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Author(s)	Zhiyong Jiang, P.Eng. and Carole Anne MacDonald, P.Geo.
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Abstract	MTO Soils and Aggregates Section, conducts an annual proficiency sample testing program with aggregates and soils for participating laboratories to evaluate their performance. The laboratories are asked to perform different tests on pairs of samples that have been prepared and randomized by MTO. MTO starts delivery of the samples to the laboratories in early May, and requires submission of results in July. A preliminary report issued late July allows the laboratories to improve their testing system. In 2019, two hundred and thirty participants from the private and public sectors submitted results for the program. Sixty-eight laboratories reported results for all consensus property tests. Same as observed in the last three years, the 2019 multi-laboratory variations in a majority of the tests show improvements over the MTO, ASTM, AASHTO or CSA precision estimates. However, strong biases remain in some aggregate tests, two of the Superpave tests and two of the six soil tests in 2019. The sieve analysis results demonstrate that the sample preparation method can produce nearly identical samples cost effectively. We expect that the mandatory quality system implemented by the Canadian Council of Independent Laboratories (CCIL) and their inspection process will improve multi-laboratory variations.
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Aggregate and Soil Proficiency Sample Testing Program for 2019

by

Zhiyong Jiang and Carole Anne MacDonald

2022

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Executive Summary

The Soils and Aggregates Section of the Engineering Materials Office conducts an annual inter-laboratory proficiency sample testing program for aggregate and soil materials as a means for the Ministry of Transportation (MTO) to evaluate the competency of laboratories providing testing services in direct support of provincial highway construction and maintenance activities. The program also allows participants to evaluate their individual performance relative to other laboratories within the province. Test results are also used by the [Canadian Council of Independent Laboratories \(CCIL\)](#) for the independent certification of laboratories in Ontario.

Participation is mandatory for laboratories conducting quality assurance (QA) and referee testing for MTO contracts, as well as for laboratories conducting compliance testing for MTO CASL (Concrete Aggregate Source List) program, and for Engineering Service Providers providing or seeking to provide Prime Consultant services. Laboratories that perform quality control (QC) testing for contractors and materials suppliers participate voluntarily.

Each laboratory is asked to perform physical property and performance related tests, including Superpave aggregate tests, on randomly selected pairs of up to 6 different materials prepared by the Soils and Aggregates Section laboratories. Samples are delivered to the participating laboratories in May, who are required to prepare, test and report their results to MTO by early July. An initial statistical analysis of the data was conducted by Soils and Aggregates staff and a preliminary report was issued at the end of July. This portion of the program is intended to give feedback to the participants while they are still operational during the current construction season and allows them to correct any problems that may exist with their testing system. A final report, including ratings for each laboratory, was issued after a full statistical analysis of the data has been completed.

Proficiency test samples were shipped to two hundred and thirty-six private and public sector laboratories who requested participation in 2019. Two hundred and thirty of the laboratories submitted test results. Of these, one hundred and twenty-five were Quality Control (QC) laboratories operated by aggregate producers and road building contractors. The remaining laboratories were operated by engineering testing consultants and owners. Laboratory tests were conducted in accordance with MTO, AASHTO, ASTM or CSA laboratory test standards.

Results of the aggregate and soil tests from the 2019 program are found to be consistent with the results from previous years and, in a majority of the tests, the multi-laboratory variations show noticeable improvements over the precision estimates published by MTO, AASHTO, ASTM or CSA.

1. Introduction

This is the final report of the 2019 Aggregate and Soil Proficiency Sample Testing Program organized by the Ontario Ministry of Transportation for aggregate and soil test methods. The results of the petrographic analysis (LS-609 and LS-616) of this program will be discussed in a separate EMO report (MacDonald, 2022). This program is a means for participating laboratories to examine their testing processes and performance in relation to others. The information is also used by the ministry to establish criteria for selection of laboratories for quality assurance (QA) and referee testing for MTO contracts. Test results are also used by the Canadian Council of Independent Laboratories (CCIL) for the independent certification of laboratories in Ontario and allow the ministry to monitor the quality of those laboratories providing testing services to the government. Participation in this program became mandatory in 1998 for laboratories to qualify for ministry work.

The design of the proficiency sample testing program is based on procedures for determining the precision and variability of test methods. Interested readers should refer to ASTM C670, C802, E177, and E178 for further information on inter-laboratory testing programs (American Society for Testing and Materials).

In the spring of 2019, proficiency test samples were distributed to two hundred and thirty-six Ontario and Quebec laboratories from the private and public sectors. A total of two hundred and thirty participants reported results, including sixty-eight laboratories that reported results for all 4 tests related to Superpave aggregate consensus properties. Participants in the testing program included both public (MTO Downsview laboratory, municipality laboratories) and private sector laboratories (contractors, aggregate producers, and engineering consultants). A preliminary report was issued to the participants at the end of July.

Laboratories conducted tests in accordance with MTO Laboratory Standards (MTO Laboratory Manual), AASHTO, ASTM standards or CSA (where applicable). By request, each laboratory selects those test methods that they wish to participate in. A minimum number of tests are required by CCIL, depending on the type of laboratory certification required.

Coarse aggregate tests include material passing the 75 μm sieve by washing (LS-601), sieve analysis (LS-602), Los Angeles impact and abrasion loss (LS-603, ASTM C131), relative density and absorption (LS-604), sulphate soundness loss (LS-606, ASTM C88), percent crushed particles (LS-607), percent flat and elongated particles (LS-608), petrographic analysis (LS-609), unconfined freeze-thaw loss (LS-614), micro-Deval abrasion loss (LS-618), percent asphalt coated particles (LS-621), standard proctor (LS-706) and granular permeability (LS-709).

Fine aggregate tests include sieve analysis (LS-602), relative density and absorption (LS-605), insoluble residue (LS-613), petrographic analysis (LS-616), micro-Deval abrasion (LS-619).

Aggregate reactivity tests include alkali carbonate reactivity (LS-615), accelerated mortar bar expansion (LS-620) and concrete prism test (CSA A23.2-14A).

Soil tests include particle size analysis (LS-702), Atterberg limits (LS-703/4, ASTM D4318) and relative density (LS-705), consolidation properties of soils (ASTM D2435), direct shear test of soils (ASTM D3080), hydraulic conductivity of saturated soils (ASTM D5084).

Superpave consensus property aggregate tests include uncompacted void content of fine aggregate (LS-629, AASHTO T304), sand equivalent value of fine aggregate (ASTM D2419), percent fractured particles in coarse aggregate (ASTM D5821), and percent flat particles, elongated particles, or flat and elongated particles in coarse aggregate (ASTM D4791).

Reports to individual laboratories contain ratings for each test method that are based on the standardized deviate for that test, i.e., ratings range from ± 5 for data within 1.0 standard deviation of the mean to a rating of 0 for data 3.0 or more standard deviations from the mean. Ratings of each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

Particularly, the following tests show improvements over the precision estimates published by MTO, AASHTO, ASTM or CSA: wash pass 75 μm , relative density and absorption of coarse and fine aggregates, magnesium sulphate soundness of coarse aggregate, percent flat and elongated particles of coarse aggregate, asphalt coated particles, insoluble residue of carbonate aggregates, accelerated mortar bar test and concrete prism test. Although the precision of most of the aggregate test methods compares favourably in relation to the results of previous studies and the precision estimates where available, strong laboratory biases remain in the following test methods: Los Angeles abrasion loss, insoluble residue test, freeze-thaw test, granular permeability, and accelerated mortar bar.

The variations in the test of specific gravity of soils show improvement and are lower than the values reported in AASHTO T100. The clay supplied in 2019 has a low plasticity, the variations obtained for all three index tests in 2019 may not be comparable to the values reported in 2018 where a clay of high plasticity was used. A strong laboratory bias remains in the test of specific gravity of soils. There is no precision statement for consolidation properties of soils and direct shear test of soils. The multi-laboratory variations of hydraulic conductivity of saturated soils show

noticeable improvements over the precision estimates published by ASTM D5084. However, the precision estimates in ASTM D5084 may not be typical of the reconstituted soil specimens that were used in the 2019 testing program.

The results of Superpave consensus property tests from the 2019 program also compare favourably with the past performance of the laboratories. The multi-laboratory variations of the following tests show noticeable improvements over the values reported in the past three years and the precision estimates published by ASTM: sand equivalent value of fine aggregate and percent of fractured particles. A strong laboratory bias still remains in the following test: sand equivalent value of fine aggregate and percent flat and elongated particles.

The computer program that was developed by MTO to handle the computation and presentation of test data has two statistical methods to detect outlying observations or outliers in a set of data, namely the Critical Value Method recommended in Section 4 of ASTM E178 and the Iterative (Jack-knife) Technique recommended by Manchester (Manchester, 1979). For details of the program, refer to the User's Manual (MERO-013) by Vasavithasan and Rutter, 2004. A number of statistical methods are available to test the hypothesis that the suspect observations are not outliers. MTO often follows the Critical Value Method to remove outliers. However, the Jack-knife method is used where the strict application of the Critical Value method tends to include extraneous results that may not stand the best chance of representing the testing performed in conformance with each of the test methods. The Critical Value method and iterative techniques are based on two different statistical approaches. As a result, the confidence intervals yielded by these two methods differ widely depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data. In the case of Iterative Technique, test results that fall beyond 2.8 times the standard deviation from the mean may be identified as outliers depending on the number of observations and distribution of data.

