Method of Test for
FINE AGGREGATE ANGULARITY – FAA
(UNCOMPACTED VOID CONTENT OF FINE AGGREGATE)
DOTD Designation: TR 121
(AASHTO T 304)

I. **Scope**
   A. This method of test determines the loose uncompacted void content of fine aggregate samples. Uncompacted void content provides an indication of angularity, sphericity, and surface texture for an aggregate of known gradation.
   B. Reference Documents
       1. DOTD S 101 - Sampling Aggregates / Aggregate Mixtures
       2. DOTD TR 106 – Determining Total Moisture and Free Moisture in Aggregate (Coarse and Fine)
       3. DOTD TR 108 – Splitting and Quartering Samples
       4. DOTD TR 112 – Amount of Material Finer than No. 200 Sieve in Aggregate
       5. DOTD TR 113 – Sieve Analysis of Fine and Coarse Aggregate
       6. DOTD TR 304 – Determination of Specific Gravity and Density Characteristics of Compressed Asphaltic Mixtures
       7. DOTD TR 640 – Calibration of Measures Used to Determine Unit Weights
       8. AASHTO T 84 – Specific Gravity and Absorption of Fine Aggregate
       9. AASHTO T 304 – Uncompacted Void Content of Fine Aggregate

II. **Apparatus**
   A. **Cylindrical Measure** – A cylinder of approximately 100 mL (3 ½ oz) capacity having an inside diameter of 39 mm (1 ½ in.) and an inside height of 86 mm (3 ½ in.) made of drawn copper water pipe. The bottom shall be metal at least 6 mm (¼ in.) thick, firmly sealed to the tubing, and have a means for aligning with the funnel.
   B. **Funnel** – Shall have sides sloped $60 \pm 4°$ from horizontal with an opening of 12.7 ± 0.6 mm (½ $\pm$ $^{1}/_{64}$ in.) in diameter. The funnel shall be smooth metal inside and at least 38 mm (1 ½ in.) high. The funnel shall have a volume of at least 200 mL (6 ¾ oz) or shall be provided with a supplemental container (1 qt mason jar with the bottom removed) to provide the required volume.
   C. **Funnel Stand** – A support capable of holding the funnel aligned with the cylindrical measure. The funnel opening shall be 115 ± 2 mm ($4.5 \pm$ $^{1}/_{16}$ in.) above the top of cylindrical measure. (Figure 1)
   D. **Glass Plate** – A 4 mm (⅛ in.) thick glass square measuring 60 mm (2 ¼ in.) x 60 mm (2 ¼ in.). Used to calibrate the cylindrical measure.
   E. **Catch Pan** – A metal or plastic container large enough to contain the stand and funnel. The container is used to catch and retain any aggregate particles overflowing during filling and strike off.
   F. **Metal spatula** – Shall have a blade approximately 100 mm (4 in.) long and at least 20 mm (¾ in.) wide with the end cut at a right angle to the edges. The spatula shall be used to strike off the aggregate.

G. **Balance** – Accurate to ± 0.1 g and capable of measuring the mass of the cylindrical measure and contents.
H. **Oven** – A constant temperature forced air oven capable of maintaining a temperature of 110 ± 5°C (230 ± 9°F).
I. **Personal protective equipment** – thermal gloves, eye protection, apron, tongs and other tools for handling hot materials.
J. **Miscellaneous** – Brushes, paper towels, etc.
K. **LA SuperPave Aggregates Form** – DOTD Form No. 03-22-0748 (Figure 2 and2A) (Worksheet on back of the form).

III.   Health Precautions
Proper precautions are to be taken whenever hot materials or equipment must
Be handled. Use container holder or thermal gloves while handling hot containers. Wear
eye protection while stirring and weighing heated materials due to possible shattering of particles.
Dry contaminated materials under a vent to prevent exposure to fumes.

IV.   Sampling
Collect a minimum 13 kg (30 lb) sample of aggregate in accordance with DOTD S 101.

V.   Calibration Procedure
Determine the actual volume of the cylindrical measure in accordance with DOTD TR 640 and
record the calibrated volume as "V" to the nearest 0.1 mL on the worksheet.

