Evaluation of Alternative Methods to Obtain Specific Gravity of Coarse Aggregate

Final Report for MLR-89-7

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Highway Division

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EVALUATION OF ALTERNATIVE METHODS TO OBTAIN SPECIFIC GRAVITY OF COARSE AGGREGATE

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ABSTRACT:

AASHTO has a standard test method for determining the specific gravity of aggregates. The people in the Aggregate Section of the Central Materials Laboratory perform the AASHTO T-85 test for AMRL inspections and reference samples. Iowa's test method 201B, for specific gravity determinations, requires more time and more care to perform than the AASHTO procedure. The major difference between the two procedures is that T-85 requires the sample to be weighed in water and 201B requires the 2 quart pycnometer jar.

Efficiency in the Central Laboratory would be increased if the AASHTO procedure for coarse aggregate specific gravity determinations was adopted.

The questions to be answered were:

1. Do the two procedures yield the same test results?
2. Do the two procedures yield the same precision?

An experiment was conducted to study the different test methods. From the experimental results, specific gravity determinations by AASHTO T-85 method were found to correlate to those obtained by the Iowa 201B method with an R^2 value of 0.99. The absorption values correlated with an R^2 value of 0.98. The single operator precision was equivalent for the two methods. Hence, this procedure was recommended to be adopted in the Central Laboratory.

INTRODUCTION:

The Aggregate Section of the Central Materials Laboratory in Ames has been routinely testing coarse aggregate for specific gravity using Iowa Method 201B. A few times every year, the AASHTO T-85 method is used to test AMRL and other external reference samples. Though Iowa Method 201B is suited for a field laboratory set up with limited facilities, it is felt that in the Central Laboratory, the AASHTO T-85 method would be preferable as this method takes less time and effort.

Since the same material is often tested both in the field laboratory and also in the Central Laboratory, it is necessary to know how the results from these two methods correlated, before a procedure change can be adopted.

OBJECTIVE:

The objective of the study is to determine the single-operator variation between the two test methods and determine the single operator precision for each method.

MATERIALS:

Six aggregates were selected by the Geology Section to represent the range of materials available in Iowa. These selected aggregates were from the following sources:

	Source	Sp. Gravity	Absorption (%)
1.	Widger (A10038)	2.62	1.41
2.	Hunt (A19006)	2.56	3.42
3.	Harris (A98002)	2.72	0.85
4.	Duenow (A66002)	2.78	0.62
5.	Gardner Nott (A41002)	2.65	1.57
6.	Bowser-Springville (A57008)	2.47	3.85

TESTING:

All the testing was done in the Aggregate Section under the direction of Cliff Dalbey. The six field samples were each separated into different size fractions using a mechanical sieve shaker. These different size fractions were then recombined in the right proportion to build up 10 identical test samples weighing about 2100 gms. from each source.

From these 10 identical samples, five were randomly picked to be tested by the Iowa method and the other five were tested using the AASHTO method. All testing by the Iowa method was done by one operator and all AASHTO method testing was done by another operator. The samples for the two methods were saturated and surface dried identically at the same time.

The AASHTO method was run twice on each sample. The first time the AASHTO test was run using the Iowa method of obtaining the saturated surface dry (S.S.D.) condition and a second time using the AASHTO procedure for obtaining the S.S.D. condition. The first procedure was called modified AASHTO and the second procedure was called AASHTO T-85 though the sample size used was about 2000 gms. instead of 4000 gms. as required in the specification.

A copy of the specification Iowa 201B and AASHTO T-85 is attached in Appendix A.

RESULTS

The results of the tests conducted are tabulated in Appendix B. The test results are shown in Table 1.

Table 1 - Summary of Test Results

	Absorption (%)		Specific Gravity	
	Avg.	Std. Dev.	Avg.	Std. Dev.
Widger Aggregate				
Iowa Method 201B	1.4096	0.0385	2.6230	0.0022
AASHTO T-85 Modified	1.5254	0.0981	2.6230	0.0022
AASHTO T-85	1.8974	0.0960	2.5919	0.0062
Hunt Aggregate				
Iowa Method 201B	3.4241	0.2772	2.5638	0.0092
AASHTO T-85 Modified	3.1032	0.1159	2.5623	0.0038
AASHTO T-85	3.6987	0.0573	2.5470	0.0023
Harris Aggregate				
Iowa Method 201B	0.8471	0.0203	2.7196	0.0022
AASHTO T-85 Modified	0.8551	0.0317	2.7176	0.0035
AASHTO T-85	1.1950	0.0786	2.7082	0.0044
Duenow Aggregate				
Iowa Method 201B	0.6239	0.0516	2.7789	0.0058
AASHTO T-85 Modified	0.6308	0.0322	2.7712	0.0016
AASHTO T-85	0.9613	0.0318	2.7614	0.0022
Gardner Aggregate				
Iowa Method 201B	1.5745	0.0798	2.6515	0.0056
AASHTO T-85 Modified	1.7044	0.0798	2.6397	0.0056
AASHTO T-85	2.0370	0.1256	2.6315	0.0077
Bowser Aggregate				
Iowa Method 201B	3.8531	0.1295	2.4682	0.0059
AASHTO T-85 Modified	3.9145	0.1039	2.4633	0.0033
AASHTO T-85	4.2345	0.0269	2.4533	0.0048

The linear regression analysis and the corresponding graphs are in Appendix C.

The correlations are as follows:

Specific Gravity

Iowa vs. Modified AASHTO

Iowa = 1.0030 (Mod. AASHTO)

R^2 = 0.992
Std. error of estimation = 0.0094

Iowa vs. AASHTO

Iowa = 1.0071 (AASHTO)

R^2 = 0.9910
Std. error of estimation = 0.0099

Absorption

Iowa vs. Modified AASHTO

Iowa = 1.0396 (Mod. AASHTO) - 0.0776

R^2 = 0.9767
Std. error of estimation = 0.1969

Iowa vs. AASHTO

Iowa = 1.0086 (AASHTO) - 0.4021

R^2 = 0.9806
Std. error of estimation = 0.1794

The correlation for the absorption "Iowa vs. Modified AASHTO" is actually the correlation of the same method performed by different operators.

SINGLE OPERATOR PRECISION

The average standard deviations in the absorption and specific gravity determinations by the AASHTO method was less than or equal to the Iowa method. The Modified AASHTO Method for absorption is also the Iowa Method performed by a different operator. Hence, the AASHTO method was more precise than the Iowa method in our lab.

Absorption	Average Std. Dev.	Difference Between Two Tests
Iowa Method	0.0995	0.282
AASHTO Method	0.0694	0.196
Modified AASHTO Method	0.0769	0.218
Specific Gravity		
Iowa Method	0.0051	0.014
AASHTO Method	0.0046	0.013
Mod. AASHTO Method	0.0040	0.011

Limits as described in ASTM recommended Practice C670.

DISCUSSION OF RESULTS

From the linear regression analysis done on the test results from the two methods, it was found that there was excellent correlation between the AASHTO T-85 specific gravity values and the Iowa 201B specific gravity values. The R^2 value in this correlation was over 0.99. The results were tested statistically at 95% confidence level, and it was found that there was no significant difference between the two sets of test results. This means that any difference found is by chance and not by reason of any inherent difference between the two test methods.

Similarly the absorption values gave an R^2 value of 0.98 and there was no significant difference between the two sets of values obtained by the Iowa 201B method and the set of values derived from the AASHTO T-85 method using the proper correlation equation when tested statistically at 95% confidence level. The absorption values obtained by the AASHTO method were higher than those obtained by the Iowa method. This is to be expected since the surface drying procedure in the AASHTO method leaves the sample consistently more moist than the Iowa method. The correlation equation was found to be Iowa Method absorption = AASHTO Method Absorption x 1.0086 - 0.4021.

