CONCRETE TECHNOLOGY LABORATORY

DEPARTMENT OF CIVIL ENGINEERING
CHULALONGKORN UNIVERSITY

Tested by ..... ID. No. .....
Date ..... Graded by .....

TEST No. C-2

PROPERTIES OF AGGREGATE

Part A Specific Gravity and Absorption of Fine Aggregate

Objective in: To determine the bulk and apparent specific gravity and absorption (after 24 hr. water) of fine aggregate

Material: About 1000 g of fine aggregate

References: ASTM Designation : C 128
JIS (Japan Industrial Standard) A 1109

Apparatus:
(1) Balance with 0.1 g in reciprocal sensibility.
(2) Glass graduate or other suitable container have a capacity of about 500 ml.
(3) Metal conical mold with 40 ± 3 mm in diameter at the top 90 ± 3 mm in diameter at the bottom and 75 ± 3 mm in height.
(4) Tamper with 345 ± 15 g in weight and having a flat circular tamping face 25 ± 3 mm in diameter.

Significance and Use

1. Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including concrete. Bulk specific gravity is also used in the computation of voids in aggregate and the determination of moisture in aggregate.

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 that is accesible to water. This value is not widely used in concrete technology.

3. Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore space within the constituent particles, compared to the dry condition.

Procedures

1. Preparation of Sample

1. Place approximately 1000 g of fine aggregate in a suitable pan or vessel. Cover the sample with water and permit to stand for 24 ± 4 hr.

2. Spread the sample on the flat surface exposed to a gently moving current of warm air and stir them frequently to secure uniform drying. Continue the operation until the fine aggregate approaches a free-flowing condition.

3. Place the sample loosely in the conical mold and lightly tamp the surface 25 times with the tamping rod and lift the conical mold up vertically. If the cone retain its shape, the free moisture is present.

4. Continue drying with constant stirring and test at frequent intervals until the cone of sample slumps upon removal of the mold. This indicates that the sample has reached a saturated surface-dry condition.

2. Testing

1. Place 500 g[1] of sample in the glass graduate which is partially filled with water, then fill additional water to approximately 90% of capacity.

2. Shake the glass graduate to eliminate air bubbles and fill with water to the full capacity and determine the total weight of water introduced into the glass graduate.

3. Remove the sample from the glass graduate and dry it in the oven to a constant weight at 110 ± 5^{o}C. Then cool in air at room temperature for 1-2 hr. and weigh to the nearest 0.1 g.

4. Determine the weight of glass graduate filled to its calibration capacity with water.

5. The specific gravity and absorption can be calculated as follows:

a) The bulk specific gravity = A/(B+S-C)
b) The bulk specific gravity on the saturated surface-dry basis = S/(B+S-C)
c) The apparent specific gravity = A/(B+A-C)
d) The percentage of absorption = [(S-A)/A]*100

where A is weight of oven-dry sample in air (g), B is weight of glass graduate filled with water (g), S is weight of saturated surface-dry sample (g) and C is weight of glass graduate with sample and water to calibration mark (g).

5. Duplicate determinations should check to within 0.02 in the case of specific gravity and 0.05% in case of absorption.

[1] Make and record all weight determination to 0.1 g.

Part B Unit Weight and Voids of Fine Aggregate

Objective To determine the unit weight and void of fine aggregate

Material About 15 kg. of fine aggregate

References ASTM Designation : C 29
JIS (Japan Industrial Standard) A 1104

Apparatus (1) Balance with 0.05 kg in reciprocal sensibility.
(2) Tamping rod with 16 mm in diameter and approximately 600 mm in length.
(3) Metal measuring cylinder which have a height of approximately equal to the diameter.

Significance and Use

1. This test method is often used to determine unit weight values that are necessary for use for many methods of selecting proportions for concrete mixture.
2. The unit weight may also be used for determining mass/volume relationship for conversions in purchase agreements. However, this test method determines the unit weight on a dry basis.
3. A procedure is included for computing the percentage of voids between the aggregate particles based on the unit weight determined by this test method.

