Washington State Department of Transportation

Materials Laboratory
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technotes

"tech notes" are a product of the State Materials Laboratory to share improvements in design and construction technology gained from WSDOT projects. This issue is from the Bituminous Materials Section discussing Superpave Gyratory Compactor Angle Calibration.

Gyratory Compactor Angle Study

Introduction:

WSDOT first purchased a Superpave Gyratory Compactor (SGC) in 1995. The initial purchase was a first generation Troxler model 4140 gyratory compactor. Since that time WSDOT has purchased several different brands and models of SGC which have been used throughout the state. Currently, there are three types of SGC in use, the Troxler model 4140, Pine-Brovold model AFGB1A, and Interlaken model GYR-001.

Troxler Model 4140

Objective:

Due to the variety of gyratory compactors in use throughout the state, there is a concern of possible variability in the angle of gyration between the different brands of compactors. Because WSDOT uses volumetric properties on many projects as part of the statistical evaluation of materials for acceptance, accurate compacted density determination is essential. Therefore, this study undertook the task of measuring and comparing both internal and external angles of gyration of Superpave gyratory compactors and the impacts these measurements have on bulk specific gravity (Gmb) and air voids (Va) of hot mix asphalt (HMA).

Background:

Research at the Asphalt Institute during the Strategic Highway Research Program determined that Gmb of HMA was most influenced by the angle of gyration[1]*. In 2002 the WSDOT Materials Laboratory purchased a Dynamic Angle Validator (DAV) and began evaluating its ability to measure the internal angle of gyration. Although the DAV was a big step toward measurement of internal angle of gyration, the calibration procedure for this device proved to be cumbersome and very time consuming. Use of HMA along with the DAV introduced procedural difficulties i.e., heating and mixing samples, determining the correct amount of HMA needed to achieve the proper height of sample. Another challenge with using HMA was the need to extrapolate the internal angle because some SGC molds could not accommodate full size samples of HMA. WSDOT observed that the internal angles measured were*


Pine-Brovold Model AFGB1A

1 Huber, Gerald A., "Development of the Superpave Gyratory Compactor," Heritage Research, Indianapolis, Indiana, 1997

Interlaken gyratory compactor.

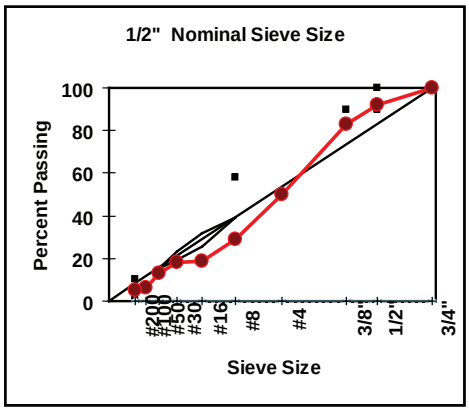


Chart 1 shows HMA Class 1/2 Inch gradation on the .45 Power Chart


Pine Instrument's Rapid Angle Measurement (RAM)

often out of specification while the external angles measured were in specification.

Because of the difficulty of use and questionable accuracy associated with the use of HMA in conjunction with the DAV, testing equipment manufacturers began developing mix-less devices for measuring internal angles of SGC's. A couple of these new devices, the Pine Instrument's Rapid Angle Measurement (RAM) and Test Quip's DAV II with Hot Mix Simulator (HMS), are equipped with rings or cones that can change the eccentricity to simulate different mix stiffness without the use of HMA specimens. During cost and product comparisons prior to purchasing a mix-less internal angle measuring device, Test Quip Inc. offered to upgrade the DAV already owned by WSDOT to the mix-less DAV II with HMS for much less than the cost of purchasing a new device.

Sample Preparation:

For the purpose of this study a ½ inch HMA 100 gyration N_{design} was selected. This design required an asphalt content of 5.9% using PG64-22 binder and a gradation as shown in Chart 1. The mixing temperature was 310°F and the compaction temperature was 289°F. Each sample was prepared at the same target gradation and weighed approximately 4740 grams to provide a final sample height of approximately 115 mm after 100 gyrations of compaction. In order to determine air voids (Va) of the HMA samples compacted in this study, an average Gmm of 2.467 was determined from the mix design prepared as described above.

Work Plan:

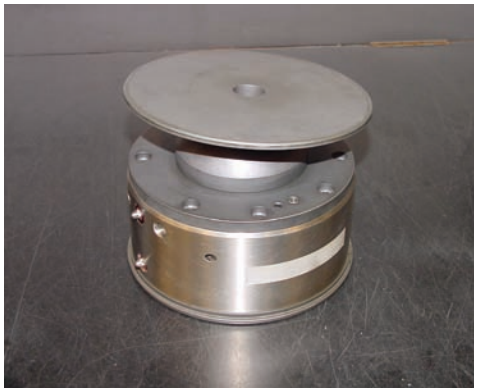
Based on the various locations and number of gyratory compactors employed by WSDOT it was decided to initiate this "Phase One" study to evaluate two to four compactors in each of the six regions throughout the state. This first phase provides an evaluation of compactors used in each region's central laboratory and others used in field applications. Depending on the findings of "Phase One", additional testing and data collection may be employed to evaluate all compactors used within WSDOT by internal angle of gyration. Prior to measuring the angle of gyration on any SGC used in this study the sample molds were calibrated to ensure specification compliance.

The first step of phase one was to calibrate each compactor used in this study by external angle measure to the standard of 1.25 ± 0.02°. After external calibration three replicate samples of the ½ inch HMA were heated to a temperature of 289°F and compacted to 100 gyrations.

