Standard Method of Test for

Determining Aggregate Shape Properties by Means of Digital Image Analysis

AASHTO Designation: TP 81-12 (2017)[1,2]

Technical Section: 1c, Aggregates

Release: Group 3 (August 2017)

AASHTO

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A A S H T O

1.	SCOPE

1.1.   This standard covers the measurement of aggregate shape properties using the digital image analysis techniques.

1.2.   *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to its use.*

2.	REFERENCED DOCUMENTS

2.1.   *AASHTO Standards*:
- M 231, Weighing Devices Used in the Testing of Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates
- T 11, Materials Finer Than 75- m (No. 200) Sieve in Mineral Aggregates by Washing
- T 27, Sieve Analysis of Fine and Coarse Aggregates
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate

2.2.   *ASTM Standards*:
- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- C802, Standard Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods for Construction Materials

2.3.   *Other Document*:
- National Cooperative Highway Research Program Report 555, *Test Methods for Characterizing Aggregate Shape, Texture, and Angularity*

3.	TERMINOLOGY

3.1.   *Definitions*:

3.1.1. *aggregate size*—sieve size in which material is retained after passing the next larger sieve.

3.1.1.1. *fine aggregate*—aggregate material passing a 4.75-mm (No. 4) sieve. Sieve sizes are 2.36 mm (No. 8), 1.18 mm (No. 16), 0.60 mm (No. 30), 0.30 mm (No. 50), 0.15 mm (No. 100), and 0.075 mm (No. 200).

3.1.1.2. *coarse aggregate*—aggregate material retained on a 4.75-mm (No. 4) sieve. Sieve sizes are 25.0 mm (1 in.), 19.0 mm ($^3/_4$ in.), 12.5 mm ($^1/_2$ in.), 9.5 mm ($^3/_8$ in.), and 4.75 mm (No. 4).

3.1.2. *Shape Properties for Each Retained Sieve (x)*:

3.1.2.1. *gradient angularity (GA)*—applies to both fine and coarse aggregate sizes and is related to the sharpness of the corners of two-dimensional images of aggregate particles. The gradient angularity quantifies changes along a particle boundary with higher gradient values indicating a more angular shape. Gradient angularity has a relative scale of 0 to 10,000, with a perfect circle having a value of 0.

Gradient Angularity:

$$GA = \frac{1}{\frac{n}{3} - 1} \sum_{i=1}^{n-3} \left| \theta_i - \theta_{i+3} \right| \tag{1}$$

where:

θ = angle of orientation of the edge points,

n = the total number of points, and

i = denoting the ith point on the edge of the particle.

3.1.2.2. *texture or microtexture (TX)*—applies to coarse aggregate sizes only and describes relative smoothness or roughness of surface features less than approximately 0.5 mm in size that are too small to affect the overall shape. Texture has a relative scale of 0 to 1000 with a smooth polished surface approaching a value of 0.

$$TX_n = \frac{1}{3N} \sum_{i=1}^{3} \sum_{j=1}^{N} \left(D_{i,j}(x,y) \right)^2 \tag{2}$$

where:

D = decomposition function,

n = decomposition level,

N = total number of coefficients in an image,

i = 1, 2, or 3 for detailed images,

j = wavelet index, and

x, y = location of the coefficients in transformed domain.

3.1.2.3. *sphericity (SP)*—applies to coarse aggregate sizes only and describes the overall three-dimensional shape of a particle. Sphericity has a relative scale of 0 to 1. A sphericity value of 1 indicates a particle has equal dimensions (cubical).

$$SP = \sqrt[3]{\frac{d_S \times d_I}{d_L^2}} \tag{3}$$

where:

d_S = particle shortest dimension,

d_I = particle intermediate dimension, and

d_L = particle longest dimension.