The critical value used in this study is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. The critical values provided in ASTM E178, Table 1 are limited to 147 observations, even though 230 laboratories participated in the 2019 program. The critical values used for this study were calculated at a five percent significance level (Grubbs' test) based on Grubbs' (1969 and 1972) recommendations for identifying outliers.

2. Test Results

2.1 Table of Test Results

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Table 1 in Appendix B. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

- Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.
- Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.
- Columns 4 and 5 show the mean (average) test value for each sample after removal of outliers and/or invalid test results from the data set for all laboratories performing the test.
- Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\bar{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized Deviate} = \frac{X_i - \bar{X}}{s}$$

If the test result is less than the mean, the standardized deviate is negative and, if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

- Rating 5 - data within 1.0 standard deviation of the mean.
- Rating 4 - data within 1.5 standard deviations of the mean.
- Rating 3 - data within 2.0 standard deviations of the mean.
- Rating 2 - data within 2.5 standard deviations of the mean.

- Rating 1 - data within 3.0 standard deviations of the mean.
- Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data, or may be the result of gross deviation from the prescribed experimental procedure, calculation errors, or errors in reporting data. The outlier criteria employed for exclusion of test results from the analysis will depend on the distribution of data and the number of participants in a test. The iterative technique is one of the methods employed in this study for the selection of outliers, and is used where the strict application of critical value method tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test, for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier, but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure, e.g., sieve analysis, should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

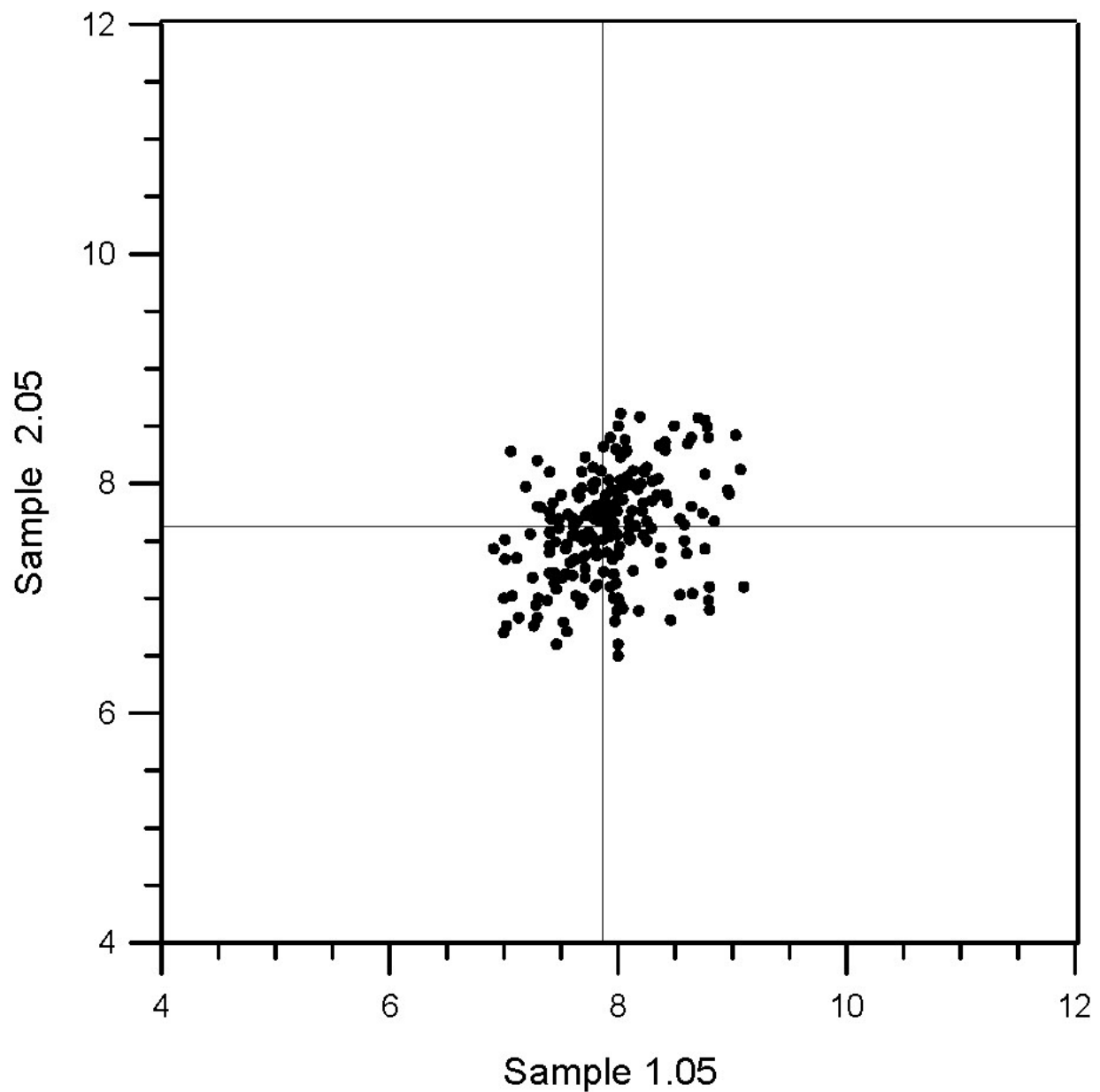
2.2 Scatter Diagrams

Youden scatter diagrams are supplied with this report (see Appendix H and Appendix I). A laboratory can locate itself on the diagrams by plotting its test value for the first

sample (1.19) on the horizontal axis, against its test value for the second sample (2.19) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot outside the boundaries of the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median, and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal crosshairs on the plots represent the mean values for all the valid results on the first sample (1.19) and the second sample (2.19), respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the departure from a circular distribution of points towards a linear (elliptical) distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 through Figure 4 below gives examples of scatter diagrams.

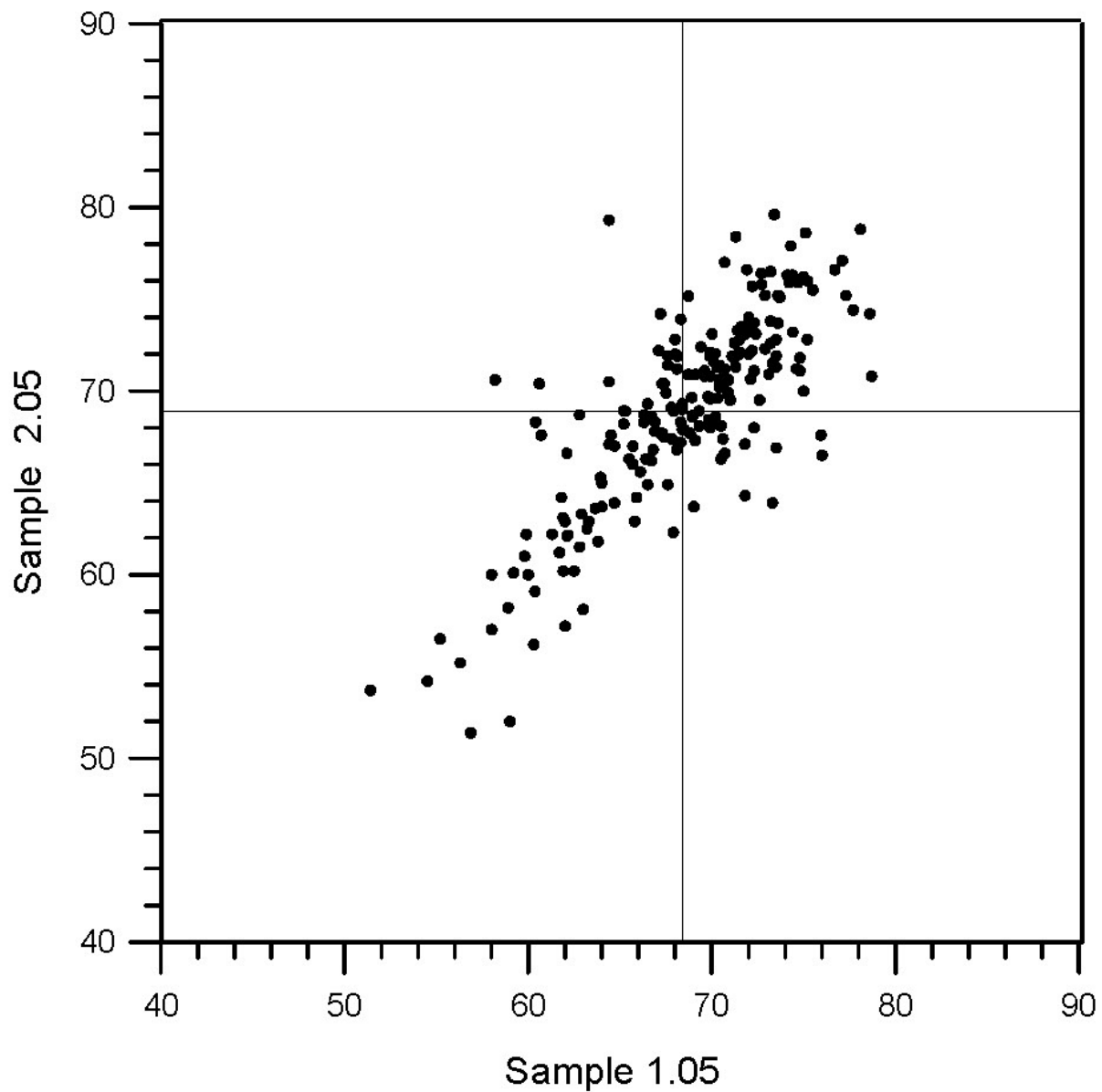


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.930	7.630
Median	7.800	7.500
Std Dev	0.460	0.470
n = 203		

Labs Eliminated: 447, 497, 452, 518

Figure 1. Scatter Diagram for a Test Showing Random Variation with Little Laboratory Bias.

