

# WSDOT FOP for ASTM D 4791<sup>1</sup>

## **Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate**

### 1. Scope

- 1.1 This test method covers the determination of the percentages of flat particles, elongated particles, or flat and elongated particles in coarse aggregates.
- 1.2 The values stated in inch-pound units are to be regarded as the standard except in regard to sieve size and the size of aggregate, which are given in SI units in accordance with Specification E 11. The SI units in parentheses are for information purposes only.
- 1.3 This standard does not purport to address all of the safety concerns, if any, 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.

**Note:** WSDOT will be determining flat and elongated particles in accordance with [Section 8.3](#).

### 2. Referenced Documents

#### 2.1 WSDOT Standards

T 2 – FOP for AASHTO for the Sampling of Aggregates

T 248 – FOP for AASHTO for Reducing Field Samples of Aggregates to Testing Size

#### 2.2 WAQTC Standards

T 27/11 – FOP for AASHTO for the Sieve Analysis of Fine and Coarse Aggregates and Materials Finer Than 75 mm (No. 200) in Mineral Aggregates by Washing

### 3. Terminology

#### 3.1 Definitions

- 3.1.1 *flat or elongated particles of aggregate* – Those particles of aggregate having a ratio of width to thickness or length to width greater than a specified value (see Terminology C 125).
- 3.1.2 *flat and elongated particles of aggregate* – Those particles having a ratio of length to thickness greater than a specified value.
- 3.1.3 *length* – Maximum dimension of the particle.
- 3.1.4 *width* – Maximum dimension in the plane perpendicular to the length.
- 3.1.5 *thickness* – Maximum dimension perpendicular to the length and width.

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<sup>1</sup>This Test Method is based on ASTM D 4791-05 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.

#### 4. Summary of Test Method

- 4.1 Individual particles of aggregate of specific sieve sizes are measured to determine the ratios of width to thickness, length to width, or length to thickness.

#### 5. Significance and Use

- 5.1 Flat or elongated particles of aggregates, for some construction uses, may interfere with consolidation and result in harsh, difficult to place materials.
- 5.2 This test method provides a means for checking compliance with specifications that limit such particles or to determine the relative shape characteristics of coarse aggregates.

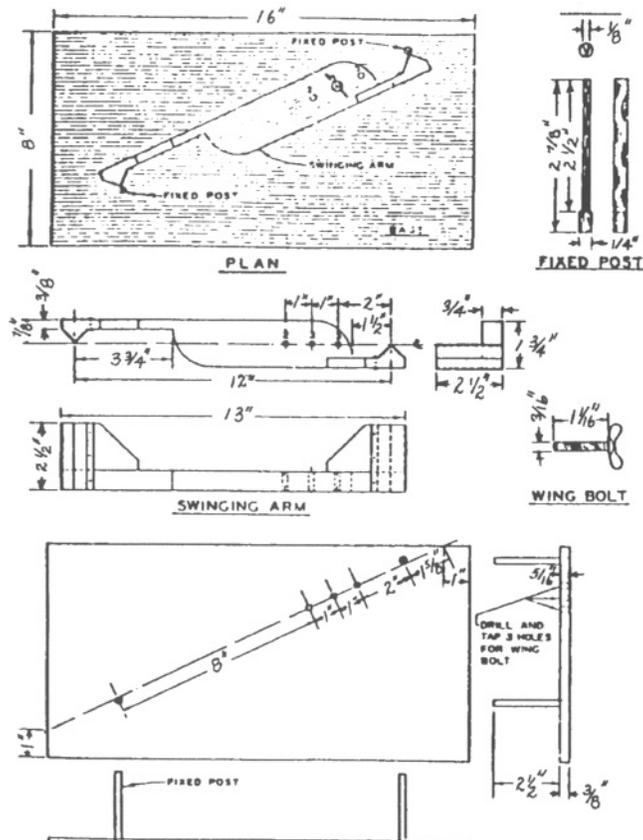
#### 6. Apparatus

- 6.1 The apparatus used shall be equipment suitable for testing aggregate particles for compliance with the definitions in [Section 3.1](#), at the dimensional ratios desired.

- 6.1.1 Proportional Caliper Device – The proportional caliper devices illustrated in [Figures 1, 2, and 3](#) are examples of devices suitable for this test method. The device illustrated in [Figures 1 and 2](#) consists of a base plate with two fixed posts and a swinging arm mounted between them so that the openings between the arms and the posts maintain a constant ratio. The axis position can be adjusted to provide the desired ratio of opening dimensions. [Figure 1](#) illustrates a device on which ratios of 1:2, 1:3, 1:4, and 1:5 may be set. The device illustrated in [Figure 3](#) contains several fixed posts and has the capability of measuring various ratios simultaneously.

- 6.1.1.1 Verification of Ratio – The ratio settings on the proportional caliper device shall be verified by the use of a machined block, micrometer, or other appropriate device.

- 6.1.2 Balance – The balance or scales used shall be accurate to 0.5 percent of the mass of the sample.



