



Materials sampling and testing methods and documentation procedures prescribed in chapter 8 of the CMM are mobilized into the contract per [standard spec 106.3.4.1](#) and [standard spec 106.3.4.3.1](#).

8.34.1 SAMPLING AND TESTING

Aggregate sampling techniques and minimum sample sizes must be in accordance with the appropriate sample method. Use of larger samples should be considered by the QC staff to increase the probability of obtaining a respective sample. When split samples are required by the provision, the field sample size shown in [CMM 8.50](#) needs to be doubled.

8.34.1.1 Sampling During Production or Post-Production

For the production or post-production sampling required by the provision, the contractor can obtain samples from the finished product conveyor belt or stockpile. Obtaining samples from the belt discharge is acceptable if the full production stream can be obtained with sufficient rapidity and safety.

Selection of random sample locations must be in accordance with the QMP provision.

8.34.1.2 Sampling During Placement

Sampling from the roadbed must be performed according to the provision. Sampling must take place after blading and shaping but before beginning compaction. The intent is to obtain samples as near to the final placement location of the material as possible so as to truly represent the aggregate placed. Sampling from roadbed windrows should only be used when the subgrade is granular and it would not be possible to differentiate the change in material between the crushed aggregate base course and the granular subgrade.

The quantity of materials for roadbed field sampling should be doubled since samples are needed for both quality control and department testing according to special provision requirements of the contract.

8.34.1.3 Sieve Analysis

Sieve analysis testing must follow AASHTO T11 and T27 as modified by WisDOT. This procedure is outlined in [CMM 8.60](#). The sample weights derived from this procedure are minimums. As has been pointed out for field sample sizes, the use of larger samples should be given careful consideration by the QC staff to increase the probability of obtaining a representative sample.

Test data and calculation results should be recorded on a copy of department form [DT1348](#), Sieve Analysis for Mixture of Fine and Coarse Aggregates. For consistency throughout the testing operations it is preferred the test mass be made in units of grams. [Figure 1](#) is an example of a completed test data sheet for a typical sample of aggregate base course material.

SIEVE ANALYSIS FOR MIXTURE OF FINE AND COARSE AGGREGATES

DT1348 2/2006

Wisconsin Department of Transportation

| Project Information | | | | | | Project 1001-01-00 | | | | | | | | |
|--|-----------------|------------|------------|---|------------|---|--------------------------------|---|--|--|--|----------------|--|--|
| Deposit Identification | | | | | | Contract H | | | County Rock | | | | | |
| <input checked="" type="checkbox"/> Crushed Stone <input type="checkbox"/> Crushed Gravel <input type="checkbox"/> Blend | | | | | | <input checked="" type="checkbox"/> Base Course <input type="checkbox"/> Other | | | <input type="checkbox"/> 3/4 inch <input checked="" type="checkbox"/> 1 - 1/4 inches <input type="checkbox"/> 3 inches <input type="checkbox"/> Open Graded <input type="checkbox"/> Other | | | | | |
| | | | | | | Contractor and/or Producer Brewers Stone | | | Sample No. 10T | | | | | |
| | | | | | | Sampled at 120 + 00, Top, 9' RT | | | Date 5/28/09 | | | | | |
| | | | | | | Materials Accepted at | | | Time 3:20 pm | | | | | |
| MOISTURE CONTENT | | | | | | Weight of Total Sample (dry, unwashed) 6513 | | | | | | | | |
| Weight of Sample (moist) 6788G | | | | | | Weight of R4.75 mm (No. 4) dry, unwashed 3879 = 0.596 (A) | | | | | | | | |
| Weight of Sample (dry) 6513G | | | | | | Weight of P4.75 mm (No. 4) dry, unwashed 2634 = 0.404 (B) | | | | | | | | |
| Moisture Loss 275G | | | | | | | | | | | | | | |
| % Moisture 4.2% | | | | | | | | | | | | | | |
| R-4.75 mm (R-4) MATERIAL | | | | P-4.75 mm (P-4) MATERIAL | | | TOTAL MATERIALS (% Passing) | | | | | | | |
| | | | | Wt. = 674 (Min. 500 g) | | | | | | | | | | |
| Sieve | Weight Retained | % Retained | % Pass (C) | Weight Retained | % Retained | % Pass (D) | 4.75 mm (R-4) (A)(C) | 4.75 mm (P-4) (B)(D) | Washed Results | | | Spec | | |
| 75mm (3") | 0 | 0 | 100 | 0 | 0 | 100 | 59.6 | 40.4 | 100 | | | | | |
| 37.5mm (1-1/2") | 0 | 0 | 100 | 0 | 0 | 100 | 59.6 | 40.4 | 100 | | | | | |
| 32.5mm (1 1/4") | 98 | 2.5 | 97.5 | 0 | 0 | 100 | 58.1 | 40.4 | 98.5 | | | 95-100 | | |
| 25 mm (1") | 153 | 3.9 | 96.1 | 0 | 0 | 100 | 57.2 | 40.4 | 97.6 | | | | | |
| 19 mm (3/4") | 1101 | 28.3 | 71.7 | 0 | 0 | 100 | 42.7 | 40.4 | 83.1 | | | 70-93 | | |
| 12.5 mm (1/2") | 1798 | 46.3 | 53.7 | 0 | 0 | 100 | 32.0 | 40.4 | 72.6 | | | | | |
| 9.5 mm (3/8") | 2471 | 64.2 | 35.8 | 0 | 0 | 100 | 21.3 | 40.4 | 61.7 | | | 42-80 | | |
| 4.75 mm (No. 4) | 3738 | 96.4 | 3.6 | 0 | 0 | 100 | 2.1 | 40.4 | 42.5 | | | 25-63 | | |
| 2 mm (No. 10) | 3796 | 97.9 | 2.1 | 233 | 34.6 | 65.4 | 1.3 | 26.4 | 27.7 | | | 16-48 | | |
| 425 µm (No. 40) | 3800 | 98.0 | 2.0 | 415 | 61.6 | 38.4 | 1.2 | 15.5 | 16.7 | | | 8-28 | | |
| 75 µm (No. 200) | 3813 | 98.3 | 1.7 | 531 | 78.8 | 21.2 | 1.0 | 8.6 | 9.6 | | | 2-12 | | |
| In pan | 19 | | | | | | | | | | | | | |
| R-4.75 mm (R-4) FRACTURE COUNT | | | | PLASTICITY CHECK | | | | Mass/m ³ (Weight/c.y.) = _____ | | | | | | |
| Fracture Particles 30.2 | | | | Can 425 µm (P-40) be rolled into 3.2 mm (1/8") thread when moist? | | | | | | | | | | |
| Questionable Particles | | | | <input type="checkbox"/> Yes <input type="checkbox"/> No | | | | | | | | | | |
| Total particles 413 | | | | | | | | | | | | | | |
| % Fracture 73 | | | | | | | | | | | | | | |
| NOTE: If test does not meet contract requirement notify Project Engineer and indicate the action taken. | | | | | | | | | | | | | | |
| Sampled by Gormon Thomas | | | | | | Date 5/28/09 | | | Tested by Paul Molitor | | | Date 6/1/09 | | |

Figure 1: Example Sieve Analysis for Mixture of Fine and Coarse Aggregates, Form DT1348

Form [WS3015](#), Running Average Calculations, is a generic sheet that may be used to calculate running average values for the aggregate gradation sieve fractions. [WS3017](#). Aggregate Gradation Control Charts, may be reproduced for plotting aggregate sieve fractions.

Gradation of aggregate should be expressed in percent passing sieve sizes. Separate charts must be kept for 2", 1-1/2", 1", 3/4", 1/2", 3/8", #4, #8, #10, #16, #30, #40 #50, #100 and #200 (50mm, 37.5mm, 25mm, 19mm, 12.5mm, 9.5mm, 4.75mm, 2.36mm, 2.00mm, 1.18mm, 600µm, 425µm, 300µm, 150µm and 75µm). Control charts for only the sieve sizes specified by the applicable specification need to be produced.

8.34.1.4 Atterberg Limits

Record Atterberg Limits test results on [WS3050](#) Atterberg Limits Worksheet.