VI.   Sample Preparation
A. Dry the sample in accordance with TR 106.
B. Sieve the sample over a 4.75 mm (No. 4) sieve in accordance with TR 113.
C. Determine the bulk specific gravity, G_{sb}, of the aggregate passing the 4.75 mm (No. 4) sieve in accordance with AASHTO T 84 and record as, G).
D. From the remaining material passing the 4.75 mm (No. 4) sieve, obtain a representative portion of approximate 2500 grams, in accordance with TR 108.
E. Using a 75 μm (No. 200) sieve, wash the representative portion in accordance with DOTD TR 112.
F. Dry the washed representative portion in accordance with DOTD TR 106.
G. Sieve the dried sample over the sieves indicated in the chart below. Composite a 190 g test specimen using the exact masses shown below.

Passing	Retained	Mass, g
2.36 mm (No. 8)	1.18 mm (No. 16)	44.0
1.18 mm (No. 16)	600 μm (No. 30)	57.0
600 μm (No. 30)	300 μm (No. 50)	72.0
300 μm (No. 50)	150 μm (No. 100)	17.0
Total Sample		**190.0**

Note 1: *When the sample does not have sufficient quantity of any of the required sieve sizes, wash the as-received sample (total material passing the 4.75 mm (No. 4) sieve from Step VI.B) over the 75 μm (No. 200) sieve and obtain a 190 g test sample in accordance with DOTD TR 108.*

    H. Thoroughly mix the test specimen with the spatula to obtain a homogenous mixture.

VII. Procedure

    A. Determine the mass of the empty cylindrical measure to the nearest 0.1 g and record as **D** on the worksheet.
    B. Assemble stand, jar, and funnel; place assembly in catch pan.
    C. Center cylindrical measure under funnel opening.
    D. Place a finger under the funnel, covering the opening, while pouring the test specimen into the funnel.
    E. Level the test specimen in the funnel with the spatula, keeping finger in place over the hole in the funnel.
    F. Quickly remove your finger and allow the specimen to flow freely into the cylindrical measure.
    G. With the straight edge of the spatula in light contact with top of the cylindrical measure strike-off the test specimen with a single pass of the spatula at a 90 degree angle.

Note 2: *Until this operation is complete, avoid vibration that could cause consolidation of the fine aggregate. After strike-off the cylindrical measure may be lightly tapped to compact the aggregate, making it easier to transfer to the scale without spillage.*

    H. Brush the outside of the cylindrical measure to remove any grains on the outside of the cylindrical measure.
    I. Determine the mass of the cylindrical measure and its contents to the nearest 0.1 g. Record as **E** on worksheet.
    J. Empty the contents of the cylindrical measure into the retaining pan and mix it thoroughly back into the rest of the composite sample.
    K. Repeat Steps VII.C through VII.I once.

VIII. Calculations

    A. Calculate the mass of fine aggregate in the cylindrical measure, **F**, to the nearest 0.1 g

    for each test using the following formula:

$$F = E - D$$

Where:
    E = mass of cylindrical measure and contents, g
    D = mass of empty cylindrical measure, g

Example:
    D = 183.6
    E = 345.0

$$F = 345.0 - 183.6$$
$$F = 161.4 \text{ g}$$

B. Calculate the uncompacted voids (U) to the nearest 0.1 percent for each test using the following formula:

$$U = \frac{V - (F / G_{sb})}{V} \times 100$$

Where:

 V = volume of cylindrical measure, mL, from calibration procedure.
 F = mass of fine aggregate in cylindrical measure, g
 G_{sb} = bulk specific gravity of fine aggregate from DOTD TR 300
 100 = constant to convert to percent

Example:

 $V = 100.8$
 $F = 161.4$
 $G_{sb} = 2.542$

$$U = \frac{100.8 - (161.4 / 2.542)}{100.8} \times 100$$

$$= \frac{100.8 - 63.49331}{100.8} \times 100$$

$$= \frac{37.30669}{100.8} \times 100$$

$$= 0.3701060 \times 100$$
$$= 37.01060$$
$$U = 37.0 \text{ %}$$

C. Calculate the average uncompacted voids of the fine aggregate (U_{avg}) from the two determinations to the nearest whole percent using the following formula:

$$U_{avg} = \frac{U_1 + U_2}{2}$$

Where:

 U_1 = uncompacted voids from test 1
 U_2 = uncompacted voids from test 2

Example:

U$_1$ = 37.0
U$_2$ = 37.4

$$U_{avg} = \frac{37.0 + 37.4}{2}$$

$$= \frac{74.4}{2}$$

$$= 37.20$$
$$U_{avg} = 37$$

IX.   **Report**

Report average uncompacted voids, **U$_{avg}$**, to the nearest whole percent, as Fine Aggregate Angularity (FAA) on the LA Superpave Aggregates Form.

