Method of Test for Flat & Elongated Particles

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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 or 3:1.

2. Apparatus:

2.1 Proportional caliper device that is equipped with a 5:1 (5 to 1) ratio setting and/or 3:1 (3 to 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 (a) in column “Total sample weight on sieve”. 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 1 ½ " sieve
Passing the 1 ½ " sieve and retained on the 1" sieve
Passing the 1" sieve and retained on the 3/4" sieve
Passing the 3/4" sieve and retained on the 1/2" sieve
Passing the 1/2" sieve and retained on the 3/8" sieve
Passing the 3/8" sieve and retained on the #4 sieve

NOTE: If there are not 100 pieces retained on the sieves, 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 (b) and record in column "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 F&E particles for each sieve sample to the nearest 0.1 gram and record in (c) (Weight of flat/elongated particles) on the form. 16

3.8 Calculate the percent of F&E Individual Sieve and the percent F&E Weighted Average to the nearest 0.1 percent by using the following equations.

Equations: F&E – Flat and Elongated

Record the total sample weight on each sieve group (a)
Add up the total sample weight and write that in the (d) box
Record the total weight of tested portion (100 pieces) (b)
Record the total weight of the F&E particles (Determined by caliper) (c)

$$\text{\% F\&E individual sieve} = \frac{\text{Weight of F\&E particles (c) x 100}}{\text{Weight of tested portion (100 particles) (b)}}$$

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$$\text{\% F\&E weight weight avg.} = \frac{\text{Weight of F\&E particles (c) x 100}}{\text{Weight of tested portion (100 particles) (b)}} \times \frac{\text{Total sample weight on sieve a)}}{\text{Total sample weight}}$$

% F&E particles is the sum of the & F&E weighted average column (e)

	a	b	c	(c/b)*100	((c/b)*(a/d))*100
Sieve Size	Total Sample Weight on Sieve	Weight of Tested Portion (100 pieces)	Weight of Flat/Elong 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"	0.0				
3/4" to 1/2"	244.4	244.0	0.0	0.0	0.0
1/2" to 3/8"	522.7	238.2	3.0	1.3	0.3
3/8 to #4	1216.8	75.6	2.1	2.8	1.7
Total Sample wt.	1983.9	d			

Percent flat and elongated particles	e	2.0
in the total sample (weighted average)	rounded	2

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. 16

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

ASTM D4791
SD 202
DOT-3 Coarse
DOT-68
DOT-69 16

Sample ID 2224661 **Sieve Analysis and P.I. Worksheet** DOT - 3 (Coarse)

File No. 9-14

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Charge to (If not above project)

Field No. 09 Date Sampled 04/01/2016 12:00 am Date Tested 04/01/2016 12:00 am

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

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

Original Dry Sample Wt. (0.1g) 10312.3

Sieve Size mm	Sieve Size in	F.M. *	Retained (.1g)	% total ret.(0.1%)	% pass. (0.1%)	% pass. (rounded)	Spec Req.
100	4						
75	3						
62.5	2 1/2						
50	2						
37.5	1 1/2		0.0	0.0	100.0	**100**	**100-100**
31.5	1 1/4						
25	1		0.0	0.0	100.0	**100**	**95-100**
19	3/4		1431.6	13.9	86.1	**86**	
16	5/8		2964.8	28.8	57.3	**57**	
12.5	1/2		1853.9	18.0	39.3	**39**	**25-60**
9.5	3/8	*	2095.4	20.3	19.0	**19**	
6.25	1/4						
4.75	#4	*	1798.4	17.4	1.6	**2**	**0-10**
Pan							
Total							

Dust Chk.	
wt. before washing(0.1g)	
wt. after washing (0.1g)	
loss from washing	
% - #200	

+ #4 Gradation Check:
within 0.3% of original dry wt.

