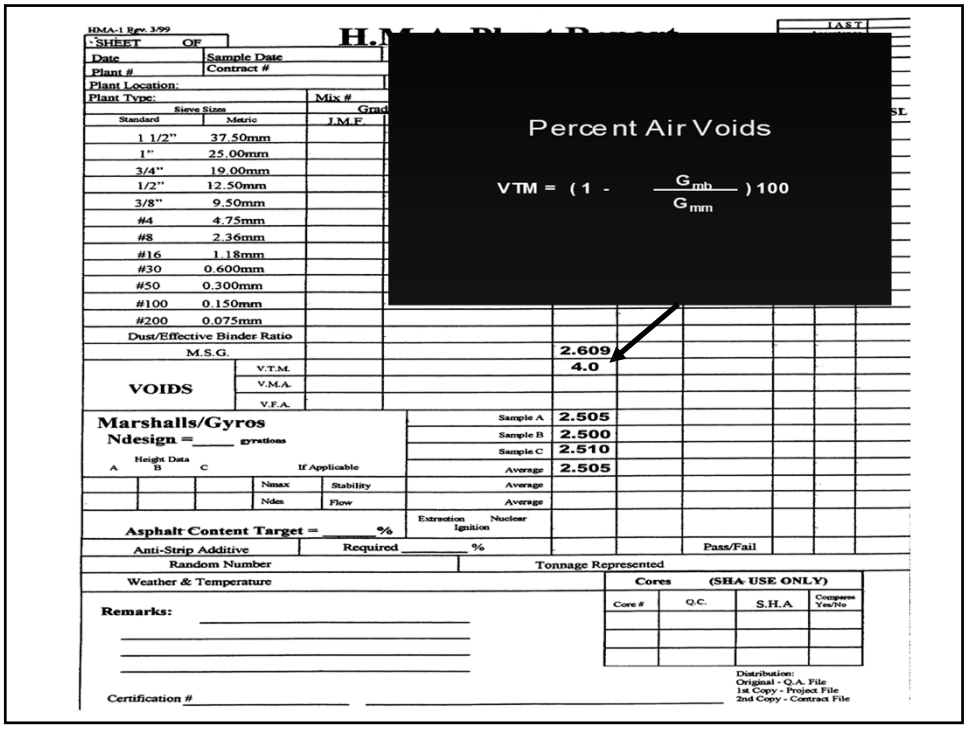
41

Lets review

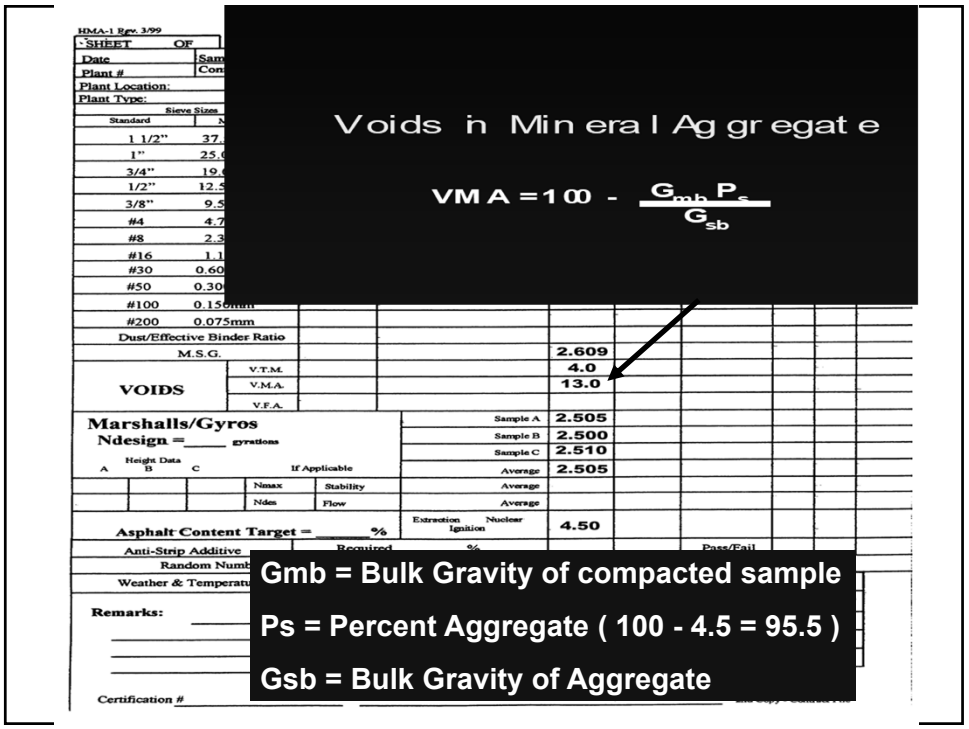
42



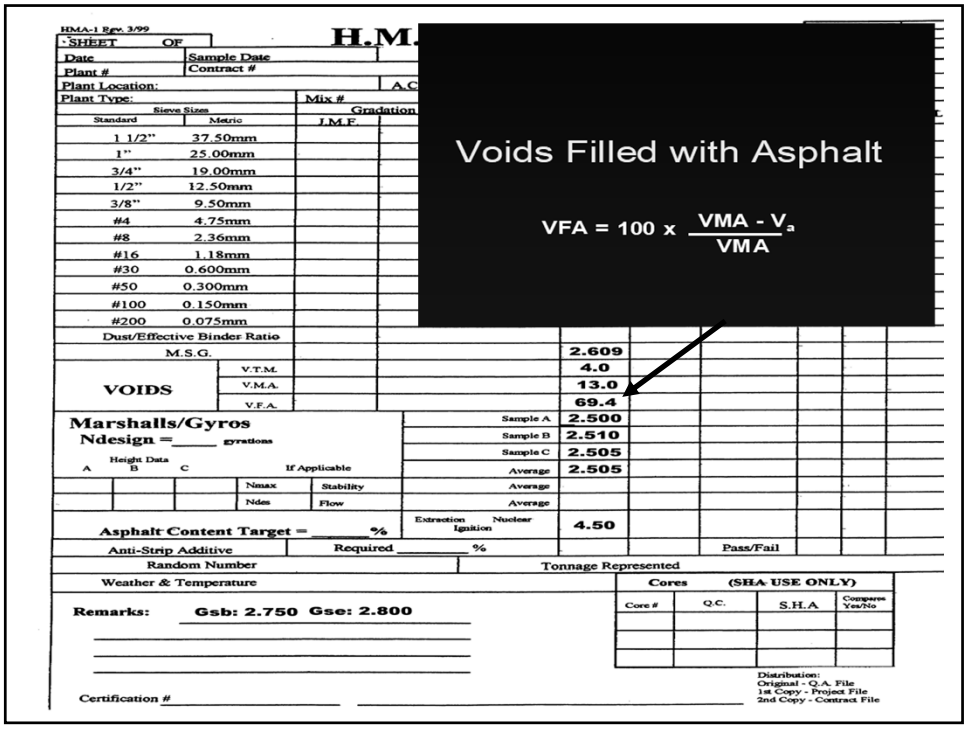
43


Percent Air Voids
VTM = (1 - Gmb / Gmm) 100
HMA-1 Rev. 3/99
SHEET OF
Date
Sample Date
Plant #
Contract #
Plant Location:
Plant Type:
Mix #
Sieve Sizes
Standard
Metric
J.M.F.
1 1/2" 37.50mm
1" 25.00mm
3/4" 19.00mm
1/2" 12.50mm
3/8" 9.50mm
#4 4.75mm
#8 2.36mm
#16 1.18mm
#30 0.600mm
#50 0.300mm
#100 0.150mm
#200 0.075mm
Dust/Effective Binder Ratio
M.S.G.
2.609
VOIDS
V.T.M.
4.0
V.M.A.
V.F.A.
Marshalls/Gyros
Ndesign = gyrations
Height Data
A B C
If Applicable
Nmax
Stability
Ndes
Flow
Sample A 2.505
Sample B 2.500
Sample C 2.510
Average 2.505
Average
Average
Asphalt Content Target = %
Extraction Nuclear Ignition
Anti-Strip Additive
Required %
Pass/Fail
Random Number
Tonnage Represented
Weather & Temperature
Cores (SHA USE ONLY)
Core #
Q.C.
S.H.A
Compares Yes/No
Remarks:
Certification #
Distribution:
Original - Q.A. File
1st Copy - Project File
2nd Copy - Contract File