**Proportional Caliper**  
**Figure 1**

7. Sampling

- 7.1 Sample the coarse aggregate in accordance with in FOP for AASHTO T 2. The mass of the field sample shall be the mass shown in FOP for AASHTO T 2.
- 7.2 Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in FOP for AASHTO T 248. The sample for test shall be approximately the mass desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined mass shall not be permitted. The mass of the test sample shall conform to the following:

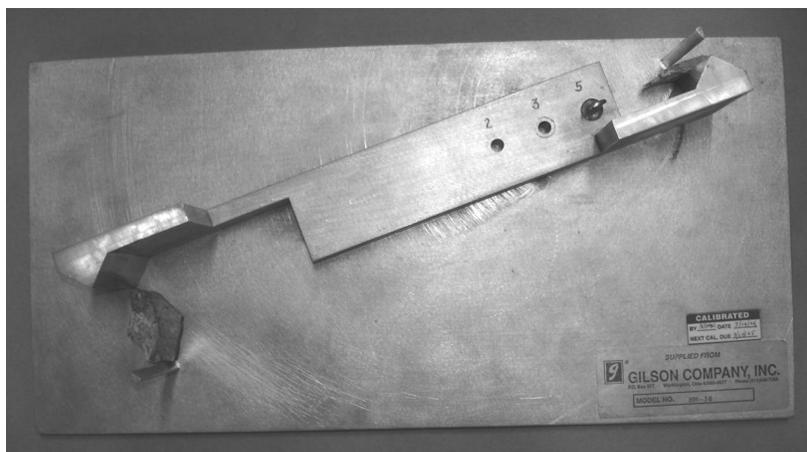
Nominal Maximum Size* Square Openings, in (mm)	Minimum Mass of Test Sample, lb (kg)
3/8 (9.5)	2 (1)
1/2 (12.5)	4 (2)
3/4 (19)	11 (5)
1 (25.0)	22 (10)
1 1/2 (37.5)	33 (15)
2 (50)	44 (20)
2 1/2 (63)	77 (35)
3 (75)	130 (60)
3 1/2 (90)	220 (100)
4 (100)	330 (150)
4 1/2 (112)	440 (200)
5 (125)	660 (300)
6 (150)	1100 (500)

\*For aggregate, the nominal maximum size, (NMS) is the largest standard sieve opening listed in the applicable specification, upon which any material is permitted to be retained. For concrete aggregate, NMS is the smallest standard sieve opening through which the entire amount of aggregate is permitted to pass.

**Note:** For an aggregate specification having a generally unrestrictive gradation (i.e., wide range of permissible upper sizes), where the source consistently fully passes a screen substantially smaller than the maximum specified size, the nominal maximum size, for the purpose of defining sampling and test specimen size requirements may be adjusted to the screen, found by experience to retain no more than 5 percent of the materials.

## 8. Procedure

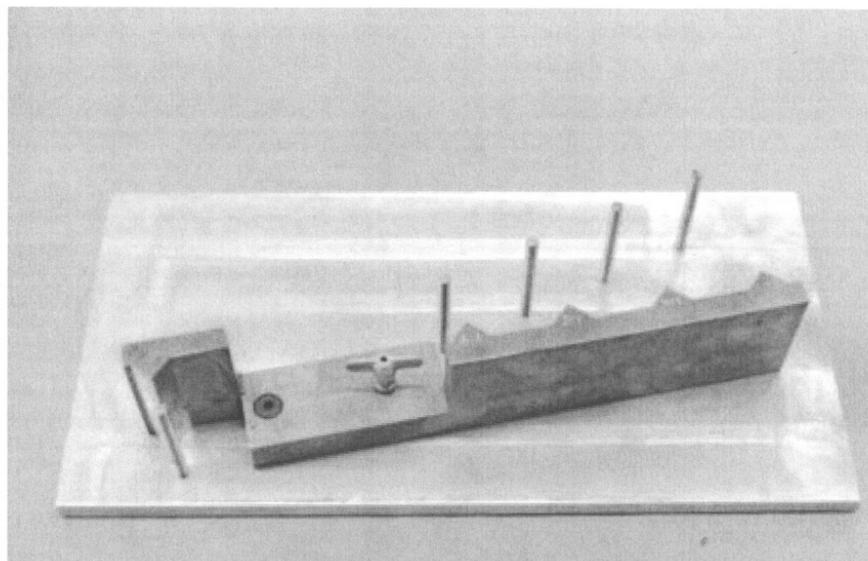
- 8.1 If determination by mass is required, oven dry the sample in accordance with FOP for AASHTO T 255. If determination is by particle count, drying is not necessary.
- 8.2 Sieve the sample to be tested in accordance with FOP for AASHTO T 27/11. If the material retained on each required size (3/8 and larger) is more than 5 percent of the sample, reduce the material in accordance with FOP for AASHTO T 248 until approximately 100 particles are obtained for each required size.
- 8.3 Flat and Elongated Particle Test – Test each of the particles in each size fraction and place in one of two groups: (1) flat and elongated or (2) not flat and elongated.
  - 8.3.1 Use the proportional caliper device, set at the desired ratio.
  - 8.3.2 Measurement
    - 8.3.2.1 On proportional caliper devices similar to the devices shown in [Figure 1](#) and [Figure 2](#), set the larger opening equal to the length of the particle. The particle is flat and elongated if the particle, (biggest to smallest) when oriented to measure its thickness (biggest), can pass completely through the smaller opening of the caliper when it is rotated in any direction.