Sieve Size mm	Sieve Size in	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	2					
37.5	1 1/2					
25.0	1					
19.0	3/4	1431.6	1431.6	0.9	0.1	0.0
12.5	1/2	4818.7	809.3	6.7	0.8	0.4
9.5	3/8	2095.4	228.5	4.6	2.0	0.4
4.75	#4	1798.4	96.7	0.9	0.9	0.2

Total sample wt. 10144.1

Percent flat and elongated particles in the total sample (weighted average): 1.0; rounded 1

Sieve Size mm	Sieve Size #		retained (0.1g)	% total ret.(0.1%)	% total X % pa.#4(0.1%)	% pass. (0.1%)	% pass. (rounded)	Spec Req.
3.35	6							
2.36	8	*	60.7	0.6		1.0	**1**	**0-5**
2.00	10							
1.70	12							
1.18	16	*						
0.850	20							
0.600	30	*						
0.425	40							
0.300	50	*						
0.180	80							
0.150	100	*						
0.075	200							
PAN	dry		98.4	98.4		wt. before washing (0.1g)	3771.0	
PAN	wash		0.0	1.0		wt. after washing (0.1g)	3728.2	
TOTAL			10303.20			**loss from washing (-#200)**	42.8	

Coarse	1.13%	x % Retain/Design	=
Chip		x % Retain/Design	=
Fine		x % Pass/Design	=
		Total/Combined - #200	

- #4 Gradation check:
within 0.3% of the wt. before washing: 0.1

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

Specific gravity of solution (1.95 ± 0.01)		1.96
wt. of lightweight particles	(0.1 g)	0.1
weight of + #4 material	(0.1 g)	1857.0
% lightweight particles		0.0
SPECIFICATION		0.0-1.0

Crushed Particles Test

weight of crushed particles	
weight of total + #4 sample	
percent of crushed particles	
SPECIFICATION ____ or more FF, min.	

Figure 2

Mix Batch Ticket, lbs./cu. yd.; Total Agg %		
1" rock	1374.00	0.776
Chip	396.00	0.224
		0
		0
Total	1770.0	1.0

Sample Id 2203625 **Sieve Analysis** **DOT - 68**
Mineral Aggregate **Stationary Plant Mix** **9-14**

Test # 04 File Number
PCN/Project B015 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 03/13/2015 12:00 am Sampled By Tester, One
Date Tested 03/13/2015 12:00 am Tested By Tester, One
Checked By Tester, Two

1" rock

Sample Wt. (0.1g) 10312.3

Sieve Size	Retained (0.1g)	% total ret.(0.1%)	% pass. (0.1%)
2			
1 1/2			
1 1/4			
1	0.0	0.0	100.0
3/4	1431.6	13.9	86.1
5/8	2964.8	28.8	57.3
1/2	1853.9	18.0	39.3
3/8	2095.4	20.3	19.0
1/4			
#4	1798.4	17.4	1.6
#8	60.7	0.6	1.0
Pan Dry	98.4		
Pan Wash	0.0		
TOTAL	10303.20		

Gradation Check==> 0.09

wt. before wash 3771.0
wt. after wash 3728.2
loss from wash 42.8
% - #200==> 1.14
Bin adj. - 200==> 0.881

Chip

Sample Wt. (0.1g) 3098.8

Sieve Size	Retained (0.1g)	% total ret.(0.1%)	% pass. (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8	0.0	0.0	100.0
1/2	0.0	0.0	100.0
3/8	104.8	3.4	96.6
1/4	1347.5	43.5	53.1
#4	935.3	30.2	22.9
#8	616.2	19.9	3.0
Pan Dry	90.5		
Pan Wash	0.0		
TOTAL	3094.30		

Gradation Check==> 0.15

wt. before wash 2752.8
wt. after wash 2707.1
loss from wash 45.7
% - #200==> 1.66
Bin adj. - 200==> 0.370

Sample Wt. (0.1g)

Sieve Size	Retained (0.1g)	% total ret.(0.1%)	% pass. (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8			
1/2			
3/8			
1/4			
#4			
#8			
Pan Dry			
Pan Wash			
TOTAL	0.0		

