

Method of Test for Flat & Elongated Particles

1. Scope:

This test is for determining the percentage by weight of coarse aggregate that have a maximum to minimum dimension greater than the specified ratio of 5:1(5 to 1) or 3:1(3 to 1).

2. Apparatus:

- 2.1 Proportional caliper device that is equipped with a 5:1 ratio setting and/or 3:1 ratio setting consisting of a base plate with two fixed vertical posts and a swinging arm mounted between them so that the opening between the arms and the posts maintain a constant ratio. The apparatus must be calibrated as stated in the procedure.
- 2.2 Balance having the capacity to weigh any sample which may be tested utilizing this procedure, accurate and readable to the nearest 0.1 gram.

3. Procedure:

- 3.1 Verification of Ratio: Ratio settings on the proportional caliper device shall be verified by the use of a calibrated machined block, micrometer, or other appropriate device.
 - A. The caliper device must close and bars touch on both sides of the caliper. Set the caliper to a 5:1 or 3:1 ratio as required by the specification. Open the larger end of the caliper to 5 inches or 3 inches and verify that the other opening is 1 inch. If needed, adjust the bars with the set screws under the caliper device to meet calibration.
- 3.2 Use + #4 material from the SD 202 sieve test. Record the weight of the sieve samples being tested as indicated below. Weigh and record the total amount of material retained on each sieve to the nearest 0.1 gram in column (A) "Total Sample Weight on Sieve" Record "Total Sample Weight" (F). Split out approximately 100 particles of material retained on each sieve group that is in the sample.

Passing the 2" sieve and retained on the 1½" sieve
Passing the 1½" sieve and retained on the 1" sieve
Passing the 1" sieve and retained on the ¾" sieve
Passing the ¾" sieve and retained on the ½" sieve
Passing the ½" sieve and retained on the ⅜" sieve
Passing the ⅜" sieve and retained on the #4 sieve

NOTE: If a 1 ¼" sieve is used in the sieving, the material retained on that sieve shall be combined with the material retained on the 1" sieve. If a 5/8" sieve is used in the sieving, the material retained on that sieve shall be combined with the material retained on the ½" sieve. If a ¼" sieve is used in the sieving, the material retained on that sieve shall be combined with the material retained on the #4 sieve. If there are not 100 pieces retained on any required sieve size for testing, test the entire amount retained on the sieve.

- 3.3 After counting out the first sample splits of approximately 100 particles per sieve size, obtain a weight to be able to use to split out the sample without counting particles in the

future. Weigh the amount of particles split out to test for each sieve size to the nearest 0.1 gram and record in column (B) "Weight of tested portion".

- 3.4 Set the longest length of the particle to be tested end to end in the larger end of the caliper device.
- 3.5 With the caliper device fixed in that position, tighten the pivot screw. Observe if the particle will pass through the smaller end of the caliper device at its minimum width or thickness. If it does, the particle should be counted as flat and elongated (F&E).
- 3.6 Repeat 3.4 and 3.5 for each particle to be tested.
- 3.7 Weigh the Flat and Elongated particles for each sieve sample to the nearest 0.1 gram and record in column (C) "Weight of Flat/Elongated Particles".
- 3.8 Calculate the "Percent of Flat/Elongated Individual Sieve" and the "Percent Flat/Elongated Weighted Average" to the nearest 0.1 percent by using the following equations.

$$\text{Percent of Flat/Elongated Individual Sieve (D)} = (C/B)100$$

$$\text{Percent Flat/ Elongated Weighted Average (E)} = (A/F)D$$

The Total Percent Flat and Elongated Particles (G) Is the sum of the Percent Flat/Elongated Weighted Average Column (E).

	(A)	(B)	(C)	(D)	(E)
Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion (100 pieces)	Weight of Flat/ Elongated Particles	Percent Flat/ Elongated Individual Sieve	Percent Flat/ Elongated Weighted Average
2" to 1 1/2"	0.0				
1 1/2" to 1"	0.0				
1" to 3/4"	1431.6	1431.6	0.9	0.1	0.0
3/4" to 1/2"	4818.7	809.3	6.7	0.8	0.4
1/2" to 3/8"	2095.4	228.5	4.6	2.0	0.4
3/8" to #4	1798.4	96.7	0.9	0.9	0.2
Total Sample Weight	10144.1	(F)			

Total Percent Flat and Elongated Particles	1.0	(G)
(Rounded)	1	

Figure 1

- 3.9 Record all test results on the appropriate form; for concrete use the form DOT-3 Coarse or DOT-68 and for asphalt use form DOT-69.

4. Report:

4.1 Report the percent flat and elongated particles in the total sample (Weighted average) to the nearest 0.1 percent or whole number as required by the specification.

5. References

SD 202
DOT-3 Coarse
DOT-68
DOT-69

Sample ID 2224661 **Sieve Analysis and P.I. Worksheet** DOT-3
 File No. 3-19
 PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
 Charge to (if not above project) _____
 Field No. 09 Date Sampled 04/01/2019 Date Tested 04/01/2019
 Sampled By Tester, One Tested By Tester, One Checked By Tester, Two
 Material Type COARSE AGGREGATE Source Hills Materils, Rapid City Quarry
 Paving Lot No. _____ Sublot No. _____
 Weight Ticket Number or Station _____ Lift _____ of _____

[Wet Sample Weight (0.1g) _____ - Original Dry Sample Weight (0.1g) 10,312.3] / dry weight x 100 = _____

Sieve Size	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
4 in.					
3 in.					
2 1/2 in.					
2 in.					
1 1/2 in.	0.0	0.0	100.0	100	100 - 100
1 1/4 in.					
1 in.	0.0	0.0	100.0	100	95 - 100
3/4 in.	1,431.6	13.9	86.1	86	
5/8 in.	2,964.8	28.8	57.3	57	
1/2 in.	1,853.9	18.0	39.3	39	25 - 60
3/8 in.	2,095.4	20.3	19.0	19	
1/4 in.					
#4	1798.4	17.4	1.6	2	0 - 10
Pan					
Total					
+ #4 Gradation Check			Dash Check		
within 0.3% of original dry weight			wt. before washing (0.1g)		
0.09			wt. after washing (0.1g)		
			loss from washing		
			% - #200		

Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/ Elongated Particles	% Flat/ Elongated Individual Sieve	% Flat/ Elongated Weighted Average
2 in.					
1 1/2 in.					
1 in.					
3/4 in.	1431.6	1431.6	0.9	0.1	0.0
1/2 in.	4818.7	809.3	6.7	0.8	0.4
3/8 in.	2095.4	228.5	4.6	2.0	0.4
#4	1798.4	96.7	0.9	0.9	0.2
Total	10144.1				1.0
				(rounded)	1
				Specification	0.0 - 10.0

Sieve Size	Retained (0.1g)	% total ret. (0.1g)	% passing (0.1g)	% passing (rounded)	Spec Req.
#6			1.6	2	
#8	60.7	0.6	1.0	1	0 - 5
#10					
#12					
#16					
#20					
#30					
#40					
#50					
#80					
#100					
#200					
Pan dry	98.4	98.4			3771.0
Pan wash	0.0	1.0			3728.2
Total	10303.2				42.8
Coarse	1.13	% x % Retain/Design	=	- #4 Gradation Check	
Fine		% x % Passing/Design	=	within 0.3% of original dry weight	
Total/Combined -#200					

Crushed Particles Test

Weight of crushed particles _____

Weight of total + #4 sample _____

Percent of crushed pieces _____

Specification _____ or more FF, min.

- #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01) _____

Weight of lightweight particles _____

Weight of - #4 material _____

% lightweight particles _____

Specification _____

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01) 1.96

Weight of lightweight particles (0.1g) 0.1

Weight of + #4 material (0.1g) 1857.0

% lightweight particles 0.0

Specification 0.0 - 1.0

Comments _____

Figure 2

Sample ID 2203625 **Sieve Analysis** DOT-68
Test# 04 **Mineral Aggregate** Stationary Plant Mix 3-19
PCN B015 **Project** PH 0066(00)15
County Aurora, Ziebach
Charge to (if not above project)
Sample Represents 1155.0 **Cu. Yd. Class and Type** COARSE AGGREGATE
Date Sampled 03/13/2019 **Sampled By** Tester, One
Date Tested 03/13/2019 **Tested By** Tester, One
Checked By Tester, Two
Contractor Roads, Inc

Mix Batch Ticket	lbs./cu. yd.	Total Agg%
1" rock	1374.0	77.6
Chip	396.0	22.4
Total	1770.0	100.0