Use of Proportional Caliper  
Figure 2

in	mm	in	mm	in	mm
1/8	3.2	7/8	21.2	2 1/2	64.0
3/16	4.8	1	25.4	2 7/8	72.0
1/4	6.3	1 1/16	27.0	3 3/4	96.0
5/16	7.9	1 1/2	38.0	8	207.0
3/8	9.5	1 5/8	41.0	16	414.0

Metric Equivalents



Proportional Caliper  
Figure 3

8.3.2.2 On calipers similar to the one described in [Figure 3](#), set the minimum dimension of the proportional caliper device such that the particle, when oriented to measure its thickness, passes snugly between the post and swing arm. The particle is flat and elongated if the particle, when oriented to measure its length, fails to pass the desired large opening of the proportional caliper device.

8.3.3 After the particles have been classified into the groups described in [Section 8.3](#), determine the proportion of the sample in each group by count or mass, as required.

**Note:** WSDOT performs this test by weight.

## 9. Calculation

9.1 Calculate the percentage of flat and elongated particles to the nearest 1 percent for each sieve size than  $\frac{3}{8}$  in and larger (9.5 mm), as required.

## 10. Report

10.1 Include the following information in the report:

10.1.1 Identification of the coarse aggregate tested.

10.1.2 Grading of the aggregate sample, showing percentage retained on each sieve.

10.1.3 For flat and elongated particle tests:

10.1.3.1 Percentages, calculated by number or by mass, or both, for flat and elongated particles for each sieve size tested.,

10.1.3.2 The dimensional ratio used in the tests.

10.1.4 When required, weighted average percentages based on the actual or assumed proportions of the various sieve sizes tested. Report the grading used for the weighted average if different from that in [Section 10.1.2](#).

10.2 Report results using one or more of the following:

- Materials Testing System (MATS)
- DOT Form 350-161
- Form approved in writing by the State Materials Engineer

## 11. Precision and Bias

See ASTM D 4791 for precision and bias statements.

# Performance Exam Checklist

## *Flat and Elongated Particles in Coarse Aggregate FOP for ASTM D 4791*

Participant Name \_\_\_\_\_ Exam Date \_\_\_\_\_

<b>Procedure Element</b>	<b>Yes</b>	<b>No</b>
1. The tester has a copy of the current procedure on hand?	<input type="checkbox"/>	<input type="checkbox"/>
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	<input type="checkbox"/>	<input type="checkbox"/>
3. Field sample obtained per AASHTO T 2?	<input type="checkbox"/>	<input type="checkbox"/>
4. Sample thoroughly mixed prior to reducing to testing size?	<input type="checkbox"/>	<input type="checkbox"/>
5. Sample reduced to testing size per AASHTO T 248?	<input type="checkbox"/>	<input type="checkbox"/>
6. Mass of the test sample conforms to the table in Section 7.2, ASTM D 4791?	<input type="checkbox"/>	<input type="checkbox"/>

### ***Procedure***

1. If determination by mass, sample oven dried to a constant weight prior to mass determination?	<input type="checkbox"/>	<input type="checkbox"/>
2. Sample sieved per AASHTO T 27/T 11?	<input type="checkbox"/>	<input type="checkbox"/>
3. Proportional caliper device positioned at proper ratio?	<input type="checkbox"/>	<input type="checkbox"/>
4. Each size fraction $\frac{3}{8}$ inch and larger retaining more than 5 percent of the original sample reduced per AASHTO T 248 until approximately 100 particles are obtained for each size fraction required?	<input type="checkbox"/>	<input type="checkbox"/>
5. Each particle of each size fraction tested for FLAT and ELONGATED using the proportional caliper device put in the appropriate group classification? (Flat and Elongated or Not Flat and Elongated)	<input type="checkbox"/>	<input type="checkbox"/>
6. Proportion of the sample of each sieve size determined by Mass?	<input type="checkbox"/>	<input type="checkbox"/>
7. Percent of Flat and Elongated particles figured to the nearest 1 percent for each sieve size?	<input type="checkbox"/>	<input type="checkbox"/>
8. Record number of particles in each sieve size tested?	<input type="checkbox"/>	<input type="checkbox"/>
9. Record percentages calculated by Mass?	<input type="checkbox"/>	<input type="checkbox"/>
10. All calculations performed correctly?	<input type="checkbox"/>	<input type="checkbox"/>

First Attempt: Pass  Fail

Second Attempt: Pass  Fail

Signature of Examiner \_\_\_\_\_

Comments:

