# 834 QMP - Aggregate

## 834.1 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 representative sample. When split samples are required, the field sample size shown in 850 needs to be doubled.

### 834.1.1 Sampling During Production or Before Placement

For contract-required production or before-placement sampling, 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.

Production samples are taken during aggregate crushing and stockpile operations and can only be conducted or witnessed by HTCP certified QC personal. Individual QMP provisions may allow for optional production testing as an alternative to in-place, stockpile or loadout samples before the beginning of a project. If production test results are submitted, documentation of random sampling must be provided.

Stockpile samples are taken after the contract is awarded, before placement and test results can be used for multiple projects within the QMP provision's specified timeframe. After aggregate placement begins, no additional stockpile samples are required for that project. Taking additional stockpile tests may be advisable depending on project circumstances. If a project is suspended and the aggregate source continues to be used on other non WisDOT projects or new material is added to the stockpile, taking a stockpile sample is advisable before resuming placement. If a project is suspended for over six months, taking an additional stockpile sample is advisable before resuming placement. Multiple stockpile tests for the same project and source are not required.

All sampling of aggregate used for acceptance testing must be random. If, for any reason, a random location will not be reached, a new random location within the partial lot may be required. Refer to standard spec 700 for partial lot sampling requirements. To prevent missing any quality control tests, the engineer should establish clear instructions for quality control sampling of partial lots as early as possible in the project; ideally at the preconstruction meeting. Instructions should be agreed upon by the engineer and contractor before any partial sublot sampling occurs.

### 834.1.2 Sampling During Placement

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.

### 834.1.3 Sieve Analysis

Sieve analysis testing must follow AASHTO T11 and T27 as modified by WisDOT. This procedure is outlined in 860. The sample weights derived from this procedure are minimums. As has been pointed out for field sample sizes, using 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 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 834-1 is an example of a completed test data sheet for a typical sample of aggregate base course material.

**FIGURE 834-1 Example Sieve Analysis for Mixture of Fine and Coarse Aggregates, DT1348**

**SIEVE ANALYSIS FOR MIXTURE OF FINE AND COARSE AGGREGATES**

Wisconsin Department of Transportation

DT1348 2/2006

| | | | | | |
|---|---|---|---|---|---|
| Project Information | | | Project 1001-01-00 | | |
| | | | H | Contract | County Rock |
| Deposit Identification | | | Contractor and/or Producer Brewers Stone | | Sample No. 10T |
| ☒ Crushed Stone ☐ Crushed Gravel ☐ Blend | ☒ Base Course ☐ Other | ☐ 3/4 inch ☒ 1 – 1/4 inches ☐ 3 inches ☐ Open Graded ☐ Other | Sampled at 120 + 00, Top, 9' RT | | Date 5/28/09 |
| | | | Materials Accepted at | | Time 3:20 pm |

MOISTURE CONTENT

| | |
|---|---|
| Weight of Sample (moist) | 6788G |
| Weight of Sample (dry) | 6513G |
| Moisture Loss | 275G |
| % Moisture | 4.2% |

Weight of Total Sample (dry, unwashed) 6513

Weight of R4.75 mm (No. 4) dry, unwashed 3879 = 0. 596 (A)

Weight of P4.75 mm (No. 4) dry, unwashed 2634 = 0. 404 (B)

| | R-4.75 mm (R-4) MATERIAL | | | P-4.75 mm (P-4) MATERIAL Wt. = 674 (Min. 500 g) | | | TOTAL MATERIALS (% Passing) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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

| | |
|---|---|
| Fracture Particles | 30.2 |
| Questionable Particles | |
| Total particles | 413 |
| % Fracture | 73 |

PLASTICITY CHECK

Can 425 µm (P-40) be rolled into 3.2 mm (1/8") thread when moist? ☐ Yes ☐ No

Mass/$m^3$ (Weight/c.y.) = _____

**NOTE:** If test does not meet contract requirement notify Project Engineer and indicate the action taken.

| Sampled by | Date | Tested by | Date |
|---|---|---|---|
| Gormon Thomas | 5/28/09 | Paul Molitor | 6/1/09 |

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.

### 834.1.4 Atterberg Limits

Record Atterberg Limits test results.

### 834.1.5 Fractured Particle Count

Fractured particle testing must be according to 860. The QC tester should make the required calculation. Fractured particle test results must be plotted on a control chart.

## 834.2 Department Testing

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

### 834.2.1 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.

### 834.2.2 Independent Assurance Review

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

## 834.3 Dispute Resolution

Split samples of the material collected for QC testing can be used to help resolve conflicts. Using these samples will be as agreed to by the contractor and the department.

## 834.4 Aggregate for Concrete Pavement

### 834.4.1 Sampling

Obtain aggregates using field sample sizes according to 850. Using larger samples should be considered by the QC staff to increase the probability of obtaining a respective sample.

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.

### 834.4.2 Aggregate Sieve Analysis

The QMP specifications allow 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 T11 and AASHTO T27 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.

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 860 for instructions to determine whether dry sieving is acceptable or if wet sieving is required. While the QMP specifications require only every 10th sample of coarse aggregate to be washed, 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.

### 834.4.3 Department Testing

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

#### 834.4.3.1 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.

**FIGURE 834-3 Pooled t-Test Procedure**

**(One-Way Analysis of Variance)**

The pooled t-test is a statistical procedure to evaluate the variability in the mean 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 only applies 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.

A step-by-step procedure illustrates how to compute the F statistic, which you will then compare to the tabulated critical values for the F distribution. If the F critical is greater than the computed F statistic, the relocated stockpile is the same as the original stockpile at a 99 percent confidence level.

Note: The minimum number of tests required on the relocated stockpile is 5 tests or 20 percent, whichever 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.

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

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

$\sigma$: 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. $A_1$ = (60+58+52+59+56+64+65+51+61+57+59+62+60+64+63) /15 = **59.33**
   $A_2$ = (54+63+58+51+49) /5 = **55.00**
2. T = (60+58+52+59+56+63+65+51+61+57+59+62+60+64+63+54+63+58+51+49) / (15+5) = **58.25**
3. SST = 5 ((55.00 - 58.25)$^2$ ) + 15 ((59.33 - 58.25)$^2$ ) = **70.31**
4. SSE = 233.35 + 126 = **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 | $(3.67)^2$ = 13.47 |
| | 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 | (-6)2 = 36 |
| | Total = 126 |

5. MST = 70.31/ 1 = **70.31**
   MSE = 359.35 / ( (15 - 1) + (5 - 1) ) = **19.96**
6. F Statistic = 70.31 / 19.96 = **3.52**
7. F Critical = **8.28** (DF = 18 for denominator)
8. F Statistic = 3.52 < F Critical = 8.28
   **Conclusion: Stockpiles are the same.**

### 834.4.3.2 Independent Assurance Review

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