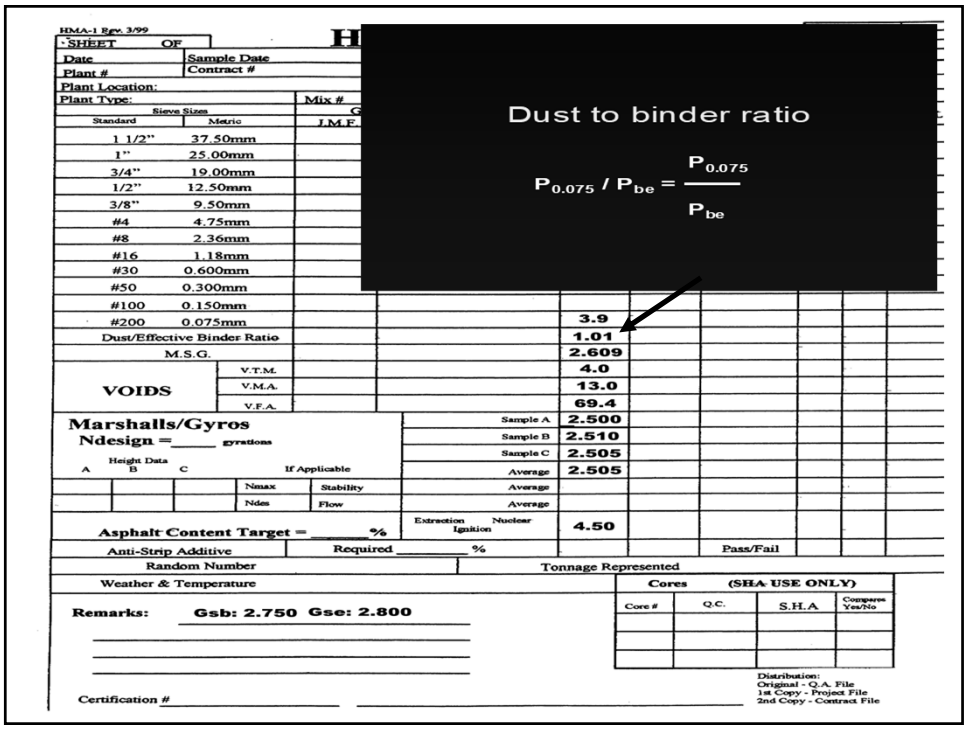
44


Voids in Mineral Aggregate
VMA = 100 - Gmb Ps / Gsb
2.609
4.0
13.0
4.50
Gmb = Bulk Gravity of compacted sample
Ps = Percent Aggregate (100 - 4.5 = 95.5)
Gsb = Bulk Gravity of Aggregate

45


Voids Filled with Asphalt
VFA = 100 x (VMA - Va) / VMA
HMA-1 Rev. 3/99
SHEET OF
Date
Sample Date
Plant #
Contract #
Plant Location:
Plant Type:
Mix #
Sieve Sizes
Standard
Metric
J.M.F.
1 1/2" 37.50mm
1" 25.00mm
3/4" 19.00mm
1/2" 12.50mm
3/8" 9.50mm
#4 4.75mm
#8 2.36mm
#16 1.18mm
#30 0.600mm
#50 0.300mm
#100 0.150mm
#200 0.075mm
Dust/Effective Binder Ratio
M.S.G.
VOIDS
V.T.M.
V.M.A.
V.F.A.
2.609
4.0
13.0
69.4
Marshalls/Gyros
Ndesign = _____ gyrations
Height Data
A B C
If Applicable
Nmax
Ndes
Stability
Flow
Sample A 2.500
Sample B 2.510
Sample C 2.505
Average 2.505
Average
Average
Extraction Nuclear Ignition
4.50
Asphalt Content Target = _____ %
Anti-Strip Additive
Required _____ %
Pass/Fail
Random Number
Tonnage Represented
Weather & Temperature
Cores (SHA USE ONLY)
Core #
Q.C.
S.H.A
Compares Yes/No
Remarks: Gsb: 2.750 Gse: 2.800
Certification #
Distribution:
Original - Q.A. File
1st Copy - Project File
2nd Copy - Contract File

46


Dust to binder ratio
P0.075 / Pbe = P0.075 / Pbe
HMA-1 Rev. 3/99
SHEET OF
Date
Sample Date
Plant #
Contract #
Plant Location:
Plant Type:
Mix #
Sieve Sizes
Standard
Metric
J.M.F.
1 1/2" 37.50mm
1" 25.00mm
3/4" 19.00mm
1/2" 12.50mm
3/8" 9.50mm
#4 4.75mm
#8 2.36mm
#16 1.18mm
#30 0.600mm
#50 0.300mm
#100 0.150mm
#200 0.075mm
Dust/Effective Binder Ratio
M.S.G.
VOIDS
V.T.M.
V.M.A.
V.F.A.
3.9
1.01
2.609
4.0
13.0
69.4
Marshalls/Gyros
Ndesign = _____ gyrations
Height Data
A B C
If Applicable
Nmax
Ndes
Stability
Flow
Sample A 2.500
Sample B 2.510
Sample C 2.505
Average 2.505
Average
Average
Extraction Nuclear Ignition
4.50
Asphalt Content Target = _____ %
Anti-Strip Additive
Required _____ %
Pass/Fail
Random Number
Tonnage Represented
Weather & Temperature
Cores (SHA USE ONLY)
Core #
Q.C.
S.H.A
Compares Yes/No
Remarks: Gsb: 2.750 Gse: 2.800
Certification #
Distribution:
Original - Q.A. File
1st Copy - Project File
2nd Copy - Contract File

47

Questions - ?

48