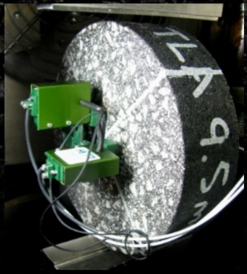
National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Aggregate Specific Gravity and Mix Cracking Tests

60th Annual Asphalt Paving Conference
Asphalt Pavement Association of Michigan
March 29, 2016
Kalamazoo, MI





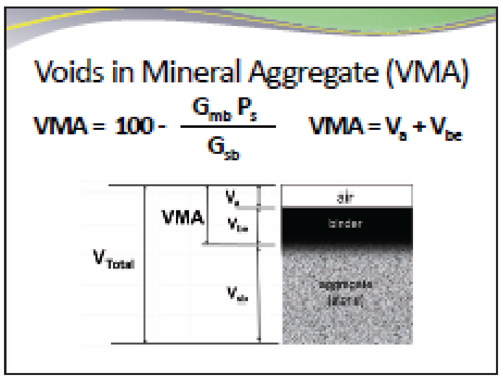

Asphalt Durability Problems?

Don't Forget the Impact of Basic Principles on Asphalt Mix Durability

In a number of states, there has been increasing concern that many asphalt mixes are not as durable as they should be. Some cases of overlays deteriorating within a few years have been reported. The problems have been attributed to a range of causes such as the use of RAS, low asphalt contents, low in-place density, poor quality underlying layers, and freeze-thaw cycles of recent harsh winters. Typically, for any particular case there are a number of factors that play a part in durability problems. The root causes can often be traced back to failing to follow basic principles of mix design and quality assurance. The aim of this article is to refresh our attention to those basic principles.

Asphalt Content

In the past few years, many highway agencies have implemented specification changes to increase asphalt contents of mix designs. Some have reduced the target air void content or increased VMA limits in mix design. In general, reducing the target air void content by 0.5% or increasing the minimum VMA by 0.5% will add about 0.2% more asphalt to mixes. Increasing asphalt contents will generally improve durability and also make the mixes more compactible. However, there is another very basic element of mix design that has a big impact on the optimum asphalt of mixes - the aggregate blend bulk specific gravity (Gsb). Using a Gsb that is higher than its true value, either by error or intent, will result in a calculated VMA that is higher than it actually is, and the net effect will be a lower asphalt content for the mix. A small change in the blend's Gsb can have a significant impact on VMA; for example, increasing Gsb by 0.029 (a change that is within the repeatability of the tests) can increase the calculated VMA by 1.0%. Therefore, it is incumbent on agencies to check the Gsb of materials used in both mix designs and mix production. The frequency of checking Gsb should be based on historical data for how much the Gsb values change over time for aggregate and RAP components.



Voids in Mineral Aggregate (VMA) is the volume of intergranular void space between the aggregate particles of a compacted paving mixture. It includes the air voids and effective volume of asphalt. It must be calculated using the Gsb of the aggregate blend.

It is also important to consider changes made to mixtures during production. In many quality assurance specifications, the air voids of lab compacted specimens have a greater impact on the contractor's pay per lot of mixture than asphalt content. This encourages a reduction of asphalt content in order to maintain air voids (and VMA), which essentially sacrifices durability in favor of rutting resistance. Agencies can discourage this practice by limiting the reduction of the target asphalt content during mix production, forcing contractors to make other adjustments in the mix to maintain volumetric properties. This will motivate mix designers to account for changes in gradation, particle shapes and dust contents that often occur during plant production as they develop new mix designs.