Procedures

1. Determine the weight of water at room temperature required to fill the metal cylinder.
2. The sample must be dry to constant weight at 110 ± 5 ^{o}C and thoroughly mixed. Then cool the sample to the room temperature.
3. Fill the measuring cylinder to 1/3 full and rod the mass with tamping rod throughout the surface with 25 strokes. The rodding operation should be distributed over the surface.
4. Fill the cylinder to 2/3 full and repeat the rodding operation.
5. Fill the cylinder to overflowing and again rod 25 strokes. The surplus aggregate is struck off by using the tamping rod as a straight edge.
6. Determine the net weight of sample from the weight of sample plus measure, G and the weight of measure alone, T. The test should be performed at least two times with the samples taken at the same time and the measured values should be averaged. Results from the same sample should agree within 1%.
7. The unit weight, M can be calculated from the weight of sample and the volume of measure, V as follows:

$$M = \frac{G - T}{V}$$

8. The unit weight determined by this test method is for aggregate in an oven-dry condition. The SSD unit weight, M_{ssd} can be calculated as:

$$M_{ssd} = M(1 + \frac{A}{100})$$

where A = absorption (%)

9. The void content can be calculated from the unit weight, M and bulk specific gravity (oven-dry basis) associated with the density of water, W as follows :

$$\text{Voids}(\%) = \frac{(S * W) - M}{(S * W)} * 100$$

Part C Specific Gravity and Absorption of Coarse Aggregate

Objective — To determine the bulk and apparent specific gravity and absorption (after 24 hr in water) of coarse aggregate.

Material — About 5 kg of coarse aggregate.

References — ASTM Designation : C 127
BS (British Standard) 812
JIS (Japan Industrial Standard) A 1110

Apparatus
(1) Balance with 0.5 g in reciprocal sensibility
(2) Sample container (wire basket)
(3) Water bath
(4) ASTM No. 4 sieve (5 mm)

Significance and Use

1. Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including concrete. Bulk specific gravity is also used in the computation of voids in aggregate. Bulk specific gravity @ SSD is used if the aggregate is wet. Conversely, the bulk specific gravity @ oven-dry is used for computations when the aggregate is dry or assumed to be dry.

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 that is accesible to water. This value is not widely used in concrete technology.

3. Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore space within the constituent particles, compared to the dry condition.

4. The pores in lightweight aggregates may or may not become essentially filled with water after immersion for 24 h. Therefore, this test method is not intended for use with lightweight aggregate.

Procedures

1. Reject all material passing a No. 4 sieve. Wash thoroughly the sample to remove dust or other coatings from the surface of particles. Dry the sample to constant weight at 110 ± 5 ^{o}C, cool in air at room temperature for 1 - 3 hr. Then immerse the sample in water for 24 ± 4 hr.

2. Remove the sample from water and roll it on a large absorbent cloth until all visible films of water are removed, although the surfaces of particles still appear to be damp. Wipe the larger fragments individually. Take care to avoid evaporation during the operation of drying.

3. Weight the sample in the saturated surface-dry (SSD) condition to the nearest 0.5 g. Then immediately place the SSD sample in the wire basket and determine the weight in water. Remove all entrapped air before weighing by shaking the container while immersed.

4. Dry the sample in the oven to a constant weight at a temperature of 110 ± 5 ^{o}C, cool to the room temperature and weigh to the nearest 0.5 g.

5. The specific gravity and absorption can be calculated as follows :

a) The bulk specific gravity = A/(B-C)
b) The bulk specific gravity (SSD basis) = B/(B-C)
c) The apparent specific gravity = A/(A-C)
d) The percentage of absorption = [(B-A)/A]*100

where A is weight of oven-dry sample in air (g), B is weight of SSD sample in air (g) and C is weight of SSD sample in water.