RECOMMENDATIONS

AASHTO T-85 Method of Determination of Specific Gravity and Absorption of Coarse Aggregates is easier and less time consuming to perform in the laboratory setting. The results obtained are easily comparable to those obtained by the Iowa method by applying the proper correlation factor and better precision can be achieved. Hence it would be of advantage to do these determinations using the AASHTO T-85 method rather than the Iowa method. In order to correlate the AASHTO values to the values obtained in the field by the Iowa Method, the following equations may be used.

Iowa Method Sp. Gravity = 1.0071 x AASHTO Method Sp. Gravity

Iowa Method Absorption =
1.0086 x AASHTO Method Absorption - 0.4021

APPENDIX A

IOWA DEPARTMENT OF TRANSPORTATION

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METHOD OF TEST FOR DETERMINING THE SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

Scope

This method of test describes the procedure for determining the specific gravity and absorption of coarse aggregate by the pycnometer method.

Procedure

A. Apparatus

1. A two-quart pycnometer consisting of a Mason fruit jar supplied with a gasket and conical pycnometer top that will form a tight seal.
2. Constant temperature water bath capable of maintaining a temperature of 72 ± 1°F.
3. Balance having a capacity of 5000 grams or more, accurate to 0.5 gram.
4. Drying table with overhead electric fan.
5. Oven capable of maintaining a temperature of 212 to 230°F.
6. Absorbent cloth.
7. Six quart pan.

B. Sample Preparation

1. Separate the sample as received by sieving over the 1.06", 3/4", 0.530", 3/8" and No. 4 sieves.
2. Build back a sample, of at least 2100 grams, to the original grading of the material as received with the exception that all material passing the No. 4 sieve must be discarded.

C. Calibration of Pycnometer

1. Fill the pycnometer jar nearly full of water at 72 ± 1°F.
2. After rinsing the pycnometer top and pycnometer jar with water, screw the top onto the jar tightly so that it will not leak.
3. Fill the pycnometer completely by pouring water into the hole in the top.
4. Using compressed air, blow any water from under the lip of the jar. Dry the exterior of the pycnometer with an absorbent cloth and weigh to the nearest 0.5 gram. Record this weight as P.

D. Test Procedure

1. Thoroughly wash the sample to remove dust or other coatings from the surface of the particles.
2. Immerse the sample in water for a period of not less than 16 hours.
3. Remove the sample from the water, rewash it, and roll it in a large absorbent cloth to remove excess moisture.
4. Place the sample on the drying table, turn on the overhead fan and dry the sample to a saturated surface dry condition by stirring and turning the particles so they will dry evenly. Weigh the sample to the nearest 0.5 gram and record the weight as SssD.

   Note: As coarse aggregates approach the saturated surface dry condition there is ordinarily a rather definite change in the appearance of the particles. The glossy wet appearance changes to a dull finish as the free moisture is removed from their surfaces.

5. Place the sample in a previously calibrated two-quart pycnometer containing about 2 inches of water.
6. Nearly fill the pycnometer jar with water from the constant temperature bath. Rinse the pycnometer top and pycnometer jar with water and screw the top onto the jar tightly so it will not leak.

7. Entirely fill the pycnometer by adding water through the hole in the top.

8. Hold one finger over the hole in the top and gently roll and shake the pycnometer to remove entrapped air in the sample.

9. Refill the pycnometer with water and repeat the rolling until all of the air is removed. Add water to the pycnometer again until it is completely filled.

10. Place the pycnometer in the constant temperature bath until it reaches a constant temperature of 72 $\pm$ 1°F.

11. Remove the pycnometer from the bath and using compressed air, blow all of the water from under the lip of the jar ring and, with an absorbent cloth, dry the exterior surface of the pycnometer.

12. Weigh the pycnometer and its contents to the nearest 0.5 gram and record as W.

13. Pour the sample from the pycnometer into a previously tared 6-quart pan. Pour off the excess water being careful not to lose any particles. Place the sample in the oven for 16 hours or until it has dried to a constant weight. Allow the sample to cool upon removal from the oven, weight to the nearest 0.5 gram and record the weight as SoD.

E. Calculations

1. Bulk Specific Gravity (S.S.D.) =

$$\frac{SssD}{P+SssD - W}$$

2. Bulk Specific Gravity (Oven dry) =

$$\frac{SoD}{P+SssD - W}$$

3. Apparent or Absolute Specific Gravity =

$$\frac{SoD}{P+SoD - W}$$

4. Absorption, percent =

$$\frac{SssD - SoD}{SoD} \times 100$$

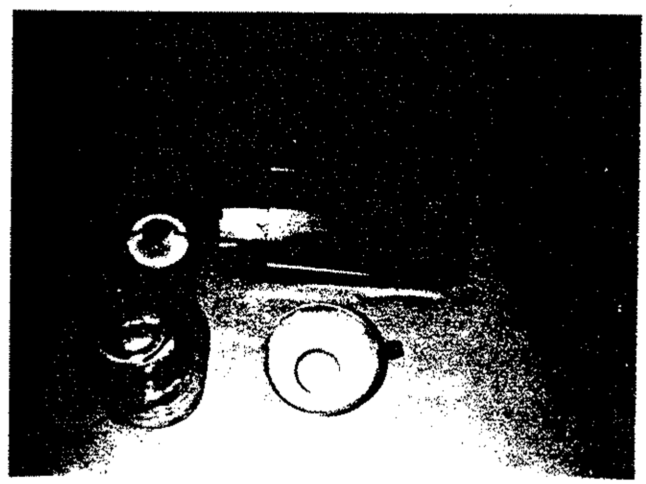


Figure 1
Two-quart Pycnometer, Funnel and Filling Pan

Standard Method of Test for

Specific Gravity and Absorption of Coarse Aggregate

AASHTO DESIGNATION: T 85-85[1]
(ASTM DESIGNATION: C 127-81)

1. SCOPE

1.1 This method covers the determination of specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk specific gravity, bulk specific gravity (saturated-surface-dry (SSD)), or apparent specific gravity. The bulk specific gravity (SSD) and absorption are based on aggregate after 15 h soaking in water. This method is not intended to be used with lightweight aggregates.

[1]This method agrees with ASTM C 127-81 except for differences in soaking time and accuracy of weighing.

2. APPLICABLE DOCUMENTS

2.1 AASHTO Standards
- M 43 Standard Sizes of Coarse Aggregate for Highway Construction
- M 92 Wire Cloth Sieves for Testing Purposes
- T 2 Sampling Aggregates
- T 19 Unit Weight and Voids in Aggregate
- T 27 Sieve Analysis of Fine and Coarse Aggregates
- T 84 Specific Gravity and Absorption of Fine Aggregate
- T 248 Reducing Field Samples of Aggregate to Testing Size
- T 255 Total Moisture Content of Aggregate by Drying

2.2 ASTM Standards
- C 125 Definition of Terms Relating to Concrete and Concrete Aggregates
- C 670 Practice for Preparing Precision Statements for Test Methods for Construction Materials
- E 12 Definition of Terms Relating to Density and Specific Gravity of Solids, Liquids and Gases

3. SUMMARY OF METHOD

3.1 A sample of aggregate is immersed in water for approximately 15 h to essentially fill the pores. It is then removed from the water, the water dried from the surface of the particles, and weighed. Subsequently the sample is weighed while submerged in water. Finally the sample is oven-dried and weighed a third time. Using the weights thus obtained and formulas in the method, it is possible to calculate three types of specific gravity and absorption.