Lower Ndesign

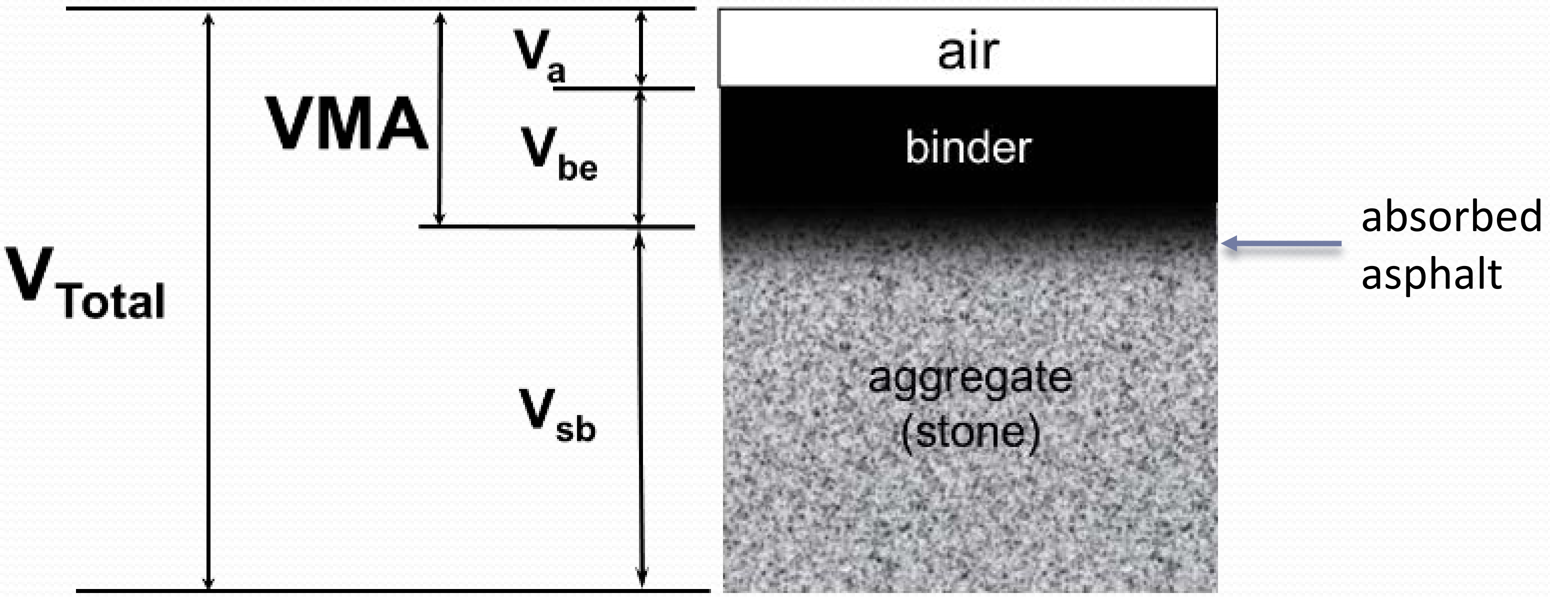
Reducing the laboratory compactive effort by itself will not necessarily increase the asphalt content of mixes, but it can help improve mixes in other ways such as enabling mix designers to use finer gradations. In general, fine-graded mixes are easier to compact than coarse-graded mixes both in the laboratory and in the field. When Superpave was introduced in many parts of the country, mix designers were encouraged to use coarse gradations in an effort to make mixes more rut resistant. A direct impact of using high-gyration, coarse-graded mixes was that achieving the minimum density specification in the field also became much tougher. NCHRP Project 9-9(1) found the SGC compactive effort table in AASHTO R35 to be too high. This study was published as NCHRP Report 573. Using data from numerous projects across the US, it showed that pavements were not densifying under traffic to the levels achieved in the SGC. The report recommended Ndesign levels 20 to 25% lower than in R35. A few states took a more radical step and set Ndesign to 60 or 65 gyrations for all mixes, regardless of the design traffic level, and have encountered no ill effects of that change. As long as Superpave aggregate criteria are met and the appropriate binder grade is used, those states found that lower gyration levels improved mix designs without causing rutting problems. The NCAT Test Track has also proven that 65 gyration mixes can hold up to very heavy traffic conditions.