8.34.1.5 Fractured Particle Count

Fractured particle testing must be according to [CMM 8.60](#). The QC tester should complete the test form by making the required calculation. Fractured particle test results must be plotted on a control chart. The tester may use [WS3019](#) Base Aggregate Fractured Particle Control Chart, for reproduction as needed.

8.34.2 DEPARTMENT TESTING

Verification and independent assurance sampling and testing will be performed by the department or a department representative as described in the provision.

8.34.2.1 Verification Testing

Verification testing will be performed by an HTCP certified department representative on random samples collected independently of the contractor's samples. Testing of the material will be conducted in a separate laboratory and with separate equipment from the contractor's tests.

8.34.2.2 Independent Assurance Review

Independent assurance reviews will be conducted by a department representative in accordance with the provision and the department's Independent Assurance Program. These reviews will be made of the contractor's quality control and the department's verification sampling and testing equipment and personnel.

8.34.3 DISPUTE RESOLUTION

Dispute resolution will be conducted according to the provision. The split samples of the material collected for QC testing can be used to help resolve conflicts. The use of these samples will be as agreed to by the contractor and the department.

8.34.4 AGGREGATE FOR CONCRETE PAVEMENT

8.34.4.1 Sampling

Obtain aggregates using field sample sizes according to [CMM 8.50](#). The use of larger samples should be considered by the QC staff to increase the probability of obtaining a respective sample.

For the aggregate sampling required by the provision, the contractor can obtain samples from the finished product conveyor belt, holding bins, or stockpile. Obtaining samples from the belt discharge is excellent if the full production stream can be obtained with sufficient rapidity and safety.

Selection of random sample locations must be in accordance with the QMP provision.

8.34.4.2 Testing

8.34.4.2.1 Aggregate Sieve Analysis

The methods and frequencies for aggregate gradation sampling and testing must be according to the QMP provision.

The QMP provision allows for a portion of the gradation testing of coarse aggregates to be performed with an unwashed method. The procedures for unwashed (dry) sieve analysis are identical to those for washed (wet) sieve analysis except for references to washing operations. The processes for washed or unwashed sieve analysis testing must follow AASHTO T 11 and AASHTO T 27 as modified by WisDOT. Be aware that it is necessary to grade (sieve) all individual samples of both fine and coarse aggregates through the coarse and fine sieve series. Test data must be recorded on a copy of [WS5015](#) Sieve Analysis for Concrete Aggregate, as shown in [Figure 2](#).

The sieve analysis test data sheet, and all subsequent use of the data should clearly indicate whether washed or unwashed testing was used. The tester must refer to [CMM 8.60](#) for instructions to determine whether dry sieving is acceptable or if wet sieving is required. While the QMP special provisions specify only every 10th sample of coarse aggregate is to be subjected to a washed analysis, the intention is that a dry analysis should be used only if it will provide reliable data. If, when comparing test results, sieve analysis comparisons are marginal or P/200 is above the warning limit, a washed sieve analysis must be performed on each sample until results by washed sieving meet the criteria.

8.34.4.2.2 Fineness Modulus

The fineness modulus of fine aggregate is required to be calculated by the special provision and is intended to be for information only. Fineness modulus must be calculated for the fine aggregate as outlined below. Data and

calculations should be recorded on a copy of [WS5015 Sieve Analysis for Concrete Aggregate](#), as shown in [Figure 2](#). Fineness modulus is determined by adding the total percentages of material by weight retained on sieve Nos. 4, 8, 16, 30, 50 and 100 then dividing by 100, as shown in the following example.

| WS5015 SIEVE ANALYSIS FOR CONCRETE AGGREGATE | | | | | | |
|--|----------|--|--|---|-------------------------------|--|
| PROJECT DESCRIPTION | | | | SAMPLE INFORMATION | | |
| Project ID. | Contract | | | Material Source | | |
| Highway | County | | | Material (Type, Grade, Etc.) <i>Fine, Conc. Agg.</i> | | |
| Description | | | | Sampled By: | | |
| Contractor | | | | Date Sampled <i>5/11/08</i> | Time <i>10:00 am</i> | |
| | | | | Tonnage of Sampling <i>5000</i> | Sample No. <i>311-02-F</i> | |

