

Importance of Accurate Specific Gravity Measurements on Coarse SuperPave and SMA Asphalt Mixes

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Introduction

Density measurements obtained from the water displacement method are routinely used during asphalt design, quality control, quality assurance and field correlation with nuclear gauges. The conventional testing methods ASTM D2726 and AASHTO T166 for specific gravity measurements are repeatable for fine graded mixtures. However, for coarse mixes the density results obtained by these methods are higher than the actual density of the asphalt cores. This problem is recognized and reported by many in the industry. Dr. Ray Brown of the National Center for Asphalt Technology (NCAT) and others, have on numerous occasions cautioned the industry on the problems related to inaccurate specific gravity measurements on design and quality control of coarse asphalt mixtures.

Since the completion of the Strategic Highway Research Program (SHRP) in 1995, an increased number of road surfaces have been paved with SuperPave and SMA mixtures. These mixes generally employ higher proportions of large aggregates, creating an open mixture. During specific gravity (water displacement) tests, water infiltrates these samples quickly and will also drain out of the sample quickly, causing higher than actual specific gravity (density) measurements. Furthermore, the rate of water infiltration into and out of these samples causes problems with repeatability and accuracy.

ASTM D2726 requires the cores to be sealed, if the samples retain more than 2% water during the testing process. Unfortunately, the currently used sealing methods (Paraffin wax and Parafilm) have poor repeatability, are highly sensitive to operator error, and have no specifications for sealing six inch diameter core samples. Consequently, few agencies require the use of this method. The new automatic vacuum sealing method, the *Corelok™*, by InstroTek is designed to address this problem.

The *Corelok* uses a vacuum chamber capable of evacuating and sealing asphalt cores up to six inches thick. This device can, in less than one minute, completely seal laboratory and/or field cores. The system involves very little operator involvement and protects the samples against water infiltration. The sample can later be removed from the seal and used for other tests. The results obtained using the *Corelok* method are extremely repeatable and accurate.

Problems Related to Inaccurate Specific Gravity Measurements

Specific gravity (density) is the single most specified parameter in the asphalt industry. The results from these tests are used from design through production as well as the laydown stage of the asphalt. Inaccurate density results can have a ripple effect throughout the entire asphalt production process. The following items briefly address some of the possible problems related to specific gravity measurements of coarse graded mixtures:

- 1- Design: Designers can use specific gravity values for estimation of air void and asphalt content of the mixture. Inaccurate air and asphalt contents based on erroneous specific gravity can seriously effect the performance of the roadway and its quality.
- 2- Field Compaction: Overestimating the specific gravity in the laboratory can cause compaction headaches for the contractors in the field. Since field cores and laboratory prepared samples generally have different surface texture, the field core results will be relatively lower than the laboratory core densities for the same material. This might create the perception that compaction has not been reached. Field compaction problems have been reported as one of the key issues for SuperPave mixtures. We believe the results from the specific gravity tests should be considered when providing solutions to this costly compaction problem.
- 3- Quality Control/Quality Assurance: Field cores are generally different from laboratory prepared cores in surface texture and thickness. Using the gyratory compactors, the mixture is confined on all surfaces. This creates voids on all surfaces, especially sides, that are not normally seen on field cores. The difference in surface roughness of these two different sampling methods in effect produces a different degree of water absorption and drainage during water displacement tests. This causes laboratory and field samples with the same air content, asphalt content and density to measure differently when tested with water displacement method. Obviously, without a standardized result, Q/C and Q/A procedures begin to resemble the practice of “shooting in the dark”.
- 4- Field Correlation to Nuclear Density Gauges: Nuclear gauges are very sensitive to surface roughness. It is difficult to achieve accurate results using nuclear density gauges with SuperPave and SMA mixes. Generally, gauge readings are corrected to match core density results obtained from the water displacement method. Obviously, with inaccuracies in water displacement measurements, a reliable correlation cannot be developed between these two methods to assess the asphalt pavement performance.

The Corelok Method:

This method utilizes an automatic vacuum chamber with specially designed, puncture resistant, resilient bags. The sealing method involves very little involvement from the operator. Using a 1.5 hp vacuum pump, the unit automatically evacuates and seals the bag during the vacuum operation. The vacuum pump is capable of pulling to 30 in. Hg (1 TORR). The bags are designed in two different sizes to accommodate different thickness

of cores. To maximize the effectiveness of the vacuum system, it is important to select the correct bag dimensions for the size of core being tested. Since the volume displaced by the bag is determined and the bags are manufactured with tight specifications, no trimming or adjustments are necessary to the bags. The steps involved in sealing and analyzing the samples are as follows:

- ✓ Place the sample inside the bag in the CoreLok chamber
- ✓ Close the chamber door. The vacuum pump will start automatically and evacuate the chamber.
- ✓ In approximately two minutes, the chamber door will open automatically. The sample is completely sealed, ready for water displacement analysis.
- ✓ Perform water displacement analysis. Correct the results for the bag apparent density.