NCAT Newsletter, Spring 2015

Voids in Mineral Aggregate (VMA)

$$VMA = 100 - \frac{G_{mb}\,P_s}{G_{sb}}$$

$$VMA = V_a + V_{be}$$



Challenges with Gsb

1. Time Consuming Tests
   - Reduces frequency of checking
   - Shortcuts
2. Lack of precision
   - Agency verification is not good
   - Opens door for playing with numbers

Standard Method of Test for

Specific Gravity and Absorption of Coarse Aggregate

AASHTO Designation: T 85-91 (2004)[1]
ASTM Designation: C

1. SCOPE

1.1. This method cover
The specific gravit
surface-dry (SSD)
are based on aggre
with lightweight a

1.2. The values stated i

1.3. *This standard may*
not purport to add
the user of this sta
determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*
- M 43, Sizes of Aggregate for Road and Bridge Construction
- M 92, Wire-Cloth Sieves for Testing Purposes

Multi-laboratory Precision	Acceptable Range of Two Results
Coarse Aggregate	0.038
Fine Aggregate	0.066

Table 1—Precision

	Standard Deviation (1S)[a]	Acceptable Range of Two Results (D2S)[a]
Single-operator precision:		
Bulk specific gravity (dry)	0.009	0.025
Bulk specific gravity (SSD)	0.007	0.020
Apparent specific gravity	0.007	0.020
Absorption,[b] percent	0.088	0.25
Multilaboratory precision:		
Bulk specific gravity (dry)	0.013	0.038
Bulk specific gravity (SSD)	0.011	0.032
Apparent specific gravity	0.011	0.032
Absorption,[b] percent	0.145	0.41

[a] These numbers represent, respectively, the (1S) and (D2S) limits as described in ASTM C 670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory reference sample data from laboratories using 15-hour minimum saturation times and other laboratories using 24 ± 4-hour saturation time. Testing was performed on aggregates of normal specific gravities and started with aggregates in the oven-dry condition.

[b] Precision estimates are based on aggregates with absorptions of less than 2 percent.

Standard Method of Test for

Specific Gravity and Absorption of Fine Aggregate

AASHTO Designation: T 84-00 (2004)[1]

f bulk and apparent specific gravity, 23/23°C
regate.

in water) the bulk specific gravity and the apparent
bulk specific gravity on the basis of mass of saturated
as defined in M 132.

garded as the standard.

terials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*
- M 132, Terms Relating to Density and Specific Gravity of Solids, Liquids, and Gases
- M 231, Weighing Devices Used in the Testing of Materials

Table 1—Precision

	Standard Deviation (1S)[a]	Acceptable Range of Two Results (D2S)[a]
Single-operator precision:		
Bulk specific gravity (dry)	0.011	0.032
Bulk specific gravity (SSD)	0.0095	0.027
Apparent specific gravity	0.0095	0.027
Absorption,[b] percent	0.11	0.31
Multilaboratory precision:		
Bulk specific gravity (dry)	0.023	0.066
Bulk specific gravity (SSD)	0.020	0.056
Apparent specific gravity	0.020	0.056
Absorption,[b] percent	0.23	0.66

[a] These numbers represent, respectively, the (1S) and (D2S) limits as described in ASTM C 670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory reference sample data from laboratories using 15- to 19-hour saturation times and other laboratories using 24 ± 4 hours of saturation time. Testing was performed on aggregates of normal specific gravities, and started with aggregates in the oven-dry condition.

[b] Precision estimates are based on aggregates with absorptions of less than one percent and may differ for manufactured fine aggregates having absorption values greater than one percent.

Voids in Mineral Aggregate (VMA)