4. SIGNIFICANCE AND USE

4.1 Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate, including portland cement concrete, bituminous concrete, and other mixtures that are proportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in T 19. Bulk specific gravity (SSD) is used if the aggregate is wet, that is, if its absorpotion has been satisfied. Conversely, the bulk specific gravity (oven-dry) is used for computations when the aggregate is dry or assumed to be dry.

4.2 Apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles which is accessible to water.

4.3 Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregate for approximately 15 h in water. Aggregates mined from below the water table may have a higher absorption, when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than the 15 h soaked condition. For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined by T 255.

4.4 The general procedures described in this method are suitable for determining the absorption of aggregates that have had conditioning other than the 15 h soak, such as boiling water or vacuum saturation. The values obtained for absorption by other methods will be different than the values obtained by the prescribed 15 h soak, as will the bulk specific gravity (SSD).

4.5 The pores in lightweight aggregates may or may not become essentially filled with water after immersion for 15 h. In fact, many such aggregates can remain immersed in water for several days without satisfying most of the aggregates' absorption potential. Therefore, this method is not intended for use with lightweight aggregate.

5. DEFINITIONS

5.1 *Specific Gravity*—the ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of water at stated temperatures. Values are dimensionless.

5.1.1 *Bulk Specific Gravity*—the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

5.1.2 *Bulk Specific Gravity (SSD)*—the ratio of the weight in air of a unit volume of aggregate, including the weight of water within the voids filled to the extent achieved by submerging in water for approximately 15 h (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

5.1.3 *Apparent Specific Gravity*—the ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

5.2 *Absorption*—the increase in the weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry weight. The aggregate is considered "dry" when it has been maintained at a temperature of 110 ± 5°C for sufficient time to remove all uncombined water.

NOTE 1—The terminology for specific gravity is based on terms in Definitions E 12, and that for absorption is based on that term in Definitions C 125.

6. APPARATUS

6.1 *Balance*, conforming to the requirements of AASHTO M 231, Class G5. The balance shall be equipped with suitable apparatus for suspending the sample container in water from the center of the weighing platform or pan of the weighing device.

6.2 *Sample Container*—A wire basket of 3.35 mm (No. 6) or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4 to 7 L for 37.5-mm (1½-in.) nominal maximum size aggregate or smaller, and a larger container as needed for testing larger maximum size aggregate. The container shall be constructed so as to prevent trapping air when the container is submerged.

6.3 *Water Tank*—A watertight tank into which the sample is placed while suspended below the balance, equipped with an overflow outlet for maintaining a constant water level.

6.4 *Sieves*—A 4.75 mm (No. 4) sieve or other sizes as needed (see Sections 7.2, 7.3, and 7.4), conforming to M 92.

7. SAMPLING

7.1 Sample the aggregate in accordance with T 2.

7.2 Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed using the applicable procedures in T 248. Reject all material passing a 4.75 mm (No. 4) sieve by dry sieving and thoroughly washing to remove dust or other coatings from the surface. If the coarse aggregate contains a substantial quantity of material finer than the 4.75 mm sieve (such as for Size No. 8 and 9 aggregates in M 43, use the 2.36 mm (No. 8) sieve in place of the 4.75 mm sieve. Alternatively, separate the material finer than the 4.75 mm sieve and test the finer material according to T 84.

7.3 The minimum weight of test sample to be used is given below. In many instances it may be desirable to test a coarse aggregate in several separate size fractions; and if the sample contains more than 15% retained on the 37.5-mm (1½-in.) sieve, test the material larger than 37.5 mm in one or more size fractions separately from the smaller size fractions. When an aggregate is tested in separate size fractions, the minimum weight of test sample for each fraction shall be the difference between the weights prescribed for the maximum and minimum sizes of the fraction.

Nominal Maximum Size, mm (in.)	Minimum Weight of Test Sample, kg (lb)
12.5 (½) or less	2 (4.4)
19.0 (¾)	3 (6.6)
25.0 (1)	4 (8.8)
38.1 (1½)	5 (11)
50 (2)	8 (18)
63 (2½)	12 (26)
75 (3)	18 (40)
90 (3½)	25 (55)
100 (4)	40 (88)
112 (4½)	50 (110)
125 (5)	75 (165)
150 (6)	125 (276)

7.4 If the sample is tested in two or more size fractions, determine the grading of the sample in accordance with T 27, including the sieves used for separating the size fractions for the determinations in this method. In calculating the percentage of material in each size fraction, ignore the quantity of material finer than the 4.75 mm (No. 4) sieve or 2.36 mm (No. 8) sieve when that sieve is used in accordance with Section 7.2).

8. PROCEDURE

8.1 Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature for 1 to 3 h for test samples of 37.5 mm (1½-in.) nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C). Subsequently immerse the aggregate in water at room temperature for a period of 15 to 19 hours.

NOTE 2—When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more subsamples, and the values obtained combined for the computation described in Section 9.

8.2 Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirment for initial drying to constant weight may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the 15 h soaking may also be eliminated.

NOTE 3—Values for absorption and bulk specific gravity (SSD) may be significantly higher for aggregate not oven dried before soaking than for the same aggregate treated in accordance with Section 8.1. This is especially true of particles larger than 75 mm (3 in.) since the water may not be able to penetrate the pores to the center of the particle in the prescribed soaking period.

8.3 Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. A moving stream of air may be used to assist in the drying operation. Take care to avoid evaporation of water from aggregate pores during the operation of surface-drying. Weigh the test sample in the saturated surface-dry condition. Record this and all subsequent weights to the nearest 1.0 g or 0.1% of the sample weight, whichever is greater.

8.4 After weighing, immediately place the saturate-surface-dry test sample in the sample container and determine its weight in water at 23 ± 1.7°C (73.4 ± 3°F), having a density of 997 ± 2 kg/m^3. Take care to remove all entrapped air before weighing by shaking the container while immersed.

NOTE 4—The container should be immersed to a depth sufficient to cover it and the test sample during weighing. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

8.5 Dry the test sample to constant weight at a temperature of 110 ± 5°C (230 ± 9°F), cool in air at room temperature 1 to 3 h, or until the aggregate has cooled to a temperature that is comfortable to handle (approximately 50°C), and weigh.

9. CALCULATIONS

9.1 *Specific Gravity:*

9.1.1 *Bulk Specific Gravity*—Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Bulk sp gr} = A/(B - C)$$

where:
A = weight of oven-dry test sample in air, g,
B = Weight of saturated-surface-dry test sample in air, g, and
C = weight of saturated test sample in water, g.

9.1.2 *Bulk Specific Gravity (Saturated-Surface-Dry)*—Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), on the basis of weight of saturated-surface-dry aggregate as follows:

$$\text{Bulk sp gr (saturated-surface-dry)} = B/(B - C)$$

9.1.3 *Apparent Specific Gravity*—Calculate the apparent specific gravity, 23/23°C (73.4/73.4°F), as follows:

$$\text{Apparent sp gr} = A/(A - C)$$

9.2 *Average Specific Gravity Values*—When the sample is tested in separate size fractions the average value for bulk specific gravity, bulk specific gravity (SSD), or apparent specific gravity can be computed in accordance with Section 9.1 using the following equation:

$$G = \frac{1}{\dfrac{P_1}{100\,G_1} + \dfrac{P_2}{100\,G_2} + \dots \dfrac{P_n}{100\,G_n}}$$

(see Appendix X1)

where:
G = average specific gravity. All forms of expression of specific gravity can be averaged in this manner.
$G_1, G_2 \dots G_n$ = appropriate specific gravity values for each size fraction depending on the type of specific gravity being averaged.
$P_1, P_2 \dots P_n$ = weight percentages of each size fraction present in the original sample.