The second step was to measure the internal angle using the DAV II™. If the measured internal angle of gyration was outside the standard tolerance it was adjusted to 1.16 ± 0.02° and three replicate samples of the ½ inch HMA were heated to a temperature of 289°F and compacted to 100 gyrations. If the measured internal angle of gyration was within the standard of 1.16±0.02° no additional HMA samples were compacted on that SGC.

When a compactor requires an adjustment to achieve the internal angle after being calibrated by external means the potential for variation in Gmb exists so compacting samples for comparison purposes is essential. All of the angle measurements, calibrations, and sample testing for this study were performed by one technician using the SGC and testing equipment located at the regional laboratory or field testing trailer. Within 15-24 hours of compaction, the Gmb testing was performed in accordance with AASHTO T166.

Once the angle calibrations and sample compactions were completed each SGC used in this study was returned to its original state, the SGC was recalibrated to the specified external gyration angle of 1.25±0.02°.



Test Quip's DAV II with Hot Mix Simulator (HMS)

Data Collection:

Table 1 identifies the location, make, model, and serial number of the seventeen compactors used in this study.

Table 1 Compactors Used in Internal Angle Study

Location	Designation	Make	Model	Serial #
Olympic Region Lab	OR1	Pine-Brovold	AFGB1A	5128
Olympic Region, Aberdeen	OR2	Pine-Brovold	AFGB1A	5127
State Materials Lab	ML1	Troxler	4140	463
State Materials Lab	ML2	Troxler	4140	738
State Materials Lab	ML3	Troxler	4140	111
Southwest Region Lab	SW1	Pine	BGC-1	59919
Southwest Region Lab	SW2	Pine-Brovold	AFGB1A	5136
Southwest Region Lab	SW3	Pine-Brovold	AFGB1A	5364
Eastern Region Lab	ER1	Interlaken	GYR-001	CDG
Eastern Region Lab	ER2	Pine-Brovold	AFGB1A	5143
South Central Region Lab	SC1	Troxler	4140	132767
South Central Region Lab	SC2	Pine-Brovold	AFGB1A	5109
North Central Region Lab	NC1	Pine-Brovold	AFGB1A	5121
Northwest Region Lab	NW1	Pine-Brovold	AFGB1A	5116
Northwest Region, Issaquah	NW2	Pine-Brovold	AFGB1A	5118
Northwest Region, Auburn	NW3	Pine-Brovold	AFGB1A	5088
Northwest Region, Everett	NW4	Pine-Brovold	AFGB1A	5117

Test Quip's DAV II with Hot Mix Simulator (HMS) in gyratory mold.

Table 2 shows the initial external, initial internal, and adjusted internal angle of gyration for each compactor listed in

Table 2 Angle Measurements			
Designation	Initial External Angle	Internal Angle	Adjusted Internal Angle
OR1	1.24	1.12	1.15
OR2	1.25	1.20	1.16
ML1	1.25	1.14	
ML2	1.26	1.15	
ML3	1.27	1.18	
SW1	1.24	1.17	
SW2	1.24	1.18	
SW3	1.24	1.18	
ER1	1.25	1.17	
ER2	1.24	1.20	1.16
SC1	1.25	1.16	
SC2	1.26	1.19	1.16
NC1	1.25	1.19	1.16
NW1	1.24	1.18	1.17
NW2	1.23	1.17	
NW3	1.25	1.19	1.16
NW4	1.24	1.18	
Average	1.25	1.18	1.16

Table 3 Population Average and Standard Deviation				
	External Calibration			
	Gmb	VMA	VA	VFA
Average	2.373	15.0	3.8	75
St.Dev	0.013	0.46	0.52	2.68
	Internal Calibration			
	Gmb	VMA	VA	VFA
Average	2.369	15.1	4.0	74
St.Dev	0.012	0.42	0.47	2.42

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Table 1. It should be noted that, upon initial inspection, all of the external angle measurements were within the specification of 1.25 ± 0.02º. Seven out of 17 (41%) of the compactors used in this study required adjustment to achieve the standard internal angle of 1.16 ± 0.02° after being calibrated by external means. All of the compactors that required internal angle adjustment were Pine-Brovold AFGB1A models.

Summary:

Ultimately, we are given the choice of two methods to calibrate the angle of gyration of Superpave gyratory compactors (SGC). Either externally using different manufacturers' methods or internally using one of the new internal angle validation devices. As seen in the data generated from this study, when a difference is observed between external and internal angle of compaction (i.e. adjustment is necessary to achieve internal angle when calibrated externally) the Gmb results are consistently lower. Table 3 shows the lower Gmb value will produce slightly higher air voids (Va) when calculated with a constant Gmm value. It will also increase the voids in mineral aggregate (VMA) and decrease the voids filled with asphalt (VFA). Consequently, this change in test data could affect the acceptance of HMA produced for volumetrically accepted WSDOT projects.

Many of the SGC's used in this study were within specification for both external and internal angle of compaction but 41% required adjustment to achieve the internal angle when calibrated externally. 41% is substantial enough to raise concern about potential for variation of volumetric results among multiple laboratories. The Gmb data in this study confirms this variation. Studies performed around the country have identified variation among different gyratory compactors. Given this information, one way to eliminate some of the variation in volumetric test results may be to calibrate all of the gyratory compactors with one device using one method. As stated earlier, external angle adjustment methods vary from manufacturer to manufacturer. The only method of calibration that uses the same methodology and equipment is an internal angle measurement system.