X.   **Normal Testing Time**

If G$_{sb}$ is known, the normal testing time is 2 hours. If tests to determine G$_{sb}$ are needed, the total testing time is 3 days.
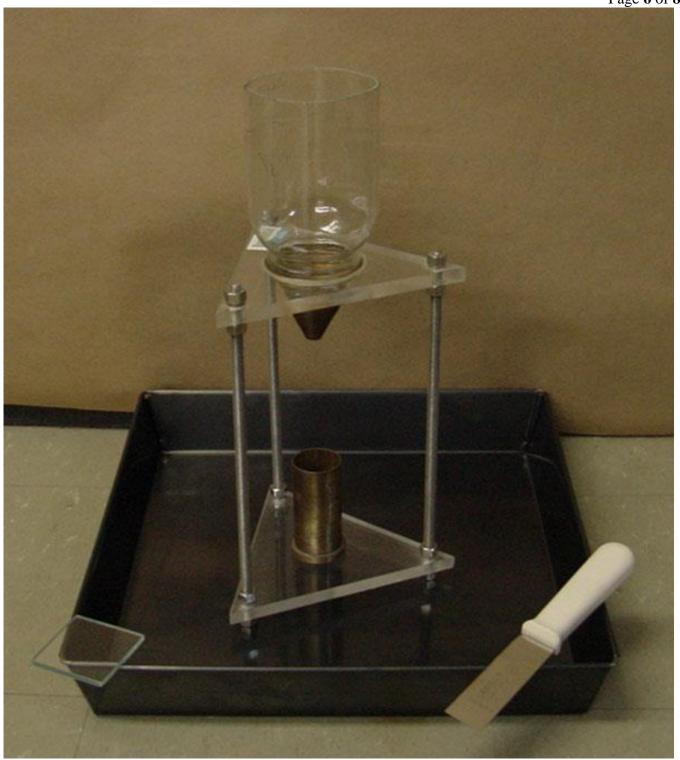
Figure 1
Apparatus
(Funnel, Funnel Stand, Cylindrical Measure, Catch Pan, Glass Plate, and Metal Spatula)

03-22-0748
2/00

MATT MENU SELECTION - 09

Louisiana Department of Transportation and Development
Materials and Testing Section
LA SUPERPAVE AGGREGATES

Project No. | | | | | - | | | | - | | | | | | |

Date Rec'd. _10/1/02_

Material Code | 6 | 5 | 0 |

Lab No. | 5 | 8 | - | | | | | | | | | |

Date Sampled | 0 | 9 | - | 2 | 5 | - | 0 | 2 |

Submitted By | | | | | |

Quantity | | | | | | | | **Units** | M | 9 | |

Purpose Code | |

Source Code | | | | | |

Spec. Code | |

P O No. | | | | | | | | |

Date Tested | / | 0 | - | 0 | 2 | - | 0 | 2 |

Ident. | | | | | | | |

Remarks 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Remarks 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Item No. | | | | | (| | | |) | (| | |) |

Sampled By:_____ **Date:**_____

(ALL WORKSHEETS USED THAT ARE NOT INCLUDED ON BACK OF THIS FORM SHOULD BE ATTACHED) **P/F**

PLANT CODE . . . . | H | | | | |X X X |

MIX LEVEL (1M, 1, 2 OR 3) . . . . | | | |X X X|

MIX TYPE (WC, BC, BASE) . . . . | | | | | |X X X|

MIX CODE . . . . | | | |x x x|

SEQUENCE NO. . . . . | | | | |x x x|

ASPHALTIC CONCRETE AGGREGATES MATERIAL CODE . . . . | | | | |x x x|

BULK SPECIFIC GRAVITY (G_{sb}) (AASHTO T 84 OR T 85) . . . . | 2 | • | 5 | 4 | 2 | | |x x x|

APPARENT SPECIFIC GRAVITY (G_{sa}) (AASHTO T 84 OR T 85) . . . . | | • | | | | | |x x x|

ABSORPTION % (AASHTO T 84 OR T 85) . . . . | | • | | |x x x|

COARSE AGGREGATE ANGULARITY(+2 Faces) (TR 306) . . . . | | | | | | |

FLAT AND ELONGATED (5:1) (ASTM D4791) . . . . | | | | |

FINE AGGREGATE ANGULARITY (FAA) (AASHTO T304 METHOD A) . . . . . | 3 | 7 | | |

SAND EQUIVALENT (-4.75mm) (AASHTO T176) . . . . | | | | | | |

RECLAIMED ASPHALT PAVEMENT (RAP) | x x x x x x x x x x x x x x x x x x x x x x x x | |x x x|