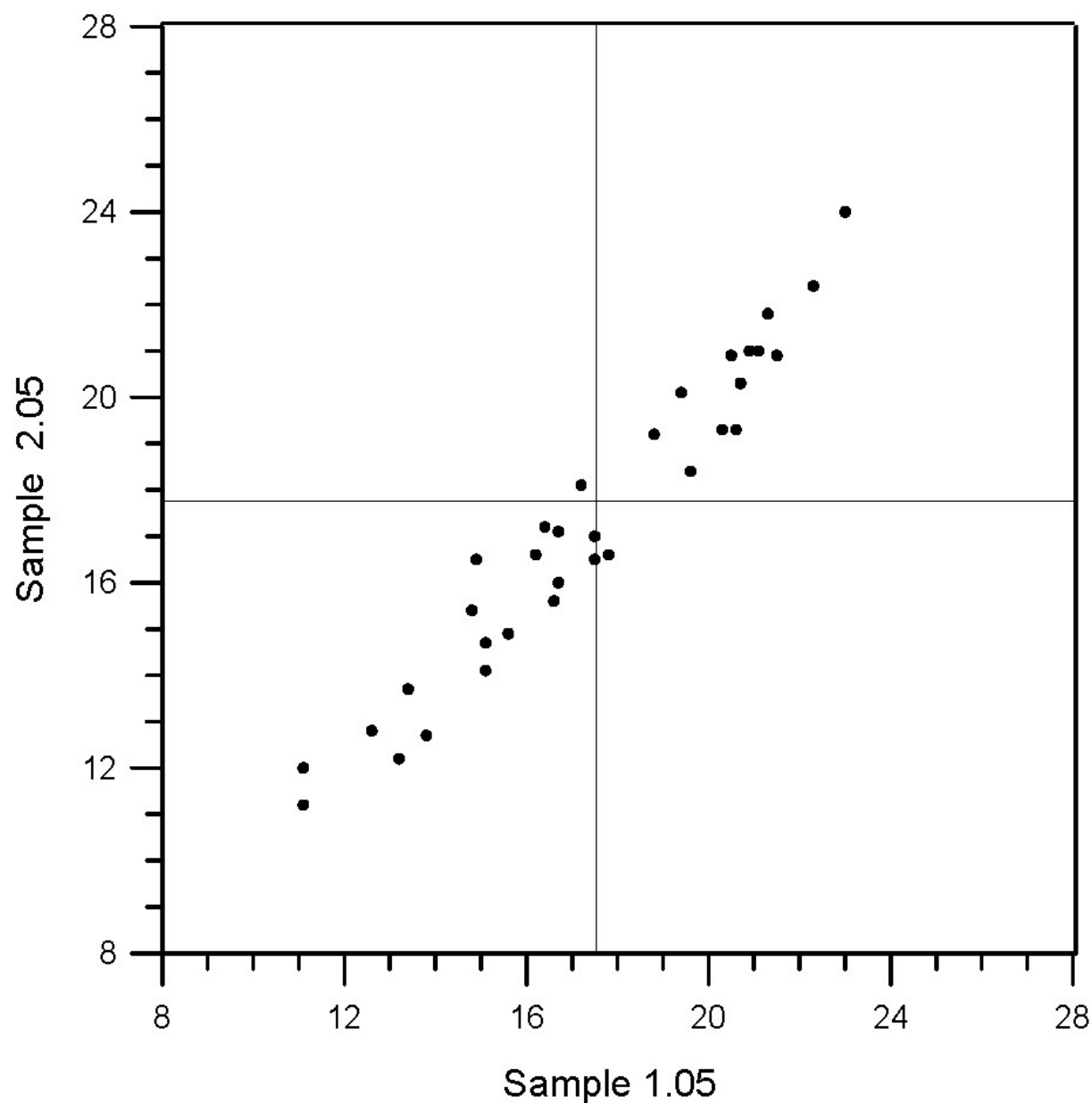


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	68.491	68.905
Median	68.300	64.500
Std Dev	5.054	5.402
n = 201		

Labs Eliminated: 345, 350, 436, 480

Figure 2. Scatter Diagram for a Test Showing a Combination of Random Variation and Laboratory Bias for some Laboratories.

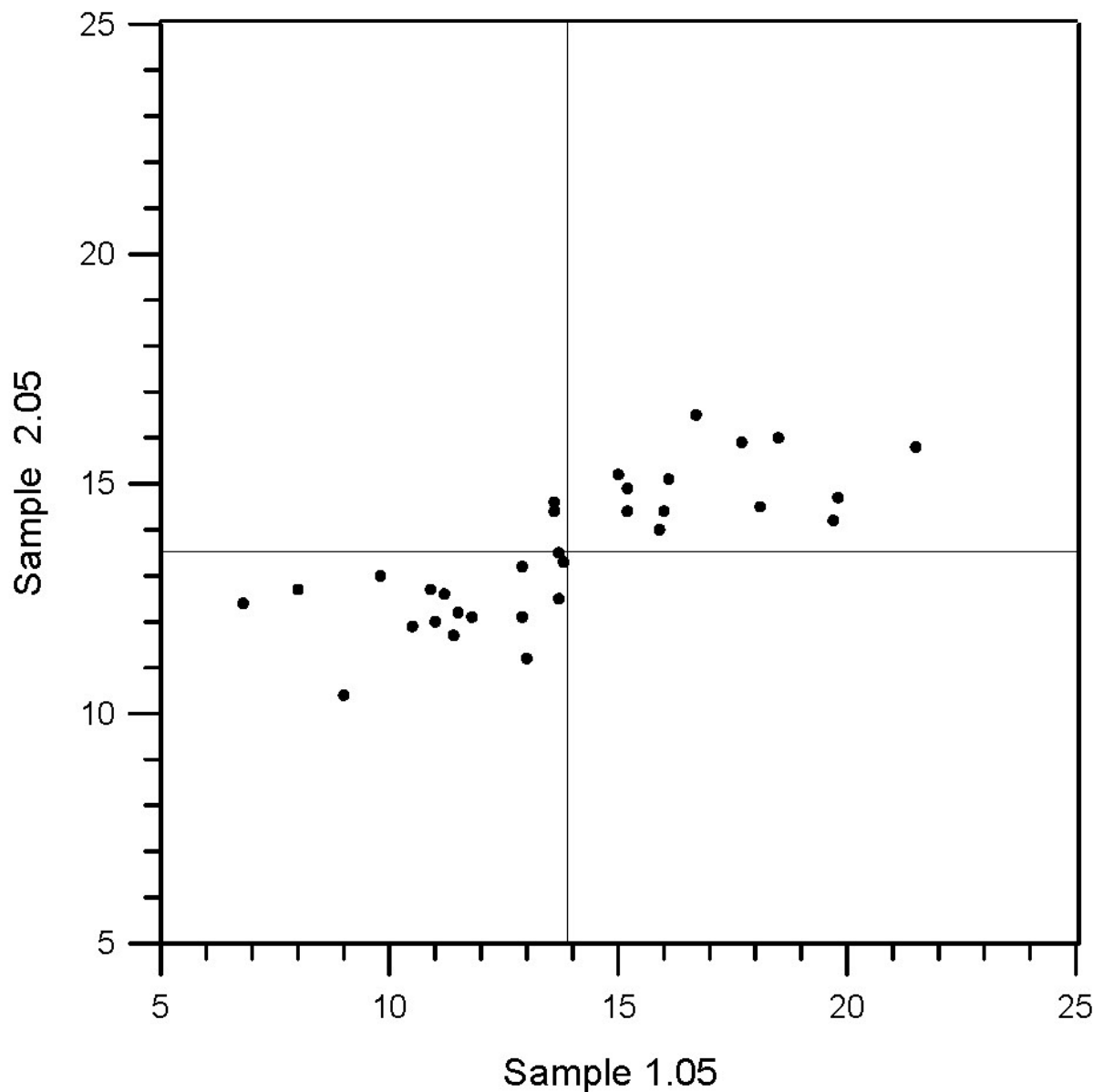


Test 29: MgSO₄ Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.370	17.258
Median	15.800	15.600
Std Dev	3.276	3.325
n = 32		

Lab Eliminated: None

Figure 3. Scatter Diagram for a Test Showing Pronounced Between-Laboratory Bias and Equal Variation for each Material.



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.890	13.570
Median	12.900	13.600
Std Dev	3.533	1.541
n = 31		

Lab Eliminated: None

Figure 4. Scatter Diagram for a Test with Pronounced Between-Laboratory Bias but Unequal Variation for each Material.

2.3 Outliers

In dealing with suspected outlying observations or 'outliers', the purpose is to remove those observations that do not belong to the sample population and provide the statistical criteria for doing so. For most cases, ASTM E178 states: "the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected". The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution, or universe.

