

1214 **DETERMINATION PERCENTAGE OF CRUSHED
PARTICLES IN AGGREGATES**
ASTM D 5821 Mn/DOT Modified

1214.1 SCOPE

This test method covers the determination of percent of particles which, by visual inspection, have the essential characteristics of crushed aggregates.

1214.2 SIGNIFICANCE and USE

The specifications and special provisions contain requirements for percentage of crushed particles, with the purpose of maximizing shear strength in either bound or unbound aggregate mixtures. This method can be used in determining the acceptability of coarse, dense-graded, and open-graded aggregates with respect to such requirements. This procedure is used primarily for bituminous aggregates.

NOTE 1: The intended purpose of determining percent of crushed particles is to indicate a degree of internal friction between particles.

NOTE 2: The intended purpose of crushing aggregates is to change the particle surface texture from smooth to rough and the particle shape from round to angular. These alterations in characteristics will aid in the aggregate particles interlock and adhesion.

1214.3 TERMINOLOGY

Fractured Face - Broken surface constituting an area equal to at least 25% of the maximum projected area (maximum cross-sectional area) of the particle, as viewed perpendicular to (looking directly at) the fractured face.

NOTE 3: A fractured face is defined as being caused either by mechanical means or by nature. Natural fractures, to be accepted, must be similar to fractures produced by a crusher. The fractured face should have sharp or slightly blunted edges.

Crushed Particle - A particle of aggregate having at least one fractured face, or two fractured faces, as required for that class/type of aggregate in the specifications and/or special provisions.

NOTE 4: The following three statements on "Angle at Edge of Fractured Face", "Edge Condition" and "Surface Condition" are intended to convey the intent of this method with regard to the description of crushed particles. The three statements are for **general guidance** and are **not to define rigidly enforced limits**.

Angle at Edge of Fractured Face - The angle between the two fractured faces, or between a fractured face and the remaining surface of the particle should normally be moderately abrupt, approximately 1 radian (60°) minimum from the plane of the fractured face. Lesser angles should be considered questionable.

Edge Condition - The edge of a fractured face should be sharp or only slightly blunted. For example, a piece of crushed limestone in handling may have a small amount abraded from the sharp edge, making it slightly rounded. This is still acceptable.

Surface Condition - The surface of the fractured face should be rough (not smooth or polished) in texture.

1214.4 APPARATUS

- A. Sieves - A set of sieves, appropriate for the sample type, conforming to the requirements of AASHTO M 92.
- B. Balances - **For Sieving**, conforming to AASHTO M 231 and appropriate for the size of the initial sample (see Section 1202). **For Crushed Particle Determination**, conforming to AASHTO M 231, Table 2, with a readability, sensitivity and accuracy of 0.1g.
- C. Spatula - A spatula or similar tool to aid in sorting the aggregate particles.
- D. Paper Containers.

1214.5 SAMPLING

Obtain a representative sample from the coarse gradation. (See Sections 1002, 1201 and 1202.)

NOTE 5: Since the sample is frequently taken after the coarse gradation process, it is necessary to determine the correct proportions between the two fractions described in NOTE 6. This may be calculated from gradation results; all the material passing and retained on the appropriate sieves for the selected fractions are weighed, the sum of the weights is the total +4.74mm (#4) and material from each fraction is split down to the required size (This is the method used in the example, Section 1214.7B); or any other method that maintains the proportional relationship between the two fractions and provide a representative sample for each fraction.

TEST SAMPLE SIZES

SIEVE SIZE (mm)	SIEVE SIZE	SAMPLE SIZE (g)
9.5 - 4.75	#4 - 3/8"	100 - 200
9.5 - 12.5	3/8 - 1/2"	500 - 700
12.5 - 19.0	1/2 - 3/4"	1500 - 4000
19.0 - 25.0	3/4 - 1"	5000 - 7000
+25.0	+1"	10000 - 13000

NOTE 6: Weights are for guidance only. In no case shall the number of particles examined in any fraction be less than 150.

1214.6 PROCEDURE

- A. Wash and then dry to a constant weight. Weigh the test sample to the nearest 0.1g and record as "Test Sample Weight".
- B. Spread the test sample on a clean, flat surface large enough to permit the material to be spread thinly for careful inspection and evaluation.
- C. Using the spatula or a similar tool separate the particles into one of the following three categories.
 1. **Crushed Particles**, using the criteria of "one or more fractured faces" or "two or more fractured faces" as is consistent with the requirements in the specifications and/or special provisions.
 2. **Uncrushed Particles**
 3. **Questionable Particles**
- D. Determine the weight of the "Crushed Particles" and "Questionable Particles" separately and record the weights as "Weight of Crushed Particles" and "Weight of Questionable Particles".

NOTE 7: The weight of the Questionable Particles shall not exceed 15% of the total Test Sample Weight. If the Questionable Particle weight is in excess of 15%, re-examine (evaluate) all the particles in the questionable portion and make a more definitive determination, so that the questionable portion is not greater than 15%.