MOISTURE CONTENT: Percent Moisture = $\frac{W_s - D_w}{D_w - T} (100) = \frac{(730 - 705)}{(705 - 215)} (100) = 5.1\%$

T = Weight of Container
Ww = Weight of Container + Wet Sample Weight
Dw = Weight of Container + Dry Sample Weight

SIEVE ANALYSIS: Dry, Unwashed Total Sample

Washed: _____ Unwashed: Weight, gms: *515*

Fine: Coarse #1: _____ Coarse #2: _____

| | Wt. Ret'd, gms. | % Ret'd | % Pass | Fine | C.A. #1 | C.A. #2 |
|------------------|--------------------|-------------|--------------|---------------|---------|---------|
| SIEVE | | | | | | |
| 2" (50 mm) | | | | | | |
| 1 1/2" (37.5 mm) | | | | | | |
| 1" (25 mm) | | | | | | |
| 3/4" (19 mm) | | | | | | |
| 3/8" (9.5 mm) | <i>0</i> | <i>0.0</i> | <i>100.0</i> | <i>100</i> | | |
| #4 (4.75 mm) | <i>15</i> | <i>2.9</i> | <i>97.1</i> | <i>90-100</i> | | |
| #8 (2.36 mm) | <i>97</i> | <i>18.8</i> | <i>81.2</i> | | | |
| #16 (1.16 mm) | <i>218</i> | <i>42.3</i> | <i>57.7</i> | <i>45-80</i> | | |
| #30 (0.6 mm) | <i>308</i> | <i>59.8</i> | <i>40.2</i> | | | |
| #50 (0.3 mm) | <i>423</i> | <i>82.1</i> | <i>17.9</i> | <i>10-30</i> | | |
| #100 (0.15 mm) | <i>498</i> | <i>96.7</i> | <i>3.3</i> | <i>2-10</i> | | |
| #200 (0.075 mm) | <i>510</i> | <i>99.0</i> | <i>1.0</i> | <i>0-1.5</i> | | |
| Wt in Pan = | <i>5</i> | | | | | |

FINENESS MODULUS (Fine Aggregate):

Fineness Modulus = $\frac{\sum \text{total \% Ret'd on: \#4, \#8, \#16, \#30, \#50, \#100}}{100}$

= $(\underline{3} + \underline{19} + \underline{42} + \underline{60} + \underline{82} + \underline{97}) / 100 = \underline{3.03}$

Remarks:

Figure 2: Sieve Analysis for Concrete Aggregate

Example 1

| Sieve No. | Spec. Percent Passing | Sample Percent Passing | Sample Percent Retained |
|-------------|-----------------------|------------------------|-------------------------|
| 4 (4.75mm) | 90-100 | 98 | 2 |
| 8 (2.36mm) | | 80 | 20 |
| 16 (1.18mm) | 45-80 | 60 | 40 |
| 30 (600µm) | | 32 | 68 |
| 50 (300µm) | 10-30 | 20 | 80 |
| 100 (150µm) | 2-10 | 8 | 92 |
| | | Total = | 302 |

Fineness Modulus = $302/100 = 3.02$

8.34.4.3 Corrective Action

Corrective action must be implemented according to the provision.

8.34.4.4 Department Testing

Quality verification and independent assurance sampling and testing will be performed by the department or a department representative as described in the provision. Sampling and testing will be performed by a certified technician.

8.34.4.4.1 Verification Testing

Verification testing will be performed by an HTCP certified department representative on samples collected independently of the contractor's samples. Testing of the material will be conducted in a separate laboratory and with separate equipment from the contractor's tests.

With this provision, the contractor has two options for when the department's quality verification testing will be performed on the aggregate for concrete pavement.

1. For option 1:

Quality Verification testing is performed at the time of production.

2. For option 2:

Quality Verification testing is performed at the time the aggregate is being used or relocated.

Regardless of which option is used, the contractor is responsible for the product after it has been sampled, tested and accepted. Minimal segregation, contamination, and degradation must occur with relocation of the material. The engineer may require additional sampling and testing at the concrete plant site and use a statistically based Pooled T-Test to evaluate whether the quality of the material has been maintained. Follow procedure for the Pooled T-Test.