This study follows the criteria recommended for single samples in Section 4 of ASTM E178 for rejecting the doubtful observations at the ninety-five percent confidence level. The Critical Value method is based on the assumption of normality, and the critical values are calculated using Student's T distribution. The assumption in this method is that all of the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n , for that observation, n , in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected. A revised mean and standard deviation are calculated after deleting the outlier. Ratings for the laboratories are determined based on the revised mean, standard deviation, and standardized deviate.

In some cases, the strict application of the Critical Value method tends to include laboratories in the population that report extraneous results. These results may not represent testing performed in conformance with the test method. In those cases, the application of the Iterative Technique (Manchester) is used. The Constant C in the Iterative Technique is computed using Fisher's F distribution and depends on the number of participating laboratories in a particular test. In this technique, an outlying observation is rejected based on a statistical criterion, but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the Iterative Technique, after screening test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and the test result farthest from the mean by a unit of Cs (standard deviation, s , multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of Critical Value method.

Four of the test methods included in this proficiency sample testing program require reporting of control sample results to demonstrate that the testing process of the laboratory is in control. The laboratories that have calculation errors or report control sample results outside the range of values established for the material are identified during the screening of test results for any errors or deviations. These laboratories are manually removed from the data set during the analysis and considered as outliers.

3. Discussion

The following discussion contains general and test-specific comments for the 2019 test period. Detailed discussion of petrographic analysis results (LS-609 and LS-616) will be covered in a separate report. Where ASTM, AASHTO or MTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 Material Sources

Materials used in this test period were as follows:

- Granular A (OPSS 1010) from Heidelberg Pit, St. Jacobs (MTO MAIDB No. C12-038). Coarse and fine aggregate tests, including Sieve Analysis, Percent Flat and Elongated Particles, Moisture Density Relationship, Micro-Deval Abrasion Loss, Relative Density and Absorption, Freeze-Thaw Loss, Uncompacted Void Content, Sand Equivalent Value, and Percent Fractured Particles and Percent Flat, Elongated, or Flat and Elongated Particles.
- Coarse Aggregate also from Heidelberg Pit, St. Jacobs (MTO MAIDB No. C12-038). Coarse aggregate tests, including Wash Pass 75 µm sieve, Percent Crushed Particles (coarse), Relative Density and Absorption, Magnesium Sulphate Soundness Loss (coarse), and Los Angeles Abrasion Loss.
- Coarse aggregate from a carbonate quarry in the Kingston, Ontario area. Accelerated Mortar Bar Test Material M1, Potential Alkali-Carbonate Reactivity of Carbonate Rocks by Chemical Composition, Acid Insoluble Residue of Aggregates, Fine Aggregate Petrographic Analysis (pre-crushed for participants).
- Coarse Aggregate from a gravel deposit located northeast of Sudbury. Accelerated Mortar Bar Test Material M2.
- Coarse aggregate from a carbonate quarry in the Kingston, Ontario area with fine aggregate from a quarry on the Niagara Escarpment. Combination used for the 2019 (1-year test duration) CSA A23.2-14A Potential expansivity of aggregates (procedure for length change due to alkali-aggregate reaction in concrete prisms at 38°C).
- Soil from Waterford Law quarry (MTO MAIDB No. W03-002).

3.2 Sample Preparation

The material processed for the coarse and fine aggregate tests conforms approximately to the gradation requirements of OPSS Granular A. Bulk samples were prepared by MTO using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory, i.e., see Figures 2 and 3 in (Lane & Rogers, 2000). The use of a spinning riffler ensures that, as far as possible, each sample is identical to every other sample. It has been found that this is a good technique for minimizing sample bias.

A bobcat loader was used to move aggregates from the stockpile to a hopper/bin which fed material onto a conveyor belt to fill 33 sample bags (fitted with funnels) on a spinning turntable. About 25 revolutions of the turntable were required to fill each bag with 30 ± 1 kg of material (underweight or overweight bags are rejected). In total, eight hundred and four ~30 kg samples of Granular A were prepared for the coarse and fine aggregate tests. The samples were individually randomized in 402 pairs for distribution to participating laboratories across Canada. Each participant was responsible for the preparation of their own fine aggregate samples (3.18 and 4.18) from the pair of Granular A samples supplied.

In addition to the Granular A samples, a coarse aggregate with approximately 99% material retained on 4.75 mm sieve was also supplied. The turntable required about 25 revolutions for this material to fill each sample bag to approximately 30 ± 1 kg. In total, eight hundred and four ~30 kg samples were prepared and randomized in pairs for distribution to participating laboratories.

Soil material was air-dried and mechanically broken down and passed through a 4.75 mm sieve to remove oversized particles. The passed 4.75 mm material was then processed to pass through a 2.0 mm sieve using a Fritsch Soil Mill Pulveriser and placed in 20 kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter capable of filling 24 identical 2 kg containers per run. This method was used to create uniform 500 g proficiency test samples that were then randomized in pairs for distribution to participating laboratories.

M1 material for Accelerated Mortar Bar Test was mechanically crushed to pass through a 4.75 mm sieve and placed in 25 kg pans. The material in each pan was mixed thoroughly. Individual scoops were collected from each pan to fill the hopper of the small spinning riffle splitter. This method was used to create uniform ~5 kg samples that were then randomized in pairs for distribution to participating laboratories. M2 material for Accelerated Mortar Bar Test was a coarse aggregate with approximately 97% material retained on 4.75 mm sieve. M2 material was sampled from a stockpile and split

to create proficiency test samples (10 kg to 11 kg per bag) that were then randomized in pairs for distribution to participating laboratories.

The material evaluated by Concrete Prism Test was a coarse aggregate with approximately 90% material retained on 4.75 mm sieve. Each of the coarse aggregate proficiency test sample was graded into 3 fractions (P19 mm/R13.2 mm, P13.2 mm/R9.5 mm, and P9.5 mm/R4.75 mm) by splitting and sieving. Each fraction weighed 9 kg to 10 kg. The coarse aggregate samples (each containing the 3 fractions) were then randomized in pairs for distribution to participating laboratories.

3.3 Notes on Individual Tests

For each test, comments have been made pertaining to the variation illustrated by the associated scatter diagrams shown in Appendix H and Appendix I. The technique used to test for outliers is stated and where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in Appendix F and Appendix G. Along with the comparison made to MTO, ASTM, AASHTO or CSA precision statements, comparison of the variation between previous test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasized that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test normally exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 Proficiency Sample Tests

3.4.1 LS-601 - Wash Pass 75 μ m (Coarse Aggregate) – Test No. 1

Two hundred and twenty-seven laboratories reported results for this test in 2019. Nineteen outliers were identified and rejected using the iterative technique. The standard deviations of 0.09 for both samples obtained in 2019 are lower than the values in past three years. The standard deviations in 2019 are also lower than the multi-laboratory variation of 0.20 published in the MTO Test Method LS-601 for aggregates with less than 2.5% material passing the 75 μ m sieve and the variation of 0.22

published by ASTM C 117 for aggregates with 1.5% of material finer than the 75 μ m sieve. The mean value of the aggregate used in 2019 consisted of approximately 0.46% material finer than 75 μ m, which is in line with the values for which the ASTM and MTO precision statements were established. Further, the coefficient of variation of 19.6% obtained in 2019 is slightly higher than the values reported in the past three years. The scatter diagram provided in the Appendix H shows a random variation with little laboratory bias. The laboratories that are identified as outliers should examine their test procedure more closely, especially the washing procedure and the achievement of constant dry mass at the beginning and end of the test.

3.4.2 LS-602 - Sieve Analysis (Coarse Aggregate) – Test Nos. 2 to 6

These tests represent the coarse aggregate portion of the Granular A sample gradation. Tests 20-25 carried out on the material passing 4.75 mm sieve as prepared by the participants (samples 3.19 and 4.19) represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format as Vogler and Spellenberg.

The Granular A samples 1.19A and 2.19A supplied for the sieve analysis test consisted of approximately 47% of the material retained on 4.75 mm sieve, and conform to the grading of Granular A materials used in the past MTO Aggregate and Soil Proficiency Sample Testing Programs. The gradings reported for Test Nos. 2-6 represent the combined gradings of coarse and fine aggregates. The proficiency test samples were prepared with the large spinning riffler described in Section 3.2.

The standard deviations obtained in 2019 for all of the sieves are found to be in line with or slightly higher than the variations given in the ASTM C 136 precision statements, except for the 9.5 mm sieve that is lower than the corresponding variation in the ASTM C 136.

Two hundred and twenty-nine laboratories reported results for the sieve analysis test in 2019. Outliers were eliminated using the iterative technique. Successive scatter diagrams show a fairly uniform distribution of points about the mean (i.e. a random variation with little laboratory bias). The number of outliers identified varies from sieve to sieve, and ranges from four for the 13.2 mm sieves to a maximum of fifteen for the 4.75 mm sieve.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), sieving sufficiency and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (using ASTM E11 as guides) and your sieve shaker(s) thoroughly. Once satisfied that they are in order, perform a sieving sufficiency test as described in LS-602 to pinpoint any problems.