Gradation Check==>

wt. before wash
wt. after wash
loss from wash
% - #200==>
Bin adj. - 200==>

Sample Wt. (0.1g)

Sieve Size	Retained (0.1g)	% total ret.(0.1%)	% pass. (0.1%)
2			
1 1/2			
1 1/4			
1			
3/4			
5/8			
1/2			
3/8			
1/4			
#4			
#8			
Pan Dry			
Pan Wash			
TOTAL	0.0		

Gradation Check==>

wt. before wash
wt. after wash
loss from wash
% - #200==>
Bin adj. - 200==>

Figure 3

mso.mat 9-16

Figure 3a

Composite Coarse Aggregate

Sieve Size	1" rock	Chip			Retained Total	Cumulative % Passing	Spec. 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	22.4	0.0			22.4	66.9	67	
1/2	14.0	0.0			14.0	52.9	53	25-60
3/8	15.8	0.8			16.5	36.4	36	
1/4		9.7			9.7	26.6	27	
# 4	13.5	6.8			20.3	6.4	6	0-10
# 8	0.5	4.5			4.9	1.4	1	0-5
Pan	0.7	0.7			1.4	0.1	0	
Total	77.6	22.4	0.0	0.0	99.9			

Total Combined - 200 ==> 1.25

+ #4 % Particles less than 1.95 Specific Gravity

Specific gravity of solution (1.95 ± 0.01)		.	.	.	.
wt. of lightweight particles	(0.1 g)				
weight of + #4 material	(0.1 g)				
% lightweight particles					
Bin Adj. % lightweight particles					
Composite % lightweight particles					
SPECIFICATION maximum				0.0-1.0	

Coarse	1.25%	x % Retain/Design	58.00	=	0.73
Chip		x % Retain/Design		=	
Fine	1.45%	x % Pass/Design	42.00	=	0.61
04 Referenced		Total/Combined - #200			1.3

Flat and Elongated Particles

	Sieve Size mm	Sieve Size inches	Total Sample Weight on Sieve	Weight of Tested Portion	Weight of Flat/ Elongated Particles	Percent Flat/ Elongated Individual Sieve	Percent Flat/ Elongated Weighted Average
Rock Size	50.0	2					
1"	37.5	1 1/2					
% of Rock	25.0	1					
77.6	19.0	3/4	1431.6	1431.6	0.9	0.1	0.0
	12.5	1/2	4818.7	809.3	6.7	0.8	0.4
	9.5	3/8	2095.4	228.5	4.6	2.0	0.4
	4.75	#4	1798.4	96.7	0.9	0.9	0.2
	Total sample wt.		10144.1				
			Percent flat and elongated particles in: 1"				1.0
			Percent flat and elongated particles in Total Rock:				0.8

Rock Size	50.0	2					
Chip	37.5	1 1/2					
% of Rock	25.0	1					
22.4	19.0	3/4					
	12.5	1/2	0.0	0.0	0.0		
	9.5	3/8	104.8	75.0	0.0	0.0	0.0
	4.75	#4	2282.8	40.8	1.1	2.7	2.6
	Total sample wt.		2387.6				
			Percent flat and elongated particles in: Chip				2.6
			Percent flat and elongated particles in Total Rock:				0.6

Rock Size	50.0	2					
	37.5	1 1/2					
% of Rock	25.0	1					
	19.0	3/4					
	12.5	1/2					
	9.5	3/8					
	4.75	#4					
	Total sample wt.		0.0				
			Percent flat and elongated particles in:				0.0
			Percent flat and elongated particles in Total Rock:				

Combined Percent Flat and Elongated Particles for Total Rock:	**1.4**
Rounded:	1
Spec Max:	10

Figure 3b

Sample ID 2203604 **Gyratory Aggregate Worksheet** **DOT - 69**
File No. **9-14**

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Field No. QC03 Date Sampled 03/12/2015 Date Tested 03/12/2015
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) 8289.9