Note: The *Corelok* method does not damage the sample. The dry sample can easily be removed from the bag for subsequent tests.

Results:

Table 1 is the average and standard deviation obtained for three different coarse graded mixes. Each average is the result of three different samples.

Table 1

Mix	Average Density(g/cm ³)	Standard Deviation
1	2.291	0.0015
2	2.139	0.0020
3	2.162	0.0021

Table 2 is a comparison of T166, Corelok and volumetric density measurement methods for three asphalt samples each of Open Graded Friction Coarse (OGFC) and Stone Matrix Asphalt (SMA). The volumetric (mass/volume) measurement was used as a reference. The volumetric method has poor repeatability and underestimates the density of coarse mixes. Some agencies have considered using the volumetric method as a replacement for the SSD method, a method which should not be used for analysis of coarse asphalt mix density.

Table 2

Mix	T166 Density(g/cm³)	Corelok Density(g/cm³)	Volumetric Density(g/cm³)
OGFC	2.156	1.975	1.921
SMA	2.351	2.305	2.262

Table 3 is the repeatability data collected on a single OGFC core by four different operators. Each operator sealed and analyzed the sample three times by the Corelok method. It is important to note that operator 3 and 4 had never performed a water displacement analysis. The repeatability they obtained verifies our claim of superior repeatability attainable using this method, even with inexperienced operators. The combined standard deviation (repeatability) of the Corelok method based on the results of this test is 0.002 g/cm³ (0.12 lb/ft³). The single operator repeatability based on this test ranged from 0.0003g/cm³ to 0.0027g/cm³ (0.02 lb/ft³ to 0.17 lb/ft³).

Table 3

Operator	Density(g/cm³)	Std. Deviation
1	2.024	0.0027
2	2.029	0.0011
3	2.032	0.0014
4	2.035	0.0003

Conclusions:

Current water displacement tests for coarse asphalt mixtures can produce higher than actual specific gravity results. This error can have a ripple effect throughout the design, development and production of asphalt. An automatic sealing device, Corelok, has been developed specifically to provide accurate and precise density analysis of coarse SuperPave and SMA mixtures. This method is very user friendly and requires very little operator involvement in sealing the sample. Corelok protects the sample from water infiltration and the dry sample can be easily removed from the bag and used for other tests. The repeatability and accuracy of this method is superior over all other methods presently used for coarse mixes. The combined repeatability based on tests performed by four different operators on an Open Graded Friction Coarse mixture was calculated as 0.002 g/cm³ or 0.12 lb/ft³. The single operator precision based on these tests ranged from 0.0003g/cm³ to 0.0027g/cm³ (0.02 lb/ft³ to 0.17 lb/ft³).

Corelok™ Specifications

The CoreLok™ system is specially designed for asphalt sample sealing so that the densities may be measured by water displacement method. Samples are automatically sealed in specially designed puncture resistant polymer bags. The nominal density of the bag is predetermined at the factory. Densities measured with the Corelok system are highly reproducible. The Corelok system consists of a vacuum chamber and bags designed for sealing four or six inch diameter laboratory or field cores. Call InstroTek for other sample size requirements.

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MECHANICAL/ELECTRICAL

- 1.25 hp Busch vacuum pump force vented from both ends for cool operation and long life.
- Built in sight glass and drain system
- Friction reducing slide mechanism for puncture control
- Controlled and calibrated vacuum and exhaust system
- Lid hold down mechanism
- Vacuum level 29.95 in. Hg, 1TORR, 1.33 MBARS
- 10 weight vacuum oil
- Metal frame
- Injected molded high-tech engineered composite lid, basin and chassis
- Viewing window with 3/8" tempered glass
- 16 inch (406mm) Pressure induced automatic wire sealing element
- Net weight 120 pounds (63 kg)
- Shipping weight 145 pounds (64 kg)
- Standard 120 VAC, 60 Hz, 13 amps or optional 220VAC, 50 Hz, 6.5 amps
- Overall Size 19"X19"X25" (483X483X635 mm) (W X H X Depth)
- Flat chamber, 16.75"X7.25"X19.6" (425X184X497 mm) (W X H X Depth)
- Footprint 3.25 Sq. Ft.

PERFORMANCE

Precision as determined by repeated testing of five 6" cores and five 4" cores is 0.002 gr/cm³ for both core sizes.

BAG SPECIFICATIONS

- Impermeable to water
- Flexible to conform to core surface irregularities
- Puncture-resistant
- Does not adhere to asphalt cement
- Two specially designed bag sizes for 4" and 6" diameter asphalt samples

Made in USA
(Patent Pending)

The Corelok™ is available from:

InstroTek, Inc.

3201 Wellington Court, Suite 101, Raleigh, NC 27615, Phone 919-875-8371, Fax 919-875-8328