3.4.3 LS-603 - Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Eleven laboratories reported results for this test in 2019. No outlying laboratory was detected by the use of iterative technique method. Considering the number of observations (11) used, the analysis may not yield any meaningful or representative statistical data. The scatter diagram shows a strong between laboratory bias. The standard deviations obtained in 2019 are higher to the values reported in the past three years.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range of 10% to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, the results from two different laboratories should not differ by more than 12.7%. The mean loss of 25.0% in this test is within the range of values for which ASTM C 131 data was established. This year's coefficient of variation (average 6.9%) is higher than the value of 4.5% in the ASTM precision statements.

3.4.4 LS-604 - Relative Density of Coarse Aggregate – Test No. 9 and Absorption of Coarse Aggregate – Test No. 10

MTO Test Method LS-604 follows the procedures described in ASTM C 127 for the determination of relative density (Test No. 9) and absorption property (Test No. 10) of coarse aggregates. ASTM C 127 provides precision statements only for relative density but does not provide precision estimates for the absorption property. LS-604 provides precision estimates for both relative density and absorption of coarse aggregates with absorption properties less than 2.0%. The precision statements published in LS-604 were established using the data collected for a period of fourteen years, through the MTO Proficiency Sample Testing Program.

One hundred and two laboratories reported results for these tests in 2019. Two laboratories for relative density and four laboratories for absorption were identified as outliers using the iterative technique. The standard deviations of 0.007 obtained for bulk relative density in 2019 are consistent with the values reported in the past three years as well as the precision estimate of 0.006 published in the LS-604. The standard deviations obtained in 2019 are one-half of the value of 0.013 published in ASTM C 127. In the case of absorption test, the standard deviations of 0.091 and 0.086 obtained this year are in line with the precision estimate of 0.09 provided in the LS-604. The coefficient of variation of 6.2% for Test No. 10 obtained in 2019 is lower than the values 6.7% to 7.7% reported in the past three years. The scatter diagram for Test No. 9 shows random variation with little laboratory bias, while for Test No. 10 shows a combination of random variation and laboratory bias for some laboratories.

3.4.5 LS-606 - Magnesium Sulphate Soundness (CA) – Test No. 11

Forty-one laboratories reported results for this test in 2019. Two outliers were identified by the use of iterative technique. The scatter diagram shows a pronounced between laboratory bias. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The average mean loss of 6.8% in this test is significantly lower than the range of values (9% to 20%) for which the ASTM C 88 precision estimate was established. The coefficient of variation of 28.6% obtained in 2019 is lower than the values obtained in the past three years. ASTM reports a multi-laboratory coefficient of variation of 25% for coarse aggregate with percent loss in the range of 9% to 20%.

3.4.6 LS-607 - Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

The coarse aggregate samples supplied in 2019 did not contain adequate amount of material retained on the 19.0 mm sieve. Therefore, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same percent crushed value of the next smaller fraction, i.e., 19.0 mm – 13.2 mm, for the 26.5 mm to 19.0 mm fraction.

This year, two hundred and twenty-seven laboratories submitted results for this test. Participants were asked to compute the percent of each fraction using the gradation test results of the coarse aggregate portion, based on the total mass of material retained on 4.75 mm sieve. And all five fractions of the coarse aggregate sample shall be used in calculation of the weighted average of percent flat and elongated particles, as specified in the instructions. Nine laboratories were selected as outliers by employing the iterative technique. The standard deviations of 4.5 and 4.3 obtained in 2019 are lower than the precision estimate of 4.7 published in the MTO LS-607, although higher than the values reported in 2018. The standard deviations obtained in 2019 are lower than the value of 6.0 obtained during the 1989 MTO workshop. The average mean value of 77.6% in this test is within the range of values (55% to 85%) for which the MTO precision statements were established. The scatter diagram shows a combination of random variation and operator bias for some laboratories. ASTM has a very similar test method (D 5821) and published precision data (standard deviation of 5.2 for a mean percent crushed particles value of 76.0%) obtained from MTO study.

3.4.7 LS-608 - Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the greatest length or width to thickness ratio. The MTO procedure previously measured the ratio of mean length or width to the mean

thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants shall use the latest MTO version of the test method. Flat and elongated particles are defined in the MTO Test Method LS-608 as those pieces whose greatest dimension in the longitudinal axis, compared to the least dimension in a plane perpendicular to the longitudinal axis, exceeds a ratio of 4:1. This test method is similar to that of ASTM D 4791 and uses the same definition, with the exception of ratio, for the flat and elongated particles. In ASTM, the flat and elongated particles are defined as the pieces that exceed a ratio of 3:1 or 5:1. In LS-608, the test sample is separated into a number of fractions and the weighted average of percent flat and elongated particles is calculated using the result of every fraction tested.

The coarse aggregate samples supplied in 2019 did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same percent flat and elongated value of the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for the 26.5 mm to 19.0 mm fraction.

This year, two hundred and twenty-eight laboratories submitted results for this test. Participants in this test were asked to compute the percent of each fraction using the gradation test results of the coarse aggregate portion, based on the total mass of material retained on 4.75 mm sieve. And all five fractions shall be used in calculation of the weighted average of percent flat and elongated particles, as specified in the instructions. Ten laboratories were selected as outliers by employing the iterative technique. LS-608 provides precision estimate for coarse aggregate passing 19.0 mm and retained on 4.75 mm with percent flat and elongated particles ranging from 2.0% to 9.5%. The standard deviations of 1.8 and 2.0 obtained in 2019 are higher than the values reported in the past two years. The multi-laboratory variations obtained in 2019 are lower than the precision estimate of 2.3 published in LS-608. The average mean value of 6.9% in this test is within the range of values (2% to 9.5%) for which the MTO precision statements were established.

ASTM D 4791 is similar to LS-608 for comparison of multi-laboratory precisions obtained. In ASTM, the precision estimates are provided for individual fractions ranging from 19.0 mm to 4.75 mm (19 mm to 12.5 mm, 12.5 mm to 9.5 mm, and 9.5 mm to 4.75 mm), and the estimates are based on the coefficient of variation. A direct comparison of the precision estimates from ASTM is not appropriate with that of the estimates provided in LS-608. The precision estimates published in LS-608 are based on standard deviation, and was estimated from the weighted averages calculated using the results of four fractions ranging from 19.0 mm to 4.75 mm.

The scatter diagram provided in Appendix H shows a combination of random variation and laboratory operator bias for some laboratories. In general, laboratories that obtained a proficiency rating of less than 3 should critically examine their equipment and procedure.

3.4.8 LS-613 - Total Percentage of Insoluble Residue – Test No. 15 and Percentage of Insoluble Residue Retained 75 μ m – Test No. 98

MTO LS-613 is similar to ASTM D3042, insoluble residue in carbonate aggregates, but the scope and procedure to determine the total percentage of insoluble residue and percentage of insoluble residue retained 75 μ m in LS-613 differ from that of ASTM. In addition, mass and the maximum size of the aggregates recommended for the test sample in LS-613 differ from D3042.

Sixteen laboratories reported results for this test. Iterative technique was used to remove outliers from both sets of data, i.e., data for Test Nos. 15 and 98. Four outliers from the data for total percentage of insoluble residue and one outlier from the results for percentage of residue retained 75 μ m were removed. The scatter plots for both tests show pronounced between laboratory bias.

The standard deviations of 0.5 and 0.7 obtained for total percentage of insoluble residue are lower than the values reported in the past three years and are lower than the precision estimate published in ASTM D3042. Based on the findings published in ASTM, the precision or multi-laboratory variation appears to vary with the level of insoluble residue. The lower level of insoluble residue, represented by 4.7% as per D3042, was found to have a multi-laboratory standard deviation limit of 0.9. In the case of percentage of insoluble residue retained 75 μ m, the standard deviations 2.2 and 2.4 obtained are slightly higher than the values reported in the past three years, but are lower than the precision estimate of 3.1 published by ASTM. The data from the MTO proficiency sample testing program may be used to evaluate the future performance of this test method.

3.4.9 LS-618 - Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Eighty-one laboratories reported results for this test. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, all of the laboratories reported control sample result within the established range for the material. Three outliers were rejected using the iterative technique.

The multi-laboratory coefficient of variation of 5.4% published in the LS-618 is for 19.0 mm maximum size aggregate with abrasion losses in the range from 5% to 23%. The mean loss of 11.1 in this year's program is within the range of values for which the precision estimates were established. The average coefficient of variation of 7.5% obtained in 2019 is higher than the value of 5.4% published in LS-618 and the values

reported in the past three years. The scatter plot for this test shows random variation with little laboratory bias.

3.4.10 LS-614 - Freeze-Thaw Loss – Test No. 17

The coarse aggregate samples supplied in 2019 did not contain adequate amount of material retained on the 19.0 mm sieve. Therefore, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same freeze-thaw loss value of the next smaller fraction, i.e., 19.0 mm - 13.2 mm for the 26.5 mm to 19.0 mm fraction that need not be tested.

Fifty-eight laboratories reported results for this test in 2019. Participants in this test were asked to compute the percent of each fraction based on the total mass of material retained on 4.75 mm sieve. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratories to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, Section 9.1). Four outliers were identified using the iterative technique.

The multi-laboratory coefficient of variation of 21.6% published in LS-614 is for coarse aggregate with freeze-thaw losses in the range of 3% to 18%. The average mean loss of 6.34% in this test is within the range (3% to 18%) for which the LS-614 precision estimate was established. The average coefficient of variation of 23.6% obtained in 2019 is higher than the value of 21.6% published in the LS-614, but lower than the values of 25.2% to 36.1% reported in the past three years. The scatter plot for this test shows a strong between laboratory bias.