Sieve Size mm	in	Retained (.1g)	% total ret.(0.1%)	% pass. (0.1%)	% pass. (rounded)	Spec Req.
50	2					
37.5	1 1/2					
31.5	1 1/4					
25	1	0.0	0.0	100.0	**100**	
19	3/4	0.0	0.0	100.0	**100**	**100-100**
16	5/8	7.3	0.1	99.9	**100**	
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			
Total		8293.4				

Sand Equiv. Test	Sand Rdg.	Clay Rdg.	S.E.
Reading #1	3.1	6.6	47
Reading #2	3.1	6.5	48

Sand Equivalent Tests Results	48	42-100
Fine Aggregate Angularity Test Results	41.8	41.0-100.0
Flat and Elongated Particles Test Results	1.1	

Dust Chk.	
wt. before washing(0.1g)	709.30
wt. after washing (0.1g)	707.10
loss from washing	2.2
% - #200	0.31

+ #4 Gradation Check:
within 0.3% of original dry wt. 0.04

Sieve Size mm	#	retained (0.1g)	% total ret.(0.1%)	% total X % pa.#4(0.1%)	% pass. (0.1%)	% pass. (rounded)	Spec Req.
3.35	6						
2.36	8	187.7	29.8	18.4	43.4	**43**	**41-51**
2.00	10						
1.70	12						
1.18	16	137.2	21.8	13.5	29.9	**30**	
0.850	20						
0.600	30	112.0	17.8	11.0	18.9	**19**	
0.425	40	54.3	8.6	5.3	13.6	**14**	
0.300	50	42.7	6.8	4.2	9.4	**9**	
0.180	80						
0.150	100	35.0	5.6	3.5	5.9	**6**	
0.075	200	10.5	1.7	1.1	4.8	**4.8**	**2.9-6.9**
PAN	dry	4.8	49.2	4.8	wt. before washing (0.1g)		629.8
PAN	wash	44.4	7.8		wt. after washing (0.1g)		585.4
TOTAL		628.60			**loss from washing (-#200)**		44.4

+ #4 % Particles less than 1.95 SP. GR.		
Specific gravity of solution (1.95 ± 0.01)		1.95
wt. of lightweight particles	(0.1 g)	16.4
weight of + #4 material	(0.1 g)	1516.9
% lightweight particles		1.1
SPECIFICATION		0.0-3.0

- #4 % Particles less than 1.95 SP. GR.		
Specific gravity of solution (1.95 ± 0.01)		1.95
wt. of lightweight particles	(0.1 g)	3.1
weight of - #4 material	(0.1 g)	342.9
% lightweight particles		0.9
SPECIFICATION		0.0-3.0

Coarse	0.31%	x % Retain/Design	38.20 =	0.12
Chip		x % Retain/Design	=	
Fine	7.81%	x % Pass/Design	61.80 =	4.83
		Total/Combined - #200		5.0

- #4 Gradation check:
within 0.3% of the wt. before washing 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.	65-100

Na. Rock	31.00	Cr.Fines	28.00	Natural Fines	25.00
Osch Nat Fines	16.00	Natural Sand	.00	Ma.Sand	.00
Filler	.00	Cr.Rock	.00	Add Rock	.00

Figure 4

Comments: 12" sieves used

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	77F (25.0C)	997.03
V = volume of cylinder, mL		100.0

Dry - #4 bulk specific gravity (Gsb)	2.563	2.563	
Volume of cylinder, mL (V)	100.0	100.0	
Weight of cylinder, g (A)	183.0	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) x 100	41.7	41.8	41.8

Sieve Size mm	Sieve Size in	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	2					
37.5	1 1/2					
25.0	1					
19.0	3/4					
12.5	1/2	508.7	475.3	1.8	0.4	0.1
9.5	3/8	890.3	237.4	0.5	0.2	0.1
4.75	#4	1777.7	63.7	1.0	1.6	0.9

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

Figure 4a