     % AC In RAP . . . . | | • | | |x x x|

     % Aggregate in RAP . . . . | | | • | | |x x x|

     Max. Specific Gravity of RAP (AASHTO T209) . . . . | | • | | | | |x x x|

     Effective Specific Gravity of RAP Aggregate (G_{se}) . . . . | | • | | | | |x x x|

SPECIFIC GRAVITY OF MINERAL FILLER (G_{sb}) (AASHTO T 100) . . . . | | • | | | | |x x x|

Tested by: _LAB TECHNICIAN_   Checked by:_____   Date: _10/2/02_

APPROVED BY: _DISTRICT LAB ENGINEER_   Date: _10/2/02_

(OVER)

Figure 2
DOTD Form 03-22-0748 (Front)

UNCOMPACTED VOID CONTENT OF FINE AGGREGATE (AASHTO T304 METHOD A)

Individual Size Fraction	Mass, g
2.36 mm (No.8) to 1.18 mm (No. 16)	44
1.18 mm (No.16) to 0.600 mm (No. 30)	57
0.600 mm (No. 30) to 0.300 mm (No. 50)	72
0.300 mm (No. 50) to 0.150 mm (No. 100)	17
Total	190

Tested By: _____   Date: _____

CALCULATIONS	FORMULA	TEST 1	TEST 2	AVE.
D = Mass of Empty Measure, g		183.6		
E = Mass of the Measure and Fine Agg., g		345.0		
F = Net Mass, of Fine Agg. in Measure, g	E - D = F	161.4		
V = Volume of Cylindrical Measure, mL		100.8		
G = Bulk Dry Specific Gravity of Fine Agg.		2.542		
U = Uncompacted Voids, Present in the Material	$U = \dfrac{V - (F/G)}{V} \times 100$	37.0%		
U_a = Average Uncompacted Voids	$\dfrac{U_1 + U_2}{2}$	37		

EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE IN RAP

Tested By: _____   Date: _____

Mass of Aggregate (TR 323)	A		
Mass of RAP	B		
% Asphalt in RAP	C	$\dfrac{B - A}{B} \times 100$	
Mass of Jar + Water	D		
Mass of Jar + Water + RAP	E		
Spec Grav of RAP (AASHTO T 209)	F	$\dfrac{B}{D + B - E}$	
% Aggregate in RAP	X	100 - C	
Specific Gravity of Asphalt Cement	H		1.03
Effective Spec Grav of Aggregate	G_{se}	$\dfrac{X}{\dfrac{100}{F} - \dfrac{C}{H}}$	

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE (AASHTO T85)

Tested By: _____   Date: _____

Mass of Oven Dry Test Sample in Air, g	A	
Mass of Saturated Surf-Dry Test Sample in Air,g	B	
Mass of Saturated Test Sample in Water, g	C	
Bulk Spec Grav (Dry)	$\dfrac{A}{B - C}$	
App. Spec Grav	$\dfrac{A}{A - C}$	
Absorption, %	$\dfrac{B - A}{A} \times 100$	

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE (AASHTO T84)

Tested By: _____   Date: _____

Mass of Oven Dry Test Sample in Air, g	A	
Mass of Volumetric Flask Filled With Water, g	B	
Mass of Volumetric Flask with Test Sample and Water to Calibration Mark, g	C	
Wt. Of Saturated Surface-Dry Test Sample, g	S	
Bulk Specific Gravity (Saturated-Surf-Dry)	S/(B +S - C)	
Bulk Specific Gravity (Dry)	A/(B + S - C)	
Apparent Specific Gravity	A/(B + A - C)	
Absorption, %	(S - A)/A X 100	

Figure 2A
DOTD Form 03-22-0748 (Back)