It is likely that there are two main reasons for the spread of the data for this test: insufficient damage caused by freezing too rapidly or difference in sieving intensity. The laboratories that obtained a proficiency rating of less than 3 should adjust their processes to try and achieve losses closer to the mean loss of the control aggregate. Appendix 1 of LS 614 gives a procedure for determining and adjusting sieving time for quantitative analysis. Each laboratory must establish their sieving time, if the mechanical shaker and diameter of sieves are different from that were used to establish the sieving time provided in the Appendix 1 of LS-614.

3.4.11 LS-602 - Sieve Analysis (Fine Aggregate) – Test Nos. 20-25

The test samples for this procedure were prepared by the participants from the material passing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows the normal testing procedure in which the laboratory prepares its own test samples from the field sample. The scatter diagrams for the fine aggregate sieve

analysis show random variation with little laboratory bias. The standard deviations of the fine sieves in 2019 are in line with the values reported in 2018. For the multi-laboratory variations, the standard deviations obtained in 2019 (0.8 to 2.4) for all the sieves, except 300 μm and 75 μm , are higher than the values published in the ASTM C 136 precision statements. For 300 μm , the average standard deviation of 1.3 is lower than the value of 1.41 published by ASTM. For 75 μm , the average standard deviation of 0.55 is lower than the value of 0.65 published by ASTM.

As in previous inter-laboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained, the more efficient the sieving process and the better the precision. When there is a small amount of material retained on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

The number of outliers identified varies from sieve to sieve, and ranges from nine for 2.36 mm sieve to a maximum of nineteen for the 300 μm sieve. Outlier laboratories with a very low percent passing the 75 μm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing this sieve.

3.4.12 LS-605 - Relative Density of Fine Aggregate – Test No. 27 and Absorption of Fine Aggregate – Test No. 28

Participants in the program were asked to test the samples according to MTO Test Method LS-605. This test method follows ASTM C 128, except that it requires the removal of materials finer than 75 μm from the test specimen by washing. LS-605 requires the test specimens to be prepared in duplicate and washed on the 75 μm sieve until all of the material finer than 75 μm is removed. The presence of material finer than 75 μm in the test specimens can result in lower relative densities and higher absorption values.

In the past, MTO was using the precision estimates published in the ASTM C 128 for both relative density and absorption to compare and evaluate the multi-laboratory variations obtained from the MTO proficiency sample testing program. Considering the difference in preparation of test specimen between the ASTM C 128 and LS-604, use of the multi-laboratory variations published in the ASTM may not be appropriate to evaluate the performance of the participating laboratories. Since 2012, MTO has been using the precision estimates developed from its proficiency sample test data collected over a period of fourteen years. The latest revision of this test method provides precision estimates for both relative density and absorption of fine aggregates with absorption properties less than 2.0%.

Ninety-nine laboratories reported results for these tests in 2019. Twelve outliers for relative density (Test No. 27) and five outliers for absorption (Test No. 28) were selected using the iterative technique. As in previous years, greater variation exists in this test compared to the relative density test on coarse aggregate. It is imperative that differential drying of the various sized particles be avoided by constant stirring of the sample under the air current during the drying process. As short as 30-second periods of rest can be detrimental to the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values.

The standard deviations obtained in 2019 for both relative density (0.009 and 0.010) and absorption (0.148 and 0.148) are in line with the values published in the LS-605 and the values reported in the past three years. As in the previous studies, the multi-laboratory variations obtained in 2019 are significantly lower than that of the values published in the ASTM C 128 precision statements. ASTM publishes a multi-laboratory variation of 0.023 and 0.23 for relative density and absorption, respectively for fine aggregates with absorption properties less than 1.0%. The mean values of 1.225% and 1.213% reported by the laboratories in 2019 are beyond the limit for which the precision estimate was developed. The scatter plots for both tests show a combination of random variation and laboratory bias for some laboratories.

3.4.13 LS-621 - Amount of Asphalt Coated Particles – Test No. 30

Two hundred and twenty-five laboratories reported results for this test in 2019. twenty-one laboratories were identified as outliers using the iterative technique. Scatter diagram provided in the Appendix H shows a random variation with little laboratory bias. LS-621 provides precision estimate for 19.0 mm maximum size coarse aggregate mixed with asphalt coated particles in the range of 25% to 55%. The mean values of 38.4% and 37.2% reported by the laboratories are within the range of values for which the precision estimate was developed. The standard deviations of 2.12 and 2.84 obtained in 2019 are lower than the precision estimate of 3.9 published in the LS-621 and lower than the values reported in the past three years. Laboratories that obtained a proficiency rating of less than 3 should critically evaluate their interpretation of the definition and re-examine their samples. There is no comparable or similar ASTM test procedure.

3.4.14 LS-706 - Moisture-Density Relationship (standard) – Test Nos. 31-33

Since 2016, standard proctor test has been introduced in MTO Aggregate and Soil Proficiency Sample Testing Program to replace one-point proctor test (LS-623). Participants were asked to follow Method C of ASTM D 698 and perform the test on the Granular A samples 1.19P and 2.19P supplied.

One hundred and forty laboratories reported results for this test in 2019. Fifteen outliers for the wet density (Test No. 31), five outliers for the dry density (Test No. 32), and three outliers for optimum moisture (Test No. 33) determinations were rejected using the iterative technique. The standard deviations (0.032 and 0.033) obtained in 2019 for maximum dry density are significantly lower than the precision estimates (1.0 to 1.6) published in D698. The standard deviations for optimum moisture content are consistent with the precision estimates published in D698. However, D698 covers the laboratory compaction characteristics of soils (CH, CL, and ML) and reports precision estimates for maximum dry unit weight in pcf and optimum moisture content from the tests conducted only on soils (CH, CL, and ML). Considering the difference in the materials and reported units in 2019 MTO study, use of the multi-laboratory variations published in the ASTM may not be appropriate to evaluate the performance of the participating laboratories.

The scatter diagrams show a combination of random variation and laboratory bias for some laboratories. This test requires significant operator skill to carefully prepare each subspecimen and adjust the water content to well define the compaction curve. Those laboratories with a proficiency rating lower than 3 should examine their equipment, procedure, and calculation to discover the causes for the variation.

3.4.15 LS-619 - Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants were asked to perform the test on the fine aggregate samples 3.19A and 4.19A supplied. Eighty laboratories reported results for this test in 2019. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. Five outliers were selected by the use of iterative technique.

LS-619 provides precision estimates for fine aggregates with the abrasion loss in the range of 7% to 18%. The coefficient of variation of 7.8% obtained in 2019 is in line with the precision estimate of 7.6% published in LS-619 and lower than the value of 8.4% in 2018. The scatter diagram indicates a combination of random variation and laboratory bias for some laboratories.

3.4.16 LS-620 - Accelerated Mortar Bar – Test No. 123 and Test No. 124

The participants in this test were supplied with aggregate samples 1.19M1, 2.19M1, 1.19M2 and 2.19 M2. Each of the samples in M1 material set contains a representative sample of the fine aggregate that was prepared by MTO using a crusher and a spinning riffler. For M2 material set, the participants were instructed to crush each of the supplied coarse aggregate samples separately to prepare the test samples according to LS-620.

Twenty-one laboratories reported their test results for M1 and nineteen for M2 in 2019. The participants were instructed to test three mortar bars made with each of the aggregate samples supplied. Standard cement was also supplied for the 2019 study.

The participants reported expansion of the individual bars and the average of three bars after 1, 3, 7, 14 days. The average expansions of Test No. 123 and Test No. 124 after 14 days were shown on the scatter diagram in the Appendix H.

No outlier was identified for Test No. 123 using the iterative technique. The scatter diagram indicates a combination of random variation and laboratory biases for some laboratories. The mean expansion of M1 set at 14 days obtained from this study is 0.081% for both 1.19M1 and 2.19M1. The standard deviations obtained are 0.008 and 0.009, respectively.

Two outliers were identified from the data set using the iterative technique. The scatter diagram indicates a strong laboratory bias and equal variation. The mean expansion of M2 set at 14 days obtained from this study is 0.334% and 0.336% for 1.19M2 and 2.19M2, respectively. The standard deviations obtained are 0.049 and 0.049, respectively.

The standard deviations obtained for both M1 and M2 sets in 2019 study are lower than the values reported in 2018. The average coefficients of variation for both M1 (10.5%) and M2 (14.6%) in 2019 are smaller than the values reported in 2017 (21.9%) and 2018 (16.3%), as well as the precision statement (15.2%) published by ASTM C1260. However, only the mean expansion of M2 set is applicable to the expansion limit of larger than 0.1% for which the ASTM precision estimate was developed. A lower coefficient of variation for M1 set indicated that the sample preparation method employed by MTO is very effective and capable of producing a more uniform material.

Several steps in the test procedure can influence the results, particularly the crushing procedure, maintaining the temperature of storing the specimens, procedure of moulding the specimens, calibration of equipment and measuring procedure, variations of sodium hydroxide that was used in the test. Laboratories with a rating lower than 3 shall carefully examine their equipment and procedure.