NOTE 5—Some users of this method may wish to express the results in terms of density. Density may be determined by multiplying the bulk specific gravity (SSD), or apparent specific gravity by the weight of water (997.5 kg/m^3 or 0.9975 Mg/m^3 or 62.27 lb/ft^3 at 23°C). Some authorities recommend using the density of water at 4°C (1000 kg/m^3 or 1.000 Mg/m^3 or 62.43 lb/ft^3) as being sufficiently accurate. Results should be expressed to three significant figures. The density terminology corresponding to bulk specific gravity, bulk specific gravity (SSD), and apparent specific gravity has not been standardized.

9.3 *Absorption*—Calculate the percentage of absorption, as follows:

$$\text{Absorption, \%} = [(B - A)/A] \times 100$$

9.4 *Average Absorption Value*—When the sample is tested in separate size fractions, the average absorption value is the average of the values as computed in Section 9.3, weighted in proportion to the weight percentages of the size fractions in the original sample as follows:

$$A = (P_1A_1/100) + (P_2A_2/100) + \dots (P_nA_n/100)$$

where:
A = average absorption, %,
$A_1, A_2 \dots A_n$ = absorption percentages for each size fraction, and
$P_1, P_2 \dots P_n$ = weight percentages of each size fraction present in the original sample.

10. REPORT

10.1 Report specific gravity results to the nearest 0.01, and indicate the type of specific gravity, whether bulk, bulk (saturated-surface-dry), or apparent.

10.2 Report the absorption result to the nearest 0.1%.

10.3 If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in Section 8.2, it shall be noted in the report.

11. PRECISION

11.1 For normal weight aggregate with less than 3% absorption, the precision indexes are as follows:

	Standard Deviation (1S)[A]	Difference Between Two Tests (D2S)[A]
Multilaboratory:		
Bulk specific gravity	0.014	0.040
Bulk specific gravity (SSD)	0.010	0.028
Apparent specific gravity	0.011	0.031
Absorption, %	0.18	0.51
Single-operator:		
Bulk specific gravity	0.011	0.031
Bulk specific gravity (SSD)	0.008	0.023
Apparent specific gravity	0.007	0.020
Absorption, %	0.15	0.42

[A]These numbers represent, respectively, the (1S) and (D2S) limits as described in ASTM Recommended Practice C 670.

APPENDIXES

X1. DEVELOPMENT OF EQUATIONS

X1.1 The derivation of the equation is apparent from the followig simplified cases using two solids. Solid 1 has a weight W_1 in grams and a volume V_1 in millilitres; its specific gravity (G_1) is therefore W_1/V_1. Solid 2 has a weight W_2 and volume V_2, and $G_2 = W_2/V_2$. If the two solids are considered together, the specific gravity of the combination is the total weight in grams divided by the total volume in millilitres:

$$G = (W_1 + W_2)/(V_1 + V_2)$$

Manipulation of this equation yields the following:

$$G = \frac{1}{\dfrac{V_1 + V_2}{W_1 + W_2}} = \frac{1}{\dfrac{V_1}{W_1 + W_2} \quad \dfrac{V_2}{W_1 + W_2}}$$

$$G = \frac{1}{\dfrac{W_1}{W_1 + W_2}\left(\dfrac{V_1}{W_1}\right) + \dfrac{W_2}{W_1 + W_2}\left(\dfrac{V_2}{W_2}\right)}$$

However, the weight fractions of the two solids are:

$$W_1/(W_1 + W_2) = P_1/100 \text{ and } W_2/(W_1 + W_2) = P_2/100$$

and,

$$1/G_1 = V_1/W_1 \text{ and } 1/G_2 = V_2/W_2$$

Therefore

$$G = 1/[(P_1/100)(1/G_1) + (P_2/100)(1/G_2)]$$

An example of the computation is given in Table X1.1.

TABLE X1.1 Example of Calculation of Average Values of Specific Gravity and Absorption for a Coarse Aggregate Tested in Separate Sizes

Size Fraction, mm (in.)	% in Original Sample	Bulk Specific Gravity (SSD)	Sample Weight Used in Test, g	Absorption, %
4.75 to 12.5 (No. 4 to ½)	44	2.72	2213.0	0.4
12.5 to 37.5 (½ to 1½)	35	2.56	5462.5	2.5
37.5 to 63 (1½ to 2½)	21	2.54	12593.0	3.0

Average Specific Gravity (SSD)

$$G_{SSD} = \frac{1}{\frac{0.44}{2.72} + \frac{0.35}{2.56} + \frac{0.21}{2.54}} = 2.62$$

Average Absorption

$$A = (0.44)(0.4) + (0.35)(2.5) + (0.21)(3.0) = 1.7\%$$

X2.1 INTERRELATIONSHIPS BETWEEN SPECIFIC GRAVITIES AND ABSORPTION AS DEFINED IN METHODS C 127 AND C 128

X2.1 Let:

S_d = bulk specific gravity (dry basis),
S_s = bulk specific gravity (SSD basis),
S_a = apparent specific gravity, and
A = absorption in %.

X2.2 Then,

$$S_s = (1 + A/100)S_d \qquad (1)$$

$$S_a = \frac{1}{\frac{1}{S_d} - \frac{A}{100}} = \frac{S_d}{1 - \frac{AS_d}{100}} \qquad (2)$$

$$S_a = \frac{1}{\frac{1 + A/100}{S_s} - \frac{A}{100}} = \frac{S_s}{1 - \left[\frac{A}{100} (S_s - 1) \right]} \qquad (2a)$$

$$A = \left(\frac{S_s}{S_d} - 1 \right) 100 \qquad (3)$$

$$A = \left(\frac{S_a - S_s}{S_a (S_s - 1)} \right) 100 \qquad (4)$$

APPENDIX B

TEST RESULTS FOR WIDGER COARSE AGGREGATE(A10038)

MODIFIED AASHTO METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2124	2129	2126.5	2125	2126.5		
WT.UNDER WATER.	1310	1308	1311	1307.5	1311		
LOSS OF WT. IN WATER.	814	821	815.5	817.5	815.5		
SP. GRAVITY.	2.6093	2.5932	2.6076	2.5994	2.6076	2.6034	0.0062
OVEN DRY WEIGHT.	2095	2094	2095	2091	2094		
%ABSORPTION.	1.3653	1.6478	1.4831	1.6008	1.5301	1.5254	0.0981

IOWA METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
WT.OF BOTTLE+WATER.	2755.5	2739	2740	2750.5	2741		
WT. OF S.S.D.SAMPLE	2000	2000	2000	2000	2000		
WT. OF BOTTLE+WATER+SAMPLE.	3992.5	3977.5	3978	3987.5	3978		
WT. OF WATER DISPLACED.	763	761.5	762	763	763		
SP.GRAVITY.	2.6212	2.6264	2.6247	2.6212	2.6212	2.6230	0.0022
OVEN DRY WT. OF SAMPLE.	1971	1972	1973	1973	1972		
%ABSORPTION.	1.4713	1.4199	1.3685	1.3685	1.4199	1.4096	0.0385

AASHTO METHOD T-85.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2142	2132	2147	2097.5	2129		
WT.UNDER WATER.	1317.5	1306.5	1320.5	1286.5	1308.5		
LOSS OF WT. IN WATER.	824.5	825.5	826.5	811	820.5		
SP. GRAVITY.	2.5979	2.5827	2.5977	2.5863	2.5948	2.5919	0.0062
OVEN DRY WEIGHT.	2105	2090	2108	2055	2088		
%ABSORPTION.	1.7420	1.9774	1.8362	2.0009	1.9303	1.8974	0.0960