Part D Unit Weight and Voids of Coarse Aggregate

Objective To determine the unit weight and void of coarse aggregate

Material About 15 kg. of coarse aggregate

References ASTM Designation : C 29
BS (British Standard) 812
JIS (Japan Industrial Standard) A 1104

Apparatus (1) Balance with 0.05 kg in reciprocal sensibility
(2) Tamping rod with 16 mm in diameter and about 600 mm in length.
(3) Metal measuring cylinder which have a height approximately equal to the diameter.

Significance and Use

1. This test method is often used to determine unit weight values that are necessary for use for many methods of selecting proportions for concrete mixture.

2. The unit weight may also be used for determining mass/volume relationship for conversions in purchase agreements. However, this test method determines the unit weight on a dry basis.

3. A procedure is included for computing the percentage of voids between the aggregate particles based on the unit weight determined by this test method.

Procedures

1. Determine the weight of water at room temperature required to fill the metal cylinder.

2. The sample must be dry to constant weight at 110 ± 5 ^{o}C and thoroughly mixed. Then cool the sample to the room temperature.

3. Fill the measuring cylinder to 1/3 full and rod the mass with tamping rod throughout the surface with 25 strokes. The rodding operation should be distributed over the surface.

4. Fill the cylinder to 2/3 full and repeat the rodding operation.

5. Fill the cylinder to overflowing and again rod 25 strokes. The surplus aggregate is struck off by using the tamping rod as a straight edge.

6. Determine the net weight of sample from the weight of sample plus measure, G and the weight of measure alone, T. The test should be performed at least two times with the samples taken at the same time and the measured values should be averaged. Results from the same sample should agree within 1%.

7. The unit weight, M can be calculated from the weight of sample and the volume of measure, V as follows:

$$M = \frac{G - T}{V}$$

8. The unit weight determined by this test method is for aggregate in an oven-dry condition. The SSD unit weight, M_{ssd} can be calculated as:

$$M_{ssd} = M(1 + \frac{A}{100})$$

where A = absorption (%)

9. The void content can be calculated from the unit weight, M and bulk specific gravity (oven-dry basis) associated with the density of water, W as follows :

$$\text{Voids}(\%) = \frac{(S * W) - M}{(S * W)} * 100$$

Part E Sieve Analysis of Fine Aggregate

Objective — To determine the particle size distribution of fine aggregate

Material — Aggregate with at least 95% passing a No.8 (2.36 mm) sieve .....100 g
Aggregate with at least 85% passing a No.4 (4.75 mm) sieve and more than 5% retained on No.8 (2.36 mm) .....500 g

References — ASTM Designation : C 33, C 136
JIS (Japan Industrial Standard) A 1102
BS (British Standard) 812, 882, 1201

Apparatus
(1) Balance which is sensitive to 0.1% of the test load.
(2) Standard screen such as ASTM No. 4, 8, 16, 30, 50 and 100
(3) Oven of appropriate size and capable to maintain a uniform temperature of $110 \pm 5\ ^{o}C$.

Significance and Use

1. This method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregate. The results are used to determine compliance of the perticle size distribution with applicable specification requirements and to provide necessary data for control of the production of various aggregate products and mixture containing aggregate. The results may also be useful in developing relationships concerning porosity and packing.

2. Accurate determination of material finer than the No. 200 sieve cannot be achieved by use of this method alone. Other test method should be employed.

Procedures

1. The screen analysis of fine aggregate should be obtained by screening a sample through 8-inch screens, using a mechanical shaker. Reject any material retained on No. 4 sieve. Dry the sample to constant weight at $110 \pm 5\ ^{o}C$.

2. Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve opening. The weight retained on any sieve at the completion of the operation shall not exceed 6 kg/m^2 of sieving surface.

3. Place the sand sample in a set of standard 8-inch screens. Close the lid of the screens and place in a mechanical shaker.

4. Screening the sample until not more than 1% of the residue passes any screen during a period of 1 min shaking. Unless time saving is imperative, the shaker shall be run for 10 min.

5. Weigh materials retained on any one screen separately starting from those retained on No.8 (2.36 mm) screen and continuing in order of decreasing screen size until the material in the pan has been weighed. Carefully clean each screen with a brush; care should be taken not to damage the screen.