3.4.17 CSA A23.2-14A- Concrete Prism – Test No. 125

Since 2017, CSA A23.2-14A has been introduced in MTO Aggregate and Soil Proficiency Sample Testing Program in support of MTO CASL (Concrete Aggregate Source List) compliance program. The participants in the 2019 study were supplied with coarse and fine aggregate samples 1.19 and 2.19. This test takes a year to complete. Twelve laboratories reported their test results in 2019. The participants were asked to test three prisms made with each 1.19 and 2.19 samples supplied.

The participants reported expansion of the individual prisms and the average of three prisms after 1, 2, 4, 8, 13, 18, 26, 39, and 52 weeks. Only the average expansions after 52 weeks were shown on the scatter diagram in the Appendix H. Two outliers were

identified using Iterative technique. The scatter diagram indicates random variation with little laboratory biases. Considering the number of observations (12) used, the analysis may not yield any meaningful or representative statistical data.

The mean expansion after 52 weeks obtained from this study is 0.184% and 0.187%. The coefficient of variation (6%) obtained in 2019 study is lower than the value in 2017 (30%) and 2018 (23%), as well as the value (23%) reported in CSA A23.2-14A for an average expansion greater than 0.014%.

Several steps in the test procedure can influence the results, particularly variations of water content and sodium hydroxide in the concrete mixture, procedure of mixing and casting the prisms, maintaining the temperature of storing the prisms, maintaining the humidity inside the storage container, calibration of the length measuring device, and measuring procedure. Laboratories with a rating lower than 3 shall carefully examine their equipment and procedures.

3.4.18 LS-615 – Alkali-Carbonate Reactivity – Test Nos. 126 to 137

In 2019, LS-615 was introduced in MTO Aggregate and Soil Proficiency Sample Testing Program in support of MTO CASL compliance program. The participants were supplied with a pair of fine aggregate samples, 1.19ACR and 2.19ACR. Each of the samples contains a representative sample of the fine aggregate that was prepared by MTO using a crusher and a spinning riffler. Participants were instructed to provide the duplicate analyses of the chosen reference standard (i.e., NIST 1C, 1D, 88A or 88B) to show that the method used meets the precision and accuracy requirements of Table 1 of Test Method LS-615.

Six (6) laboratories reported their test results in 2019. All participants utilized wavelength dispersive x-ray fluorescence as the analytical method for this test. Considering the number of observations (6) used, the analysis may not yield any meaningful or representative statistical data. Hence, the data was subjected to the statistical analysis using no outlier technique.

Given no outlier is removed, the average coefficients of variation obtained in 2019 for Al_2O_3 (12.3%) and MgO (5.2%), respectively, are slightly lower than the values of 13% and 6.9% reported in LS-615 precision statements. The average coefficient of variation obtained for CaO (1.7%) is slightly higher than the value of 1.5% reported in LS-615. The mean values of the major oxides in 2019 are in line with the values for which LS-615 precision statements were established. Successive scatter diagrams show strong laboratory bias.

3.4.19 LS-702 - Particle Size Analysis of Soil – Test Nos. 40-45

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to LS-702. Ninety-five laboratories participated in the hydrometer test in 2019. All the laboratories reported results ranging from 99.6% to 100% of material passing 2.00 mm sieve. Therefore, the data for 2.00 mm sieve (Test No. 40) was also subjected to the statistical analysis using no outlier technique. Hence, no rating was assigned for 2.00 mm sieve and the results of the analysis are reported for information purpose only.

Outliers were selected using the iterative technique. The number of outliers identified by the use of iterative technique range from three for percent passing 5 μm and 2 μm to a maximum of eight for percent passing 425 μm . Scatter diagrams for percent passing 425 μm and 75 μm show random variation with little laboratory bias. For percent passing 20 μm , 5 μm and 2 μm , the scatter diagrams show a combination of random variation and laboratory biases for some laboratories. The standard deviations obtained in 2019 for all the particle sizes passing, except 75 μm and 20 μm , are either consistent with or smaller than that of the values reported in 2018. The standard deviations obtained for the 75 μm and 20 μm sizes are higher than the variations reported in 2018. The laboratories with a rating lower than 3 should examine their equipment and technician's skills to ensure that they meet the requirements of the test procedure.

3.4.20 LS-703 and 704 - Atterberg Limits of Soil – Test Nos. 46-48

One hundred and nine laboratories reported results for Atterberg limit tests in 2019. five outliers for liquid limit (Test No. 46), two for plastic limit test (Test No. 47) and four for plasticity index (Test No. 48) were identified using the iterative technique. The scatter plots for all three index tests (Test Nos. 46 to 48) show a combination of random variation and laboratory bias for some laboratories. Both liquid and plastic limit tests require significant operator skills. Liquid limit test also requires good condition and calibration of the apparatus. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce the laboratory biases.

The material supplied for the soil tests in 2019 is a low plastic clay (CL) with liquid limit in the neighbourhood of 30 (LL = 30+). In view of this, the multi-laboratory variations (1s) published in the ASTM for low plastic clay (CL) with a liquid limit of 33.4 and plastic limit of 19.9 are used to evaluate the performance of the participants in the 2019 program. The standard deviations obtained in 2019 for liquid limit are higher than the values published in the ASTM precision statements, but the plastic limit and plasticity index tests are in line with the values published in the ASTM precision statements (see Appendix F). The variations obtained for all three index tests in 2019 are comparable to the variations reported in 2017 where an intermediate plastic clay (CI) with liquid limit of

39 (LL = 39) was used. The classification of the clay supplied in 2019 was different from the high plastic clay (CH) supplied in 2016 and 2018.

3.4.21 LS-705 - Specific Gravity of Soils – Test No. 49

The participants were requested to perform this test according to LS-705. This test method requires that the test be performed on a minimum of three specimens, and the range (difference between the largest and smallest) of specific gravity values of the test specimens determined is within 0.02. Further, it requires that the test be repeated if the range exceeds the specified limit. The laboratories that reported results with the range in excess of 0.02 appear to have difficulty in repeating the test within their testing environment.

Ninety-five laboratories reported results for this test in 2019. Five outliers were identified using the iterative technique. The majority of the data points are located in the first and third quadrants of the scatter diagram showing a pronounced between laboratory bias and equal variation for each material. Several steps in this test procedure can influence the results, particularly the equipment and method employed for preparation of the test specimen and removal of entrapped air from the test specimen. Laboratories finding themselves in this situation should carefully examine their equipment and procedure.

The standard deviation of 0.024 and 0.028 obtained in 2019 are higher than the results reported in 2018, but smaller than the results reported in 2016 and 2017. LS-705 is similar to that of AASHTO T100, which reports a multi-laboratory standard deviation of 0.04. As in the past three studies, the standard deviations obtained in 2019 are lower than that of the precision estimate published in the AASHTO T100.

3.4.22 Soil and Rock Including Testing for Foundation Engineering

The proficiency sample testing program for Soil and Rock Including Testing for Foundation Engineering was introduced in 2019 to monitor the competency of Engineering Service Providers (EPSs) providing or seeking to provide consultant services in the corresponding Soil and Rock Testing specialties in the Category of Engineering Materials Testing and Evaluation.

The EPSs that participated in the tests were supplied with the following samples:

- 1 pair (approx. 3.5 kg/bag) of Soil labelled 3.19S and 4.19S, for request for participation in the medium and/or high complexity soil testing.
- 1 pair (approx. 7 kg/bag) of coarse and fine aggregate mixture labelled 5.19A and 6.19A, for request for participation in LS-709 Permeability of Granular Soils.

For the soil tests, the participants were instructed to reconstitute specimens using 3.19S and 4.19S.

A poor or good rating for a participant in one year is an indication of how that participant performed in the proficiency study, and may not reflect how the participant performs year round. A consistently poor rating over two or more years may be cause for serious concern.

ASTM D2435 – Consolidation Properties of Soils – Test No. 50

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to ASTM D2435 Method A. Participants were instructed to follow Test Method A to load the specimens in steps to a maximum consolidation pressure of 400 kPa. Fifteen (15) EPSs participated in the test in 2019. The coefficient of consolidation submitted by the EPSs was used for the proficiency study. Four (4) EPSs were identified as outliers using the iterative technique. The lower right and upper left quadrants of scatter diagram account for three of the data points, indicating a combination of random variation and bias for some EPSs. The standard deviations of 3.15×10^{-4} and 3.44×10^{-4} were obtained in 2019. There is no precision statement for this test method due to the nature of the soil materials tested by this test method. The EPSs that obtained a proficiency rating of less than 3 should review their test procedures and calibration status for apparatus deformation, as well as the skills of the technician in specimen preparation, especially the practice of minimizing disturbance of the specimen or minimizing changes in moisture and density during specimen preparation.

ASTM D3080 – Direct Shear Test of Soils – Test No. 51

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to ASTM D3080. Ten (10) EPSs participated in the test in 2019. The peak shear stress at 400 kPa normal stress submitted by the EPSs was used for the proficiency study. One (1) EPS was identified as an outlier using the iterative technique. Considering the number of observations used, the analysis may not yield any meaningful or representative statistical data. The lower right and upper left quadrants of scatter diagram account for three of the data points, indicating a combination of random variation and bias for some EPSs. The standard deviations of 7.985 and 11.294 were obtained in 2019. There is no precision statement for this test method. Applying a lower normal stress is expected to result in a lower shear stress. The EPSs that obtained a proficiency rating of less than 3 should review their test procedures, and calibration status for apparatus deformation, and inspect the device for applying the normal force for any flaws. The EPSs should also evaluate the skills of the technician in specimen preparation, especially the practice of minimizing disturbance of the specimen or minimizing changes in moisture and density during specimen preparation.