8.34.4.4.2 Independent Assurance Review

Independent assurance reviews will be conducted by a department representative in accordance with the provision and the department's Independent Assurance Program. These reviews will be made of the contractor's Quality Control and the department's verification sampling and testing equipment and personnel.

8.34.4.4.3 Dispute Resolution

Dispute resolution must be conducted according to the provision.

APPENDIX A

POOLED t-TEST PROCEDURE

POOLED t-test

The pooled t-test is a statistically based procedure to evaluate the variability in the mean (average) of test results between 2 sets of data. When QMP, Aggregate for Concrete Pavement is specified and the contractor chooses option 1, in the special provision, the contractor's test results tabulated from the sieve analysis for gradation may be evaluated and compared to the engineer's test results of the relocated aggregate, if the aggregate is relocated. This procedure will only apply to those contracts where the aggregate is produced at one location then moved to a new location. This procedure is a tool that may be used to compare the test results mean of the original stockpile (contractor's data) to the test results mean of the relocated stockpile (engineer's data). A failed comparison between the original aggregate and the relocated aggregate may be the result of segregation, contamination, or degradation that occurred in the relocation/re-stockpiling process. The engineer will make the final determination on the quality of the material.

On the following pages a step-by-step procedure illustrates how to compute the F statistic, which you will then compare to the CRITICAL VALUES FOR F DISTRIBUTION (F critical table provided). If the F critical is greater than the F statistic you computed you are sure with a 99 percent confidence level that the relocated stockpile is the same as the original stockpile.

NOTE: The minimum number of tests required on the relocated stockpile is 5 tests or 20 percent, which ever is greater, of the tests taken on the original stockpile. Therefore, if 77 tests are taken on the original stockpile you need to take at least 15 tests on the relocated stockpile.

A sample calculation of the F statistic is provided and a comparison is made to the F critical. In the example provided, the pooled t-test confirms that the stockpiles are the same.

POOLED t-TEST PROCEDURE (One-Way Analysis of Variance)

1.) Calculate Average Test Results (A) for each stockpile:

$$A_1 = \Sigma \sigma_1 / n_1 \qquad A_2 = \Sigma \sigma_2 / n_2$$

σ : the individual test result

n : the number of tests performed on that stockpile

1 : original stockpile

2 : moved stockpile

2.) Calculate the Grand Mean (T) for Pooled Data:

$$T = (\Sigma \sigma_1 + \Sigma \sigma_2) / (n_1 + n_2)$$

3.) Calculate the Treatments Sum of Squares (SST):

$$SST = n_1 ((A_1 - T)^2) + n_2 ((A_2 - T)^2)$$

4.) Calculate the Error Sum of Squares (SSE):

$$SSE = \sum_{1}^{n_1} (\sigma_1 - A_1)^2 + \sum_{2}^{n_2} (\sigma_2 - A_2)^2$$

5.) Calculate the Treatments Mean Square (MST) & Error Mean Square (MSE):

$$MST = SST / 1$$

$$MSE = SSE / ((n_1 - 1) + (n_2 - 1))$$

6.) Calculate the F-Statistic (F):

$$F = MST / MSE$$

7.) Determine the Critical F-Statistic (F critical):

Look this value up in a F Distribution Table using 1% probability values

Numerator Degrees of Freedom = 1

Denominator Degrees of Freedom = $(n_1 - 1) + (n_2 - 1)$

8.) Compare F-Statistics:

If $F < F$ critical then the stockpiles are the same

If $F > F$ critical then the stockpiles are not the same

CRITICAL VALUES FOR F DISTRIBUTION
(1% Probability Values & 1 Degree of Freedom)