TEST RESULTS FOR HUNT COARSE AGGREGATE(A19006)

MODIFIED AASHTO METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2170	2156	2157	2160	2156		
WT.UNDER WATER.	1325	1314.5	1315	1315	1315		
LOSS OF WT. IN WATER.	845	841.5	842	845	841		
SP. GRAVITY.	2.5680	2.5621	2.5618	2.5562	2.5636	2.5623	0.0038
OVEN DRY WEIGHT.	2108	2091	2090	2092	2093		
%ABSORPTION.	2.9412	3.1086	3.2057	3.2505	3.0100	3.1032	0.1159

IOWA METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV
WT.OF BOTTLE+WATER.	2747.5	2747.5	2759.5	2757	2755		
WT. OF S.S.D.SAMPLE	2000	2000	2000	2000	2000		
WT. OF BOTTLE+WATER+SAMPLE.	3972	3969	3977	3976	3972		
WT. OF WATER DISPLACED.	775.5	778.5	782.5	781	783		
SP.GRAVITY.	2.5790	2.5690	2.5559	2.5608	2.5543	2.5638	0.0092
OVEN DRY WT. OF SAMPLE.	1943	1933	1934	1927	1932		
%ABSORPTION.	2.9336	3.4661	3.4126	3.7883	3.5197	3.4241	0.2772

AASHTO METHOD T-85.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2183	2164.5	2162	2165.5	2175		
WT.UNDER WATER.	1326	1314.5	1314.5	1315	1320		
LOSS OF WT. IN WATER.	857	850	847.5	850.5	855		
SP. GRAVITY.	2.5473	2.5465	2.5510	2.5461	2.5439	2.5470	0.0023
OVEN DRY WEIGHT.	2105	2087	2087	2088	2096		
%ABSORPTION.	3.7055	3.7135	3.5937	3.7117	3.7691	3.6987	0.0573

TEST RESULTS FOR HARRIS COARSE AGGREGATE(A98002)

MODIFIED AASHTO METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2110.5	2111	2113	2112	2110		
WT.UNDER WATER.	1335	1335.5	1334.5	1334	1333		
LOSS OF WT. IN WATER.	775.5	775.5	778.5	778	777		
SP. GRAVITY.	2.7215	2.7221	2.7142	2.7147	2.7156	2.7176	0.0035
OVEN DRY WEIGHT.	2093	2094	2094	2094	2092		
%ABSORPTION.	0.8361	0.8118	0.9074	0.8596	0.8604	0.8551	0.0317

IOWA METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
WT.OF BOTTLE+WATER.	2739.5	2747.5	2755.5	2757	2755		
WT. OF S.S.D.SAMPLE	2000	2000	2000	2000	2000		
WT. OF BOTTLE+WATER+SAMPLE.	4004.5	4013	4019.5	4021	4019.5		
WT. OF WATER DISPLACED.	735	734.5	736	736	735.5		
SP.GRAVITY.	2.7211	2.7229	2.7174	2.7174	2.7192	2.7196	0.0022
OVEN DRY WT. OF SAMPLE.	1983	1984	1983	1983	1983		
%ABSORPTION.	0.8573	0.8065	0.8573	0.8573	0.8573	0.8471	0.0203

AASHTO METHOD T-85.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2115.5	2116	2119.5	2119	2115		
WT.UNDER WATER.	1336	1336	1336	1335	1333.5		
LOSS OF WT. IN WATER.	779.5	780	783.5	784	781.5		
SP. GRAVITY.	2.7139	2.7128	2.7052	2.7028	2.7063	2.7082	0.0044
OVEN DRY WEIGHT.	2092	2093	2092	2093	2090		
%ABSORPTION.	1.1233	1.0989	1.3145	1.2422	1.1962	1.1950	0.0786

TEST RESULTS FOR BOWSER SPRINGVILLE COARSE AGGREGATE(A57008)

MODIFIED AASHTO METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2162.5	2161	2174	2165.5	2168		
WT.UNDER WATER.	1285.5	1284.5	1290.5	1287.5	1286		
LOSS OF WT. IN WATER.	877	876.5	883.5	878	882		
SP. GRAVITY.	2.4658	2.4655	2.4607	2.4664	2.4580	2.4633	0.0033
OVEN DRY WEIGHT.	2084	2080	2093	2083	2083		
%ABSORPTION.	3.7668	3.8942	3.8700	3.9606	4.0807	3.9145	0.1039

IOWA METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
WT.OF BOTTLE+WATER.	2759.5	2739	2740	2750.5	2741		
WT. OF S.S.D.SAMPLE	2000	2000	2000	2000	2000		
WT. OF BOTTLE+WATER+SAMPLE.	3950	3929.5	3927.5	3943	3928.5		
WT. OF WATER DISPLACED.	809.5	809.5	812.5	807.5	812.5		
SP.GRAVITY.	2.4707	2.4707	2.4615	2.4768	2.4615	2.4682	0.0059
OVEN DRY WT. OF SAMPLE.	1928	1927	1924	1928	1922		
%ABSORPTION.	3.7344	3.7883	3.9501	3.7344	4.0583	3.8531	0.1295

AASHTO METHOD T-85.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2169.5	2163	2181	2160.5	2157		
WT.UNDER WATER.	1284.5	1282	1289	1280.5	1280		
LOSS OF WT. IN WATER.	885	881	892	880	877		
SP. GRAVITY.	2.4514	2.4552	2.4451	2.4551	2.4595	2.4533	0.0048
OVEN DRY WEIGHT.	2081	2075	2093	2072	2070		
%ABSORPTION.	4.2528	4.2410	4.2045	4.2712	4.2029	4.2345	0.0269

TEST RESULTS FOR GARDNER NORTH COARSE AGGREGATE(A41002)

MODIFIED AASHTO METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2117.5	2130	2126	2124.5	2124		
WT.UNDER WATER.	1313	1321.5	1321	1322	1320.5		
LOSS OF WT. IN WATER.	804.5	808.5	805	802.5	803.5		
SP. GRAVITY.	2.6321	2.6345	2.6410	2.6474	2.6434	2.6397	0.0056
OVEN DRY WEIGHT.	2081	2092	2090	2091	2090		
%ABSORPTION.	1.7540	1.8164	1.7225	1.6021	1.6268	1.7044	0.0798

IOWA METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
WT.OF BOTTLE+WATER.	2739.5	2747.5	2755.5	2757	2755		
WT. OF S.S.D.SAMPLE	2000	2000	2000	2000	2000		
WT. OF BOTTLE+WATER+SAMPLE.	3984.5	3995.5	4002.5	4000.5	4000		
WT. OF WATER DISPLACED.	755	752	753	756.5	755		
SP.GRAVITY.	2.6490	2.6596	2.6560	2.6438	2.6490	2.6515	0.0056
OVEN DRY WT. OF SAMPLE.	1968	1972	1968	1968	1969		
%ABSORPTION.	1.6260	1.4199	1.6260	1.6260	1.5744	1.5745	0.0798

AASHTO METHOD T-85.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2124.5	2133	2126.5	2130	2131.5		
WT.UNDER WATER.	1313	1322	1321	1322.5	1321.5		
LOSS OF WT. IN WATER.	811.5	811	805.5	807.5	810		
SP. GRAVITY.	2.6180	2.6301	2.6400	2.6378	2.6315	2.6315	0.0077
OVEN DRY WEIGHT.	2078	2090	2087	2090	2088		
%ABSORPTION.	2.2377	2.0574	1.8927	1.9139	2.0833	2.0370	0.1256

TEST RESULTS FOR DUENOW COARSE AGGREGATE(A66002)