ASTM D5084 – Hydraulic Conductivity of Saturated Soils – Test No. 52

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to ASTM D5084. Eight (8) EPSs participated in the test in 2019. The constant head hydraulic conductivity of saturated soil corrected to 20°C submitted by the EPSs was used for the proficiency study. One (1) EPS was identified as an outlier using the iterative technique. Considering the number of observations used, the analysis may not yield any meaningful or representative statistical data. The scatter diagram shows a strong between laboratory bias. The standard deviations of 1.2×10^{-11} and 6.7×10^{-12} were obtained in 2019. The standard deviations obtained for both samples are lower than the reproducibility standard deviations (6.2×10^{-9}) published in ASTM D5084 precision statements for ASTM reference soil CL-1. Although the clay of low plasticity (CL) used in 2019 was comparable to the ASTM reference soil CL-1, the precision estimate in ASTM D5084 may not be typical of the reconstituted soil specimens that were used in the 2019 testing program.

The EPSs that obtained a proficiency rating of less than 3 should review their test procedures, maintenance status of the equipment, and inspect for any leakage in the testing system, including the equipment and membrane wrapping the specimen, so that constant pressures were not maintained during the testing. The EPSs should also evaluate the skills of the technician in specimen preparation, especially the practice of minimizing disturbance of the specimen or minimizing changes in moisture and density during specimen preparation.

LS-709 – Granular Permeability – Test No. 53

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to LS-709. Ten (10) EPSs participated in the test in 2019. The granular permeability corrected to 20°C submitted by the EPSs was used for the proficiency study. One (1) EPS was identified as an outlier using the iterative technique. Considering the number of observations used, the analysis may not yield any meaningful or representative statistical data. The scatter diagram shows a strong between laboratory bias. The standard deviations of 0.0086 and 0.0084 were obtained in 2019. There is no precision statement for this test method.

The EPSs that obtained a proficiency rating of less than 3 should review their test procedures, maintenance status of the equipment and apparatus, and inspect for any leakage in the testing system. Deficient hydraulic conductivity of the porous stone will result in a faulty lower permeability of the test sample.

3.5 Superpave Consensus Property Tests

3.5.1 LS-629 - Uncompacted Void Content of Fine Aggregate – Test No. 95

The participants were asked to perform the test in accordance with LS-629, on the fine aggregates prepared by splitting the material passing 4.75 mm sieve of Granular A. This test method is a modified version of AASHTO T 304. LS-629 follows Method A of AASHTO T 304, except for the preparation of the test specimen to be used in the determination of bulk specific gravity of fine aggregates. The significant difference between the methods is that LS-629 requires the test specimens be washed on the 75 μm sieve until all the material finer than 75 μm is removed. In addition, LS-629 specifies that the bulk relative density is determined using the graded sample and not the individual size fraction method described in Clause 9.4 of AASHTO T 304. In order to minimise the testing work, the participants were advised to use the bulk relative densities reported for fine aggregate determined in accordance with LS-605 under Test No. 27, to compute the uncompacted void contents of samples 1.19 and 2.19.

Seventy laboratories submitted results for this test in 2019. Five laboratories were identified as outliers using the iterative technique. The scatter diagram plot in Appendix I indicates a combination of random variation and laboratory bias for some laboratories. The standard deviations of 0.586 and 0.569 obtained in 2019 are higher than the values obtained in the past three years. The standard deviations obtained for both samples are higher than the value of 0.33% published in AASHTO T 304 precision statements for graded standard sand. The estimates of precision published in AASHTO T 304 are based on graded sand as described in ASTM C 778, which is considered rounded, and is graded from 600 μm to 150 μm . The type of material used for the development of precision statements in AASHTO T 304 may not be typical of the sand samples that were used in this testing program. The uncompacted void contents reported were calculated using the bulk relative densities that were determined by the individual laboratories. The use of the bulk relative densities determined by the individual laboratories further compounds the variations associated with the results reported for uncompacted void contents. The laboratories that obtained a proficiency rating of less than 3 should review their test procedures and the skill of the technician.

3.5.2 ASTM D 2419 - Sand Equivalent Value of Fine Aggregate - Test No. 96

Participants were asked to prepare the fine aggregate sample for this test by splitting the Granular A material passing 4.75 mm sieve. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO methods. The participants were given the option of preparing the test specimen in accordance with either method.

Sixty-nine laboratories reported results for this test in 2019. Three outliers were identified by the use of iterative technique. The scatter diagram plot in Appendix I shows a pronounced laboratory bias. The standard deviations of 4.6 and 4.2 obtained in 2019 are lower than the values reported in the past three years and lower than the multi-laboratory precision estimate of 8.0 published by ASTM for samples with sand equivalent value less than 80.

3.5.3 ASTM D 5821 - Percent of Fractured Particles – Test No. 97

This year, the participants were advised to perform the test on all the materials retained on 4.75 mm sieve.

ASTM D 5821 is very similar to MTO LS-607. Seventy-five laboratories submitted results for this test in 2019. Two outliers were detected using the iterative technique. The scatter diagram in Appendix I shows a combination of random variation and laboratory bias for some laboratories. The standard deviations of 3.4 and 3.6 obtained in 2019 are lower than the precision estimate of 5.2 published by ASTM. This ASTM precision estimate is from the statistical data provided by MTO. The variation obtained in 2019 is lower than the variation reported in the past three years.

3.5.4 ASTM D 4791 - Percent Flat and Elongated Particles – Test No. 99

This year, the participants were advised to perform the test on all the materials retained on 4.75 mm sieve.

Seventy-three laboratories reported results for this test in 2019. Two outliers were detected using the iterative technique. Participants in this test were asked to compute the percent of each fraction using the gradation test results of the coarse aggregate portion, based on the total mass of material retained on 4.75 mm sieve. All five fractions shall be used in calculation of the weighted average of percent flat and elongated particles. The standard deviations of 1.02 and 1.09 obtained in 2019 are higher than the values reported in the past three years. The average coefficient of variation of 45.3% obtained in 2019 is higher than the value of 41.1% in 2018 study. The scatter diagram in Appendix I for this test shows a strong laboratory bias.

ASTM D 4791 requires that the percent flat and elongated particles results are reported separately for each fraction tested. The precision estimates in this test method are also provided separately for each fraction ranging from 19.0 mm to 12.5 mm, 12.5 mm to 9.5 mm, and 9.5 mm to 4.75 mm. However, the results reported in this study are based on the weighted average calculated using the results of five fractions ranging from 26.5 mm to 4.75 mm. For this reason, a direct comparison of the multi-laboratory variations obtained in this study with that of the precision estimates published by ASTM is not possible.

4. Laboratory Rating System

The laboratory rating system assigns separate overall ratings for each category of laboratories, i.e., low complexity (Production) aggregate laboratories, high complexity (Full Service) Aggregate laboratories, Soil laboratories, and Superpave laboratories. Laboratories must participate in all of the tests that are listed under each category, i.e., Production, Full Service, Soil and Superpave, to assign an overall laboratory rating. Production (CCIL Type C) laboratories are required to carry out wash pass 75 μm , sieve analysis, percent crushed particles, percent asphalt coated particles, and percent flat and elongated particles tests. In addition to these tests, Full Service laboratories (CCIL Type D) must carry out micro-Deval (coarse and fine), freeze-thaw, and/or magnesium sulphate soundness, relative density and absorption (coarse and fine) tests. Soil laboratories are required to carry out particle size analysis, Atterberg limits, and specific gravity of soil tests. Superpave aggregate laboratories are required to perform all four consensus property tests, i.e., uncompacted void content, sand equivalent value, percent fractured particles, and flat and elongated particles.

The rating system gives a maximum rating of 10 for each test, e.g., 5 for wash pass 75 μm on sample 1.19, plus -5 for wash pass 75 μm on sample 2.19, equals 10 (the negative sign indicating a test result less than the mean is ignored). See Section 2.1 for explanation of test method ratings. Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), Standard Proctor values (maximum wet and corrected dry unit weight, and corrected optimum moisture content), particle size analysis of soils, and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the sieve analysis results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by eleven coarse and fine sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Individual laboratory ratings are calculated by adding the ratings of each test in the appropriate lab category (i.e. Production, Full Service, Soil, or Superpave) and converting the sum to a percentage of the maximum available rating for the category. The spread of laboratory ratings for Production, Full Service, Soil, and Superpave laboratories are given in the form of histograms in Figure 2 to Figure 5. The rating system for “Full Service Laboratory” (Type D) shows that 57% of the participating laboratories in 2019 obtained a rating higher than 90 and, in the case of “Production Laboratory” (Type C), 48% of the participants obtained an overall laboratory rating higher than 90. The rating system for soil tests show 53% of the participants obtained an overall rating higher than 90, and in the case of consensus property tests (Superpave), 53% of the participants obtained an overall laboratory rating higher than 90. The laboratory rating system data is reported in Appendix J through Appendix M.

Laboratory ratings for each category are given to participants in the covering letter accompanying the individual laboratory results. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not reflect how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.