1" rock			Chip			TOTAL		
Sample Wt. (.1g)	10312.3	3098.8	Sample Wt. (.1g)	3098.8	3094.3	Sample Wt. (.1g)	3094.3	3094.3
Sieve Size Retained (.1g)	% total ret(0.1%)	% pass ret(0.1%)	Sieve Size Retained (.1g)	% total ret(0.1%)	% pass ret(0.1%)	Sieve Size Retained (.1g)	% total ret(0.1%)	% pass ret(0.1%)
2			2			2		
1 1/2			1 1/2			1 1/2		
1 1/4			1 1/4			1 1/4		
1	0.0	100.0	1			1		
3/4	1431.6	86.1	3/4			3/4		
5/8	2964.8	28.8	5/8	0.0	100.0	5/8		
1/2	1853.9	18.0	1/2	0.0	100.0	1/2		
3/8	2095.4	20.3	3/8	104.8	3.4	3/8		
1/4			1/4	1347.5	43.5	1/4		
#4	1798.4	17.4	#4	935.3	30.2	#4		
#8	60.7	0.6	#8	616.2	19.9	#8		
Pan Dry	98.4	1.0	Pan Dry	90.5	2.9	Pan Dry		
TOTAL	10303.2		TOTAL	3094.3		TOTAL		
Gradation Check ==>	0.09		Gradation Check ==>	0.15		Gradation Check ==>		
wt. before wash	3771.0		wt. before wash	2752.8		wt. before wash		
wt. after wash	3728.2		wt. after wash	2707.1		wt. after wash		
loss from wash	42.8		loss from wash	45.7		loss from wash		
% - #200==>	1.13		% - #200==>	1.66		% - #200==>		
Bin adj. - 200==>	0.877		Bin adj. - 200==>	0.372		Bin adj. - 200==>		

Figure 3

Composite Coarse Aggregate

Sieve Size	1" rock	Chip	Retained Total	Cumulative Passing	Specification Gradation	Job Mix Formula
2			0.0	100.0	100	
1 1/2			0.0	100.0	100	100 - 100
1 1/4			0.0	100.0	100	
1	0.0		0.0	100.0	100	95 - 100
3/4	10.8		10.8	89.2	89	
5/8	22.3	0.0	22.3	66.9	67	
1/2	14.0	0.0	14.0	52.9	53	25 - 60
3/8	15.8	0.8	16.6	36.3	36	
1/4		9.7	9.7	26.6	27	
#4	13.5	6.8	20.3	6.3	6	0 - 10
#8	0.5	4.5	5.0	1.3	1	0 - 5
Pan	0.8	0.6	1.4	0.0	0	
Total	77.7	22.4	100.1			

Total Combined - #200 ==> 1.25

Coarse	% x % Retain/Design	58.00	=	
Fine	% x % Pass/Design	42.00	=	
04 Referenced	Total/Combined - #200			

+ #4 % Particles less than 1.95 SP. GR.

Specific gravity of solution	(1.95 ± 0.01)	1.96	1" rock	1.95	Chip
wt. of lightweight particles	(0.1g)	25.0		11.0	
weight of + #4 material	(0.1g)	1500.0		1430.0	
% lightweight particles		1.7		0.8	
Bin Adj. % lightweight particles		1.3		0.2	
Composite % lightweight particles		1.5			
SPECIFICATION		0.0 - 1.0			

Figure 3A

Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
mm	inches				
Rock Size					
50.0	2				
37.5	1 1/2				
25.0	1	0.0			
19.0	3/4	1,431.6	0.9	0.1	
12.5	1/2	4,818.7	6.7	0.8	0.4
9.5	3/8	2,095.4	4.6	2.0	0.4
4.75	#4	1,798.4	0.9	0.9	0.2
Total sample wt. 10,144.1					

Percent flat and elongated particles in:	1.0
Percent flat and elongated particles in Total Rock:	0.8

Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
mm	inches				
Rock Size					
50.0	2				
37.5	1 1/2				
25.0	1				
19.0	3/4				
12.5	1/2	0.0	0.0		
9.5	3/8	104.8	75.0		
4.75	#4	2,282.8	40.8	2.7	2.6
Total sample wt. 2,387.6					

Percent flat and elongated particles in:	2.6
Percent flat and elongated particles in Total Rock:	0.6

Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/Elongated Particles	Percent Flat/Elongated Individual Sieve	Percent Flat/Elongated Weighted Average
mm	inches				
Rock Size					
50.0	2				
37.5	1 1/2				
25.0	1				
19.0	3/4				
12.5	1/2				
9.5	3/8				
4.75	#4				
Total sample wt.					

Percent flat and elongated particles in:	
Percent flat and elongated particles in Total Rock:	1.4
Combined Percent Flat and Elongated Particles for Total Rock:	1

Comments

Rounded:

Figure 3B

Sample ID 2203604
File No.