6. Convert cumulative weights on any one screen into percentages of the total weight. Compute the fineness modulus (FM) by adding the cumulative percentages of sand retained on

the screens No. 8 to No. 100 and divided the sum by 100. Keeping in mind that the fineness modulus is a measure of the coarseness or fineness of the sand but it give no idea of its grading.

7. Plot the percent cumulative retained of sand on each screen.

Part F Sieve Analysis of Coarse Aggregate

Objective To determine the particle size distribution of coarse aggregate

Material Coarse aggregate

References ASTM Designation : C 33, C 136
JIS (Japan Industrial Standard) A 1102
BS (British Standard) 812, 882, 1201

Apparatus (1) Balance which is sensitive to 0.1% of the test load
(2) Standard screen such as 6", 3", 1.5", 3/4", 3/8" and No.4
(3) Oven of appropriate size and capable to maintain a uniform temperature of $110 \pm 5\ ^{o}C$.

Significance and Use

This method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregate. The results are used to determine compliance of the perticle size distribution with applicable specification requirements and to provide necessary data for control of the production of various aggregate products and mixture containing aggregate. The results may also be useful in developing relationships concerning porosity and packing.

Procedures

1. Obtain the coarse aggregate sample by method of quartering. The sample should be in a surface dry state. The minimum weight of sample is depending on the maximum size of coarse aggregate as in the following.

max. size of aggregate	Weight of sample
9.5 mm (3/8")	1 kg
12.5 mm (1/2")	2 kg
19.0 mm (3/4")	5 kg
25.0 mm (1")	10 kg
37.5 mm (1.5")	15 kg
50.0 mm (2")	20 kg
63.0 mm (2.5")	35 kg
75.0 mm (3")	60 kg
90.0 mm (3.5")	100 kg
100.0 mm (4")	150 kg

2. Place the aggregate sample in a set of standard screens and place in a mechanical shaker. Screening the sample until not more than 1% of the residue passes any screen during a period of 1 minute shaking. Unless time saving is imperative, the shaker shall be run for 10 minutes.

3. Weigh materials retained on any one screen separately. After weighing, the materials on each screen can be used for Part D.

4. Convert cumulative weights on any one screen into percentages of the total weight. Plot the percent cumulative retained of aggregate on each screen. Compute the fineness modulus (FM) of aggregate.

Part G Trial Computation of a Combined Grading of Concrete Aggregate

Objective — To obtain a combined grading for concrete aggregate conforming to a specific requirement.

Materials — Fine aggregate and Coarse aggregate

Reference — TIS (Thai Industrial Standard) 566
ASTM Designation : C 33
BS (British Standard) 882, 1201

Procedure

Obtain by trial computation the percent cumulative retain or pass of combined aggregate to fall within the limit of good concrete aggregates. It is states that for good concrete aggregate the grading shall be within the specific limit. Some of the specifications are listed as follows:

(a) According to TIS 566

Screen size	Percent passing	
	Zone I	Zone II
75.0 mm	100	-
38.1 mm	95-100	100
19.0 mm	45-75	95-100
4.75 mm	25-45	30-50
600 μm	8-30	10-35
150 μm	0-6	0-6

(b) According to ASTM C 33

Screen size	Percent retained
1½"	0
3/4"	0-5
3/8"	34-45
No.4	58-65
No.8	65-72
No.16	72-79
No.30	79-86
No.50	95-97
No.100	97-100

(c) According to BS 882

Sieve size	Percentage by weight passing sieves	
	1.5" nominal size	3/4" nominal size
3 "	100	-
1.5"	95 - 100	100
3/4"	45 - 80	95 - 100
3/16"	25 - 50	35 - 55
No. 30 (ASTM)	8 - 30	10 - 35
No. 100 (ASTM)	0 - 6	0 - 6

Sketch all necessary figures about the test

Experimental Data and Results

Part A Specific Gravity and Absorption of Fine Aggregate

Determination	No. 1	No. 2
Type and source of fine aggregate		
Weight of glass graduate, G (g)		
Weight of glass graduate + Water, B (g)		
Weight of saturated surface-dry sand, S (g)		
Weight of water + Sand + Glass graduate, C (g)		
Weight of oven-dry sand, A (g)		
Bulk specific gravity		
Bulk specific gravity (SSD basis)		
Apparent specific gravity		
Absorption (%)		
Average bulk specific gravity		
Average bulk specific gravity (SSD basis)		
Average apparent specific gravity		
Average absorption (%)		

Part B Unit Weight and Voids of Fine Aggregate

Determination	No. 1	No. 2	No. 3
Weight of measuring cylinder, T (kg)			
Weight of cylinder and water (kg)			
Weight of water (kg)			
Volume of measuring cylinder, V (m^3)			
Weight of cylinder + sample, G (kg)			
Weight of sample alone (kg)			
Unit weight of sample,M (kg/m^3)			
Unit weight of sample at SSD, M_{ssd}			
Bulk specific gravity (oven-dry)			
Percent of voids (%)			
Average unit weight (kg/m^3)			
Average percentage of voids (%)			

Part C Specific Gravity and Absorption of Coarse Aggregate

	Sample 1		Sample 2	
	No. 1	No. 2	No. 1	No. 2
Type and source of aggregate				
Weight of SSD sample, B (g)				
Weight of container (basket) in water (g)				
Weight of container + sample in water (g)				
Weight of sample in water, C (g)				
Weight of oven-dry sample in air, A (g)				
Bulk specific gravity				
Bulk specific gravity (SSD)				
Apparent specific gravity				
Absorption (%)				
Average bulk specific gravity				
Average bulk specific gravity (SSD basis)				
Average apparent specific gravity				
Average absorption (%)Absorption (%)				

Part D Unit Weight and Voids of Coarse Aggregate

	Sample 1		Sample 2	
	No. 1	No. 2	No. 1	No. 2
Weight of measuring cylinder, T (kg)				
Weight of cylinder and water (kg)				
Weight of water (kg)				
Volume of measuring cylinder, V (m^3)				
Weight of cylinder + sample, G (kg)				
Weight of sample alone (kg)				
Unit weight of sample, M (kg/m^3)				
Unit weight of sample at SSD, M_{ssd} (kg/m^3)				
Bulk specific gravity (oven-dry)				
Percentage of voids (%)				
Average unit weight of sample (kg/m^3)				
Average percentage of voids (%)				

Part E Sieve Analysis of Fine Aggregate

Type and source of fine aggregate No. 1	
Weight of fine aggregate No. 1	
Type and source of fine aggregate No. 2	
Weight of fine aggregate No. 2	

Fine aggregate No. 1				Fine aggregate No. 2			
Screen size	Weight retained	Percent retained		Screen size	Weight retained	Percent retained	
		Individual	Cumulative			Individual	Cumulative
Fineness modulus (FM)				Fineness modulus (FM)			

Part F Sieve Analysis of Coarse Aggregate

Type and source of coarse aggregate No. 1	
Weight of coarse aggregate No. 1	
Type and source of coarse aggregate No. 2	
Weight of coarse aggregate No. 2	

Coarse aggregate No. 1				Coarse aggregate No. 2			
Screen size	Weight retained	Percent retained		Screen size	Weight retained	Percent retained	
		Individual	Cumulative			Individual	Cumulative
				Total			
Fineness modulus (FM)				Fineness modulus (FM)			

Part G Trial Computation of a Combined Grading of Concrete Aggregate

	Combination # 1	Combination # 2	Combination # 3
Coarse aggregate No. 1 (%)			
Coarse aggregate No. 2 (%)			
Fine aggregate No. 1 (%)			
Fine aggregate No. 2 (%)			
Total (%)	100	100	100

Sample of Calculation

Summary of Results (in Tabular Form), Discussion and Conclusion