MODIFIED AASHTO METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2106.5	2109	2109	2096	2108.5		
WT.UNDER WATER.	1347	1347.5	1347.5	1339.5	1348		
LOSS OF WT. IN WATER.	759.5	761.5	761.5	756.5	760.5		
SP. GRAVITY.	2.7735	2.7695	2.7695	2.7707	2.7725	2.7712	0.0016
OVEN DRY WEIGHT.	2094	2095	2095	2083	2096		
%ABSORPTION.	0.5969	0.6683	0.6683	0.6241	0.5964	0.6308	0.0322

IOWA METHOD.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
WT.OF BOTTLE+WATER.	2759.5	2739	2740	2750.5	2741		
WT. OF S.S.D.SAMPLE	2000	2000	2000	2000	2000		
WT. OF BOTTLE+WATER+SAMPLE.	4038	4021	4021.5	4029	4022		
WT. OF WATER DISPLACED.	721.5	718	718.5	721.5	719		
SP.GRAVITY.	2.7720	2.7855	2.7836	2.7720	2.7816	2.7789	0.0058
OVEN DRY WT. OF SAMPLE.	1986	1989	1988	1987	1988		
%ABSORPTION.	0.7049	0.5530	0.6036	0.6543	0.6036	0.6239	0.0516

AASHTO METHOD T 85.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG.	STD.DEV.
S.S.D.WT. IN AIR.	2112	2114.5	2114	2101	2114		
WT.UNDER WATER.	1348	1348	1348	1340	1349		
LOSS OF WT. IN WATER.	764	766.5	766	761	765		
SP. GRAVITY.	2.7644	2.7586	2.7598	2.7608	2.7634	2.7614	0.0022
OVEN DRY WEIGHT.	2092	2094	2093	2081	2095		
%ABSORPTION.	0.9560	0.9790	1.0033	0.9611	0.9069	0.9613	0.0318

SUMMARY OF ABSORPTIONS.

	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG	STD.DEV
WIDGER AGGREGATE.							
MODIFIED AASHTO METHOD.	1.3653	1.6478	1.4831	1.6008	1.5301	1.5254	0.0981
IOWA METHOD	1.4713	1.4199	1.3685	1.3685	1.4199	1.4096	0.0385
AASHTO METHOD T-85	1.7420	1.9774	1.8362	2.0009	1.9303	1.8974	0.0960
HUNT AGGREGATE.							
MODIFIED AASHTO METHOD.	2.9412	3.1086	3.2057	3.2505	3.0100	3.1032	0.1159
IOWA METHOD	2.9336	3.4661	3.4126	3.7883	3.5197	3.4241	0.2772
AASHTO METHOD T-85	3.7055	3.7135	3.5937	3.7117	3.7691	3.6987	0.0573
HARRIS AGGREGATE.							
MODIFIED AASHTO METHOD.	0.8361	0.8118	0.9074	0.8596	0.8604	0.8551	0.0317
IOWA METHOD	0.8573	0.8065	0.8573	0.8573	0.8573	0.8471	0.0203
AASHTO METHOD T-85	1.1233	1.0989	1.3145	1.2422	1.1962	1.1950	0.0786
DUENOW AGGREGATE.							
MODIFIED AASHTO METHOD.	0.5969	0.6683	0.6683	0.6241	0.5964	0.6308	0.0322
IOWA METHOD	0.7049	0.5530	0.6036	0.6543	0.6036	0.6239	0.0516
AASHTO METHOD T-85	0.9560	0.9790	1.0033	0.9611	0.9069	0.9613	0.0318
GARDNER AGGREGATE.							
MODIFIED AASHTO METHOD.	1.7540	1.8164	1.7225	1.6021	1.6268	1.7044	0.0798
IOWA METHOD	1.6260	1.4199	1.6260	1.6260	1.5744	1.5745	0.0798
AASHTO METHOD T-85	2.2377	2.0574	1.8927	1.9139	2.0833	2.0370	0.1256
BOWSER AGGREGATE.							
MODIFIED AASHTO METHOD.	3.7668	3.8942	3.8700	3.9606	4.0807	3.9145	0.1039
IOWA METHOD	3.7344	3.7883	3.9501	3.7344	4.0583	3.8531	0.1295
AASHTO METHOD T-85	4.2528	4.2410	4.2045	4.2712	4.2029	4.2345	0.0269

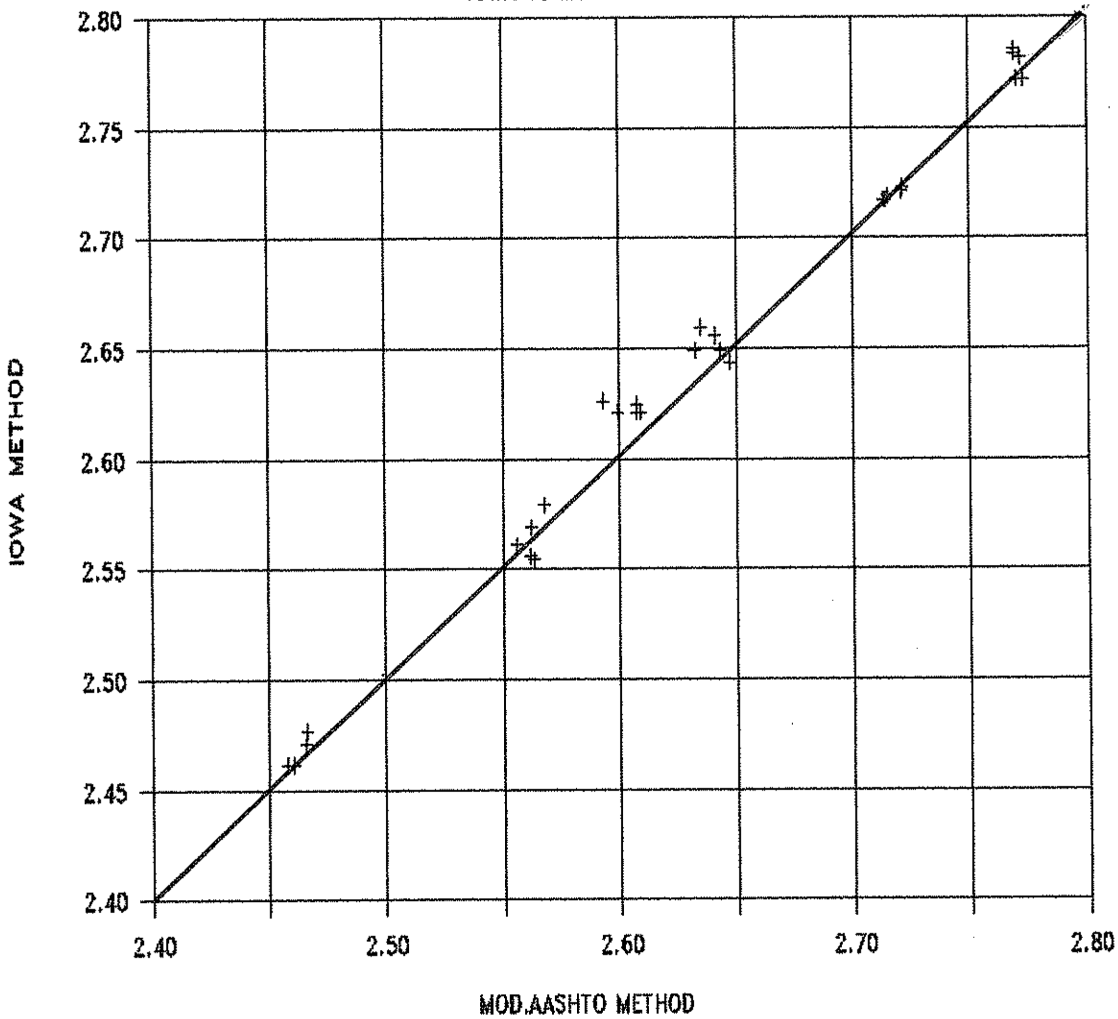
SUMMARY OF SPECIFIC GRAVITIES.