Gyratory Aggregate Worksheet

DOT-69
3-19

PROJECT PH 0066(00)15

COUNTY Aurora, Ziebach

PCN B015

Field No. QC03

Date Sampled 03/12/2019

Date Tested 03/12/2019

Sampled By Tester, One

Tested By Tester, One

Checked By Tester, Two

Material Type AGGREGATE COMPOSITE

Source Jones Pit

Lot No. 1 Sublot No. 3

Weight Ticket Number or Station # 49627 Sta. 625+25 Lt

Lift 1 of 1

% moist. = (wet wt. 8616.4 - dry wt.) / dry wt. x 100 = 3.9

Original Dry Sample Wt. (.1g) 8,289.9

Sieve Size	Retained (0.1g)	%total ret.(0.1%)	%pass. (0.1%)	%pass. (rounded)	Spec Req.				
100 4									
75 3									
62.5 2 1/2						Sand Equiv. Test	Sand Rdg.	Clay Rdg.	S.E.
50 2						Reading #1	3.10	6.60	47
37.5 1 1/2						Reading #2	3.10	6.50	48
31.5 1 1/4						Sand Equivalent Tests Results			48
25 1	0.0	0.0	100.0	100		Fine Aggregate Angularity Test Results			41.8
19 3/4	0.0	0.0	100.0	100	100 - 100				41.0 - 100.0
16 5/8	7.3	0.1	99.9	100		Flat and Elongated Particles Test Results			1.1
12.5 1/2	501.4	6.0	93.9	94	89 - 100				-
9.5 3/8	890.3	10.7	83.2	83	79 - 93				
6.25 1/4	990.4	11.9	71.3	71					
4.75 #4	787.3	9.5	61.8	62					
Pan	5116.7	61.7				wt. before washing(0.1g)			709.30
Total	8293.4					wt. after washing(0.1g)			707.10
+ #4 Graduation Check:						loss from washing			2.2
within 0.3% of orig dry wt.						% - #200			0.31

Sieve Size	Retained (0.1g)	%total ret.(0.1%)	%total x %pass. #4	%pass. (0.1%)	%pass. (rounded)	Spec Req.	
3.35 6							+ #4 % Particles less than 1.95 SP. GR.
2.36 8	187.7	29.8	18.4	43.4	43	41 - 51	Specific gravity of solution (1.95 ± 0.01) 1.95
2.00 10							wt. of lightweight particles (0.1 g) 16.4
1.70 12							weight of + #4 material (0.1 g) 1516.9
1.18 16	137.2	21.8	13.5	29.9	30		% lightweight particles 1.1
0.850 20							SPECIFICATION 0.0 - 3.0
0.600 30	112.0	17.8	11.0	18.9	19		- #4 % Particles less than 1.95 SP. GR.
0.425 40	54.3	8.6	5.3	13.6	14		Specific gravity of solution (1.95 ± 0.01) 1.95
0.300 50	42.7	6.8	4.2	9.4	9		wt. of lightweight particles (0.1 g) 3.1
0.180 80							weight of - #4 material (0.1 g) 342.9
0.150 100	35.0	5.6	3.5	5.9	6		% lightweight particles 0.9
0.075 200	10.5	1.7	1.1	4.8	4.8	2.9 - 6.9	SPECIFICATION 0.0 - 3.0
Pan dry	4.8	49.2	4.8				wt before washing (0.1g) 629.8
Pan wash	44.40	7.8					wt after washing (0.1g) 585.4
Total	628.60						loss from washing(-#200) 44.4
Coarse 0.31	% x % Retain/Design	38.20	=	0.12			- #4 Graduation check:
Fine 7.81	% x % Retain/Design	61.80	=	4.83			within 0.3% of the wt before washing
	Total/Combined - #200			5.0			0.2
Crushed Particles Test							weight of crushed particles 651.7
							weight of total + #4 sample 729.3
							percent of crushed particles 89
							SPECIFICATION 2 or more FF, min 100 - 100
Osch Nat Fines	0.00	Na. Rock	31.00	Natural Fines	25.00		
Natural Sand	0.00	Natural Sand	0.00	Osch Nat Fines	16.00		
Cr.Fines	28.00						

Figure 4

Weight of measure and glass plate		327.1
Weight of measure, glass plate & water		426.8
M = net mass of water		99.7
Water Temperature / Density	77 F	997.03
V = volume of cylinder, mL		

Dry - #4 bulk specific gravity (Gsb)	2.563		
Volume of cylinder, mL(V)	100.0		
Weight of cylinder, g (A)	183.0		
Wt of cylinder + aggregate, g (B)	332.5	332.2	
Wt. aggregate, g (F=B-A)	149.5	149.2	Average
Uncompacted voids, (nearest 0.1%) $U = ((V - (F/Gsb)) / V) \times 100$	41.7	41.8	41.8

Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/ Elongated Particles	Percent Flat/ Elongated Individual Sieve	Percent Flat/ Elongated Weighted Average
50.0					
37.5					
25.0					
19.0					
12.5	508.7	475.3	1.8	0.4	0.1
9.5	890.3	237.4	0.5	0.2	0.1
4.75	1777.7	63.7	1.0	1.6	0.9

Total sample wt.	3176.7
Percent flat and elongated particles in the total sample (weighted average)	1.1
Specifications	rounded 1 0.0 - 10.0

Comments 12" sieves used

Figure 4A