$$\mathbf{VMA = 100 - \frac{G_{mb}\,P_s}{G_{sb}}}$$

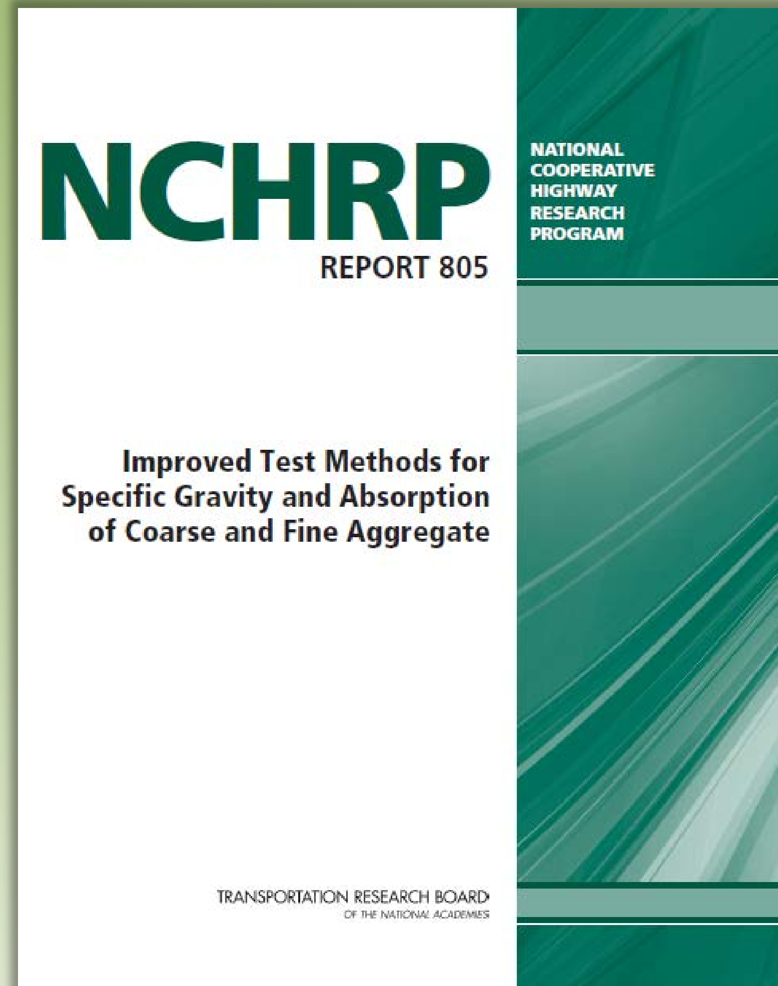
$$\mathbf{VMA = 100 - \frac{2.444 \times 95}{2.700} = 14.0\%}$$

$$\mathbf{VMA = 100 - \frac{2.444 \times 95}{{\color{red}2.750}} = 15.6\%}$$

Improved Test Methods for Specific Gravity and Absorption of Coarse and Fine Aggregate

Dr. Randy West, P.E.
Dr. Nam Tran, P.E.
National Center for Asphalt Technology

TRB webinar, Feb. 18, 2016
http://www.trb.org/Main/Blurbs/173638.aspx



Recommendations
RAP Aggregate Gsb

One method of determining RAP aggregate Gsb will not work for all material types. Agencies need to evaluate options to find the best method for their materials. The method that gives the lowest Gsb will result in the lowest mix VMA. This is desirable since it will lead to higher asphalt contents and better durability.

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With the current volumetric mix design system…

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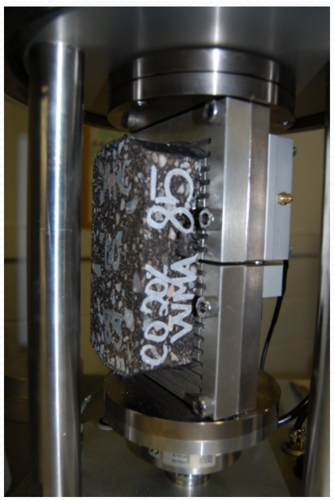
Balanced Mix Design

Cracking Resistance



Rutting Resistance

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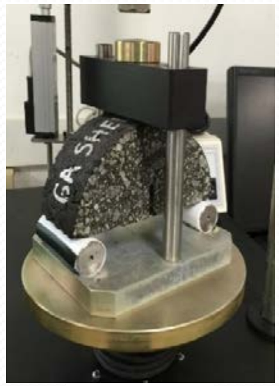
Some Tests for Assessing Cracking Resistance