| Degrees of Freedom for Denominator | F critical |
|------------------------------------|------------|
| 1 | 40.52 |
| 2 | 98.49 |
| 3 | 34.12 |
| 4 | 21.20 |
| 5 | 16.26 |
| 6 | 13.74 |
| 7 | 12.25 |
| 8 | 11.26 |
| 9 | 10.56 |
| 10 | 10.04 |
| 11 | 9.65 |
| 12 | 9.33 |
| 13 | 9.07 |
| 14 | 8.86 |
| 15 | 8.68 |
| 16 | 8.53 |
| 17 | 8.40 |
| 18 | 8.28 |
| 19 | 8.18 |
| 20 | 8.10 |
| 21 | 8.02 |
| 22 | 7.94 |
| 23 | 7.88 |
| 24 | 7.82 |
| 25 | 7.77 |
| 26 | 7.72 |
| 27 | 7.68 |
| 28 | 7.64 |
| 29 | 7.60 |
| 30 | 7.56 |
| 32 | 7.50 |
| 34 | 7.44 |
| 36 | 7.39 |
| 38 | 7.35 |
| 40 | 7.31 |
| 42 | 7.27 |
| 44 | 7.24 |

| | |
|-----|------|
| 46 | 7.21 |
| 48 | 7.19 |
| 50 | 7.17 |
| 55 | 7.12 |
| 60 | 7.08 |
| 65 | 7.04 |
| 70 | 7.01 |
| 80 | 6.95 |
| 100 | 6.90 |

EXAMPLE: POOLED T-TEST CALCULATION

$$1. \quad A_1 = (60+58+52+59+56+64+65+51+61+57+59+62+60+64+63) / 15 = \mathbf{59.33}$$

$$A_2 = (54+63+58+51+49) / 5 = \mathbf{55.00}$$

$$2. \quad T = (60+58+52+59+56+63+65+51+61+57+59+62+60+64+63+54+63+58+51+49) / (15+5) = \mathbf{58.25}$$

$$3. \quad SST = 5 ((55.00 - 58.25)^2) + 15 ((59.33 - 58.25)^2) = \mathbf{70.31}$$

$$4. \quad SSE = 233.35 + 126 = \mathbf{359.35}$$

| | |
|----------------------|--------------------------------------|
| $60 - 59.33 = 0.67$ | $(0.67)^2 = 0.45$ |
| $58 - 59.33 = -1.33$ | $(-1.33)^2 = 1.77$ |
| $52 - 59.33 = -7.33$ | $(-7.33)^2 = 53.73$ |
| $59 - 59.33 = -0.33$ | $(-0.33)^2 = 0.11$ |
| $56 - 59.33 = -3.33$ | $(-3.33)^2 = 11.09$ |
| $63 - 59.33 = 3.67$ | $(3.67)^2 = 13.47$ |
| $65 - 59.33 = 5.67$ | $(5.67)^2 = 32.15$ |
| $51 - 59.33 = -8.33$ | $(-8.33)^2 = 69.39$ |
| $61 - 59.33 = 1.67$ | $(1.67)^2 = 2.79$ |
| $57 - 59.33 = -2.33$ | $(-2.33)^2 = 5.43$ |
| $59 - 59.33 = -0.33$ | $(-0.33)^2 = 0.11$ |
| $62 - 59.33 = 2.67$ | $(2.67)^2 = 7.13$ |
| $60 - 59.33 = 0.67$ | $(0.67)^2 = 0.45$ |
| $64 - 59.33 = 4.67$ | $(4.67)^2 = 21.81$ |
| $63 - 59.33 = 3.67$ | <u>$(3.67)^2 = 13.47$</u> |
| | Total = 233.35 |

| | |
|----------------|---------------------------------|
| $54 - 55 = -1$ | $(-1)^2 = 1$ |
| $63 - 55 = 8$ | $(8)^2 = 64$ |
| $58 - 55 = 3$ | $(3)^2 = 9$ |
| $51 - 55 = -4$ | $(-4)^2 = 16$ |
| $49 - 55 = -6$ | <u>$(-6)^2 = 36$</u> |

$$\mathbf{Total = 126}$$

$$5. \quad MST = 70.31 / 1 = \mathbf{70.31}$$

$$MSE = 359.35 / ((15 - 1) + (5 - 1)) = \mathbf{19.96}$$

$$6. \quad F \text{ Statistic} = 70.31 / 19.96 = \mathbf{3.52}$$

$$7. \quad F \text{ Critical} = \mathbf{8.28}$$
 (DF = 18 for denominator)

$$8. \quad F \text{ Statistic} = 3.52 < F \text{ Critical} = 8.28$$

Stockpiles are the same.