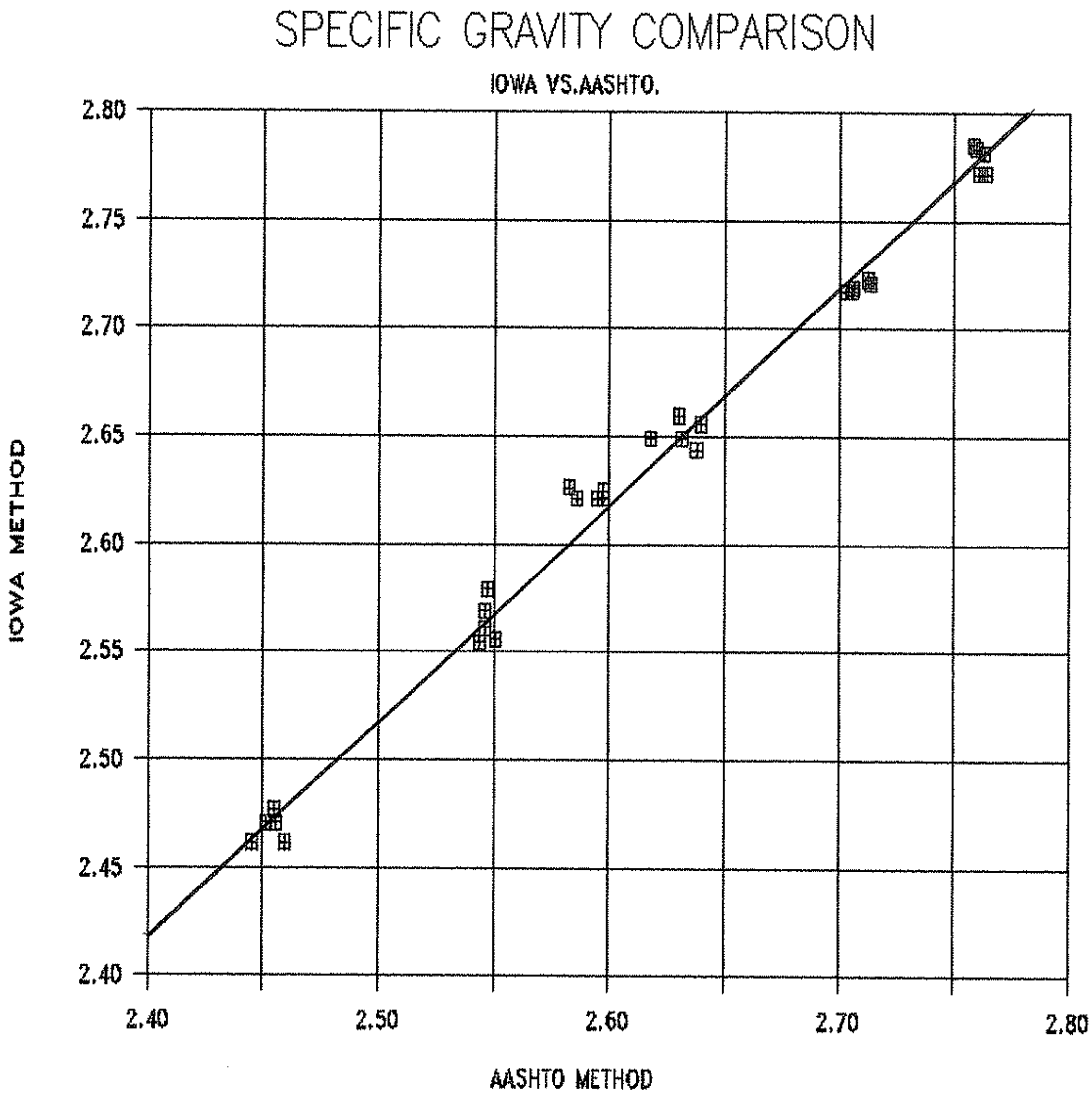
WIDGER AGGREGATE.	SAMPLE 1.	SAMPLE 2.	SAMPLE 3.	SAMPLE 4.	SAMPLE 5.	AVG	STD.DEV
MODIFIED AASHTO METHOD.	2.6093	2.5932	2.6076	2.5994	2.6076	2.6034	0.0062
IOWA METHOD	2.6212	2.6264	2.6247	2.6212	2.6212	2.6230	0.0022
AASHTO METHOD T-85	2.5979	2.5827	2.5977	2.5863	2.5948	2.5919	0.0062
HUNT AGGREGATE.							
MODIFIED AASHTO METHOD.	2.5680	2.5621	2.5618	2.5562	2.5636	2.5623	0.0038
IOWA METHOD	2.5790	2.5690	2.5559	2.5608	2.5543	2.5638	0.0092
AASHTO METHOD T-85	2.5473	2.5465	2.5510	2.5461	2.5439	2.5470	0.0023
HARRIS AGGREGATE.							
MODIFIED AASHTO METHOD.	2.7215	2.7221	2.7142	2.7147	2.7156	2.7176	0.0035
IOWA METHOD	2.7211	2.7229	2.7174	2.7174	2.7192	2.7196	0.0022
AASHTO METHOD T-85	2.7139	2.7128	2.7052	2.7028	2.7063	2.7082	0.0044
DUENOW AGGREGATE.							
MODIFIED AASHTO METHOD.	2.7735	2.7695	2.7695	2.7707	2.7725	2.7712	0.0016
IOWA METHOD	2.7720	2.7855	2.7836	2.7720	2.7816	2.7789	0.0058
AASHTO METHOD T-85	2.7644	2.7586	2.7598	2.7608	2.7634	2.7614	0.0022
GARDNER AGGREGATE.							
MODIFIED AASHTO METHOD.	2.6321	2.6345	2.6410	2.6474	2.6434	2.6397	0.0056
IOWA METHOD	2.6490	2.6596	2.6560	2.6438	2.6490	2.6515	0.0056
AASHTO METHOD T-85	2.6180	2.6301	2.6400	2.6378	2.6315	2.6315	0.0077
BOWSER AGGREGATE.							
MODIFIED AASHTO METHOD.	2.4658	2.4655	2.4607	2.4664	2.4580	2.4633	0.0033
IOWA METHOD	2.4707	2.4707	2.4615	2.4768	2.4615	2.4682	0.0059
AASHTO METHOD T-85	2.4514	2.4552	2.4451	2.4551	2.4595	2.4533	0.0048

APPENDIX C

SPECIFIC GRAVITY COMPARISON

IOWA VS.MOD.AASHTO.