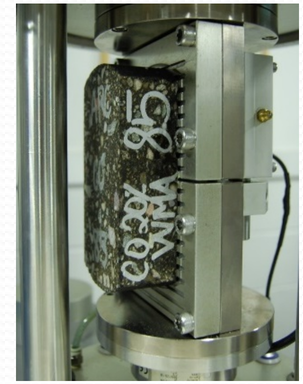
BBF



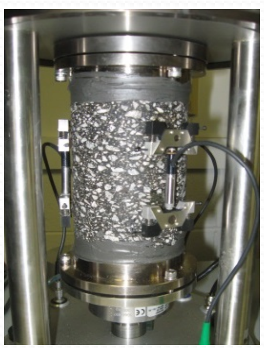
SCB-LA

I-FIT

OT-TX

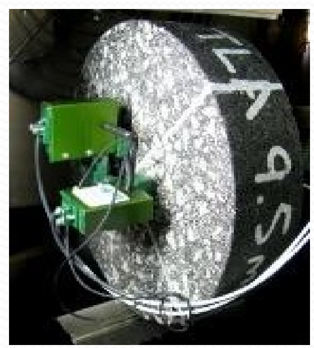


OT-NCAT



SVECD

DCT



Energy Ratio

Nflex Factor

Cantabro

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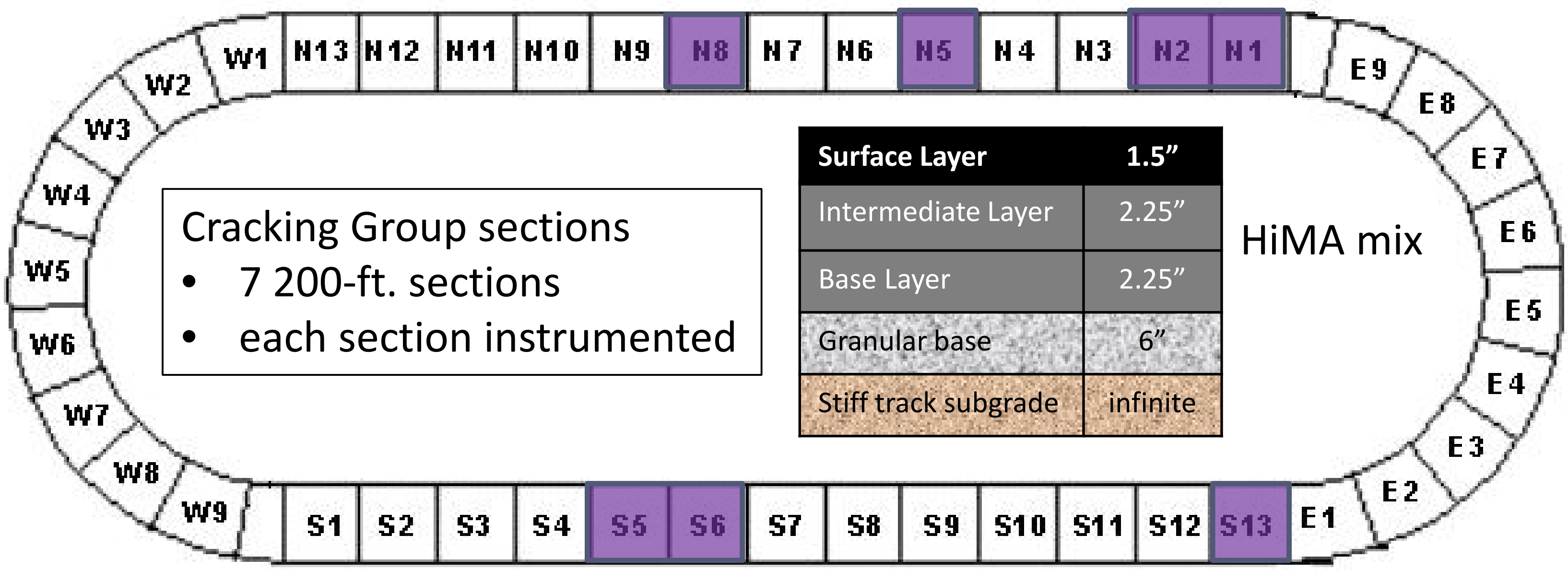
NCAT Test Track
Top-Down Cracking Sections



Cracking Group sections
- 7 200-ft. sections
- each section instrumented

Surface Layer	1.5”
Intermediate Layer	2.25”
Base Layer	2.25”
Granular base	6”
Stiff track subgrade	infinite

HiMA mix

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Pooled Fund Cracking Experiment

Safer, Smarter, Sustainable Pavements through Innovative Research

Dave Van Deusen, Ben Worel

Cracking Group (North) Pooled Fund

We all have a stake in A TO B

Any Questions?