1214.7 CALCULATION

- A. Calculate the percentage of crushed particles for each separate fraction as follows:

$$\text{Percent Crushed Particles (CP)} = \frac{A + (B/2)}{C} \times 100$$

Where: A = Weight of crushed particles with at least the specified number of fractured faces, in grams.

B = Weight of questionable particles, in grams.

C = Weight of the test sample, in grams.

In the example, 12.5 to 9.5mm (1/2 to 3/8") size:

$$A = 730$$

$$B = 104$$

$$C = 1850$$

$$\text{CP} = \frac{730 + (104/2)}{1850} \times 100 = 42.3\%$$

In the example, 9.5 to 4.75mm (3/8" to #4) size:

$$A = 350$$

$$B = 70$$

$$C = 470$$

$$\text{CP} = \frac{350 + (70/2)}{470} \times 100 = 81.9\%$$

- B. Total Percentage of Crushed Particles (TPC) Retained on the 4.75mm (#4) Sieve.

Determine the percentages on the various fractions using the material retained on the 4.75mm (#4) sieve as 100%.

Example:

$$\begin{array}{rcl}
 12.5 - 9.5\text{mm } (1/2 - 3/8\text{'}) \text{ Material} & = & 3766\text{g} \\
 9.5 - 4.75\text{mm } (3/8 - \#4) \text{ Material} & = & 7314\text{g} \\
 \hline
 \text{Total } +4.75\text{mm } (\#4) \text{ Material} & = & 11080\text{g}
 \end{array}$$

$$\text{Percent } 12.5 - 9.5\text{mm } (1/2 - 3/8\text{'}) = \frac{3766}{11080} \times 100 = 34\%$$

$$\text{Percent } 9.5 - 4.75\text{mm } (3/8\text{' to } \#4) = \frac{7314}{11080} \times 100 = 66\%$$

Total Percent Crushed Particles (TPC) =

$$(\% \text{ Crushed Particles } 12.5 - 9.5\text{mm } [1/2 \text{ to } 3/8\text{'}) \times (\% \text{ of } 12.5 - 9.5\text{mm } [1/2 \text{ to } 3/8\text{'}) \times 100$$

+

$$(\% \text{ Crushed Particles } 9.5 - 4.75\text{mm } [3/8\text{' to } \#4]) \times (\% \text{ of } 9.5 - 4.75\text{mm } [3/8\text{' to } \#4]) \times 100$$

In the Example:

$$([0.423 \times 0.34] + [0.819 \times 0.66]) \times 100 =$$

$$([0.144] + [0.541]) \times 100 = 68.5\% \text{ (TPC)}$$

1214.8 EXCEPTIONS

A. The typical Bituminous Mixture (BM) sample is approximately 2000 grams. If after extraction there is insufficient +4.75mm (#4) material to run a percent crushing count in accordance with this procedure, the Bituminous Engineering Unit has altered this procedure for BM samples as follows:

1. Use all the material retained on all the 4.75mm (#4) and larger sieves.
2. Perform the procedure in accordance with Sections 1214.3, 1214.4 and 1214.6.

3. Calculate the CP in accordance with Section 1214.7A.

NOTE 8: Since the sample was not split "CP" is the same as "TPC" and no further calculations are necessary.

NOTE 9: This procedure is not to be used for any other type of sample.

B. Specification 3138, Classes 5 and 6, stabilizing aggregate and aggregate bedding, have a required minimum percent crushing. The percent crushing referred to in that specification is **not** the same as Sections 1214.6, 1214.7 or 1214.8. Differences are as follows:

1. Percent crushing can be determined by samples taken from stockpiles prior to crushing. This is primarily a field test; however, should a laboratory receive an uncrushed sample for Specification 3138 the procedure in the Grading & Base Manual, 5-692.203, may be used.
2. The percent crushing determined by particle count on +4.75mm (#4) material is done in accordance with Grading & Base Manual, 5-692.204. This procedure does not recognize "Questionable Particles".

In addition and in order to relate to "Percent Crushing" when determined from an uncrushed stockpile, the procedure includes a factor to account for those particles which will pass a 4.75mm (#4) sieve as a result of the crushing process. It is this factor that makes "crushing" in Specification 3138.2C unrelated to "crushing" in Specification 3139.2C.

NOTE 10: No deviation from the procedures in the Grading & Base Manual will be permitted. Changes in those procedures must be initiated or approved by the Grading & Base Office.



CRUSHED PARTICLES – SHARP EDGES, ROUGH SURFACES



CRUSHED PARTICLES – SHARP EDGES, SMOOTH SURFACES



CRUSHED PARTICLES – BLUNT EDGES, ROUGH SURFACES



NON CRUSHED PARTICLES – ROUND EDGES, SMOOTH SURFACES



ROUNDED PARTICLES – SMOOTH SURFACES