SPECIFIC GRAVITY COMPARISON
IOWA VS.AASHTO.
IOWA METHOD
AASHTO METHOD
2.80
2.75
2.70
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2.45
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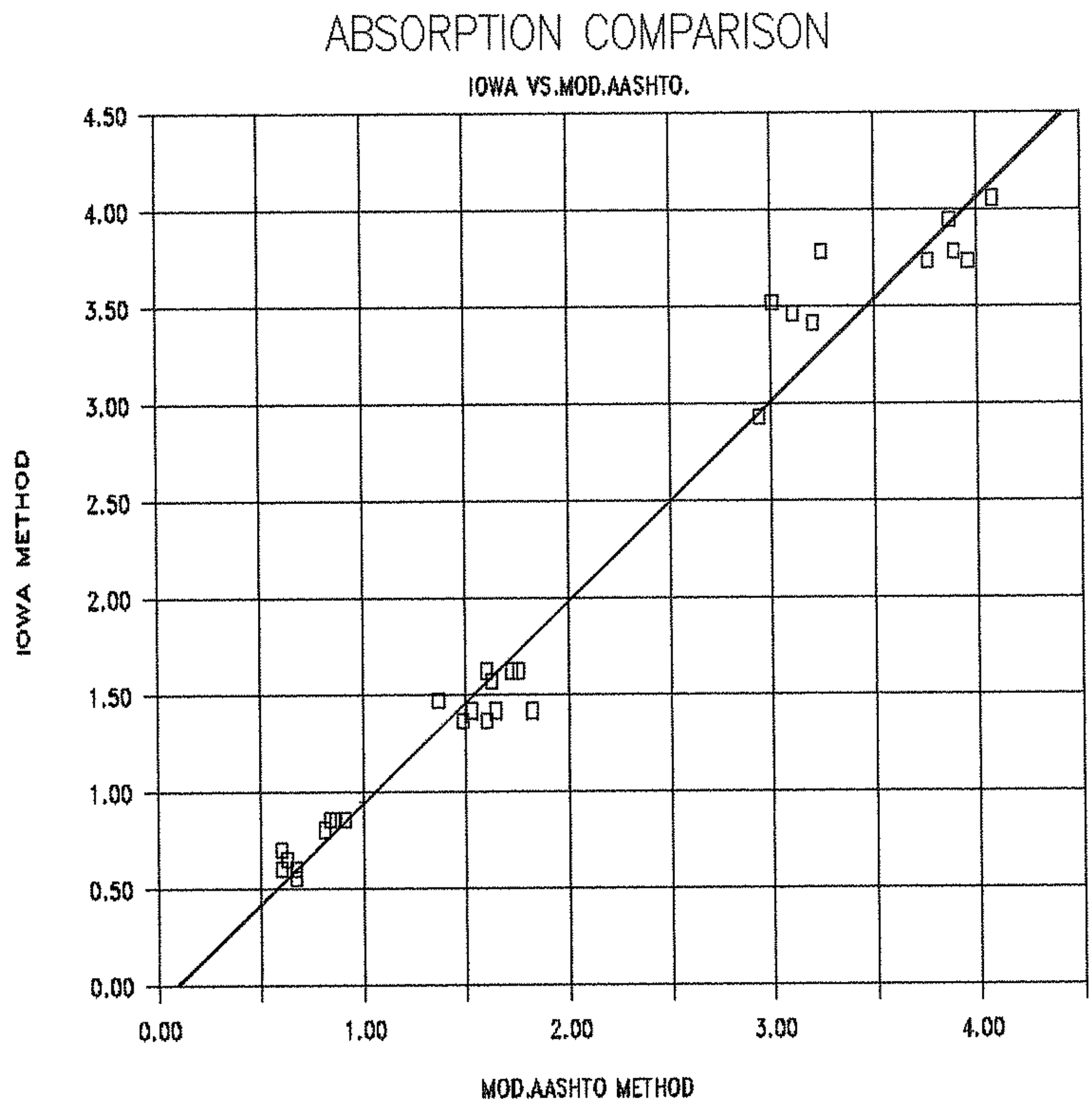
2.60
2.70
2.80


ABSORPTION COMPARISON
IOWA VS.MOD.AASHTO.
IOWA METHOD
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3.50
3.00
2.50
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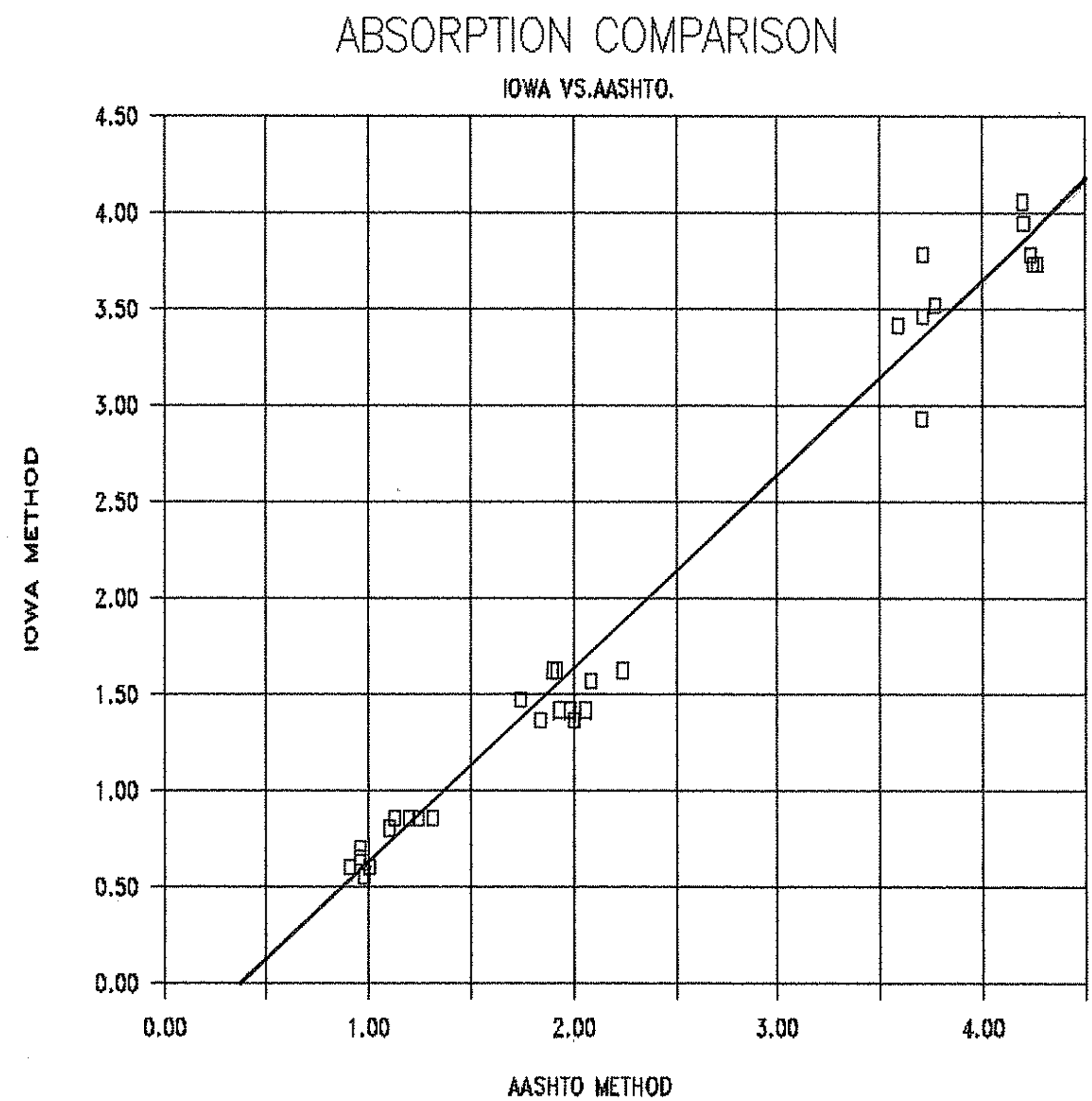
1.00
0.50
0.00
0.00
1.00
2.00
3.00
4.00
MOD.AASHTO METHOD


ABSORPTION COMPARISON
IOWA VS.AASHTO.
IOWA METHOD
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
1.00
2.00
3.00
4.00
AASHTO METHOD