Standard Practice for

Determining Aggregate Source Shape Values from Digital Image Analysis Shape Properties

AASHTO Designation: R 91-18[1]

Technical Subcommittee: 1c, Aggregates

Release: Group 3 (July)

AASHTO

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

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1. SCOPE

1.1. This standard covers the determination of aggregate source and source blend shape characteristics using gradation analysis and shape properties determined by means of digital image analysis.

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

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- T 11, Materials Finer Than 75-µm (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
- T 381, Determining Aggregate Shape Properties by Means of Digital Image Analysis

2.2. *Other Document*:

- National Cooperative Highway Research Program Report 555, *Test Methods for Characterizing Aggregate Shape, Texture, and Angularity*

3. TERMINOLOGY

3.1. *aggregate size*—material retained on a given sieve size after passing the next larger sieve.

3.1.1. *fine aggregate*—aggregate material passing 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).

3.1.2. *coarse aggregate*—aggregate material retained on 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).

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

3.2.1. *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 range of zero to 10,000, with a perfect circle having a value of zero.

Gradient angularity:

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

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.

3.2.2. *texture (or microtexture) (TX)*—applies to coarse aggregate sizes only and describes the 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 zero to 1000 with a smooth polished surface approaching a value of zero.

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

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.

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

$$SP = \sqrt[3]{\frac{d_S \times d_I}{d_L^{\,2}}} \qquad (3)$$

where:

d_S = particle shortest dimension,

d_I = particle intermediate dimension, and

d_L = particle longest dimension.

Note 1—The term "sphericity" has been used for many years in research to describe this measurement. In principle, a cube does not have a sphericity of one because the diagonal is considered to be the longest dimension. A digital image acquisition and analysis system would measure a value of one for a cube because it would be sitting in front of the camera on one of its faces and the longest dimension will be measured as the width.

3.2.4. *Form 2D*—Applies to fine aggregate sizes only and is used to quantify the relative form from 2-dimensional images of aggregate particles. Form 2D has a relative scale of 0 to 20. A perfect circle has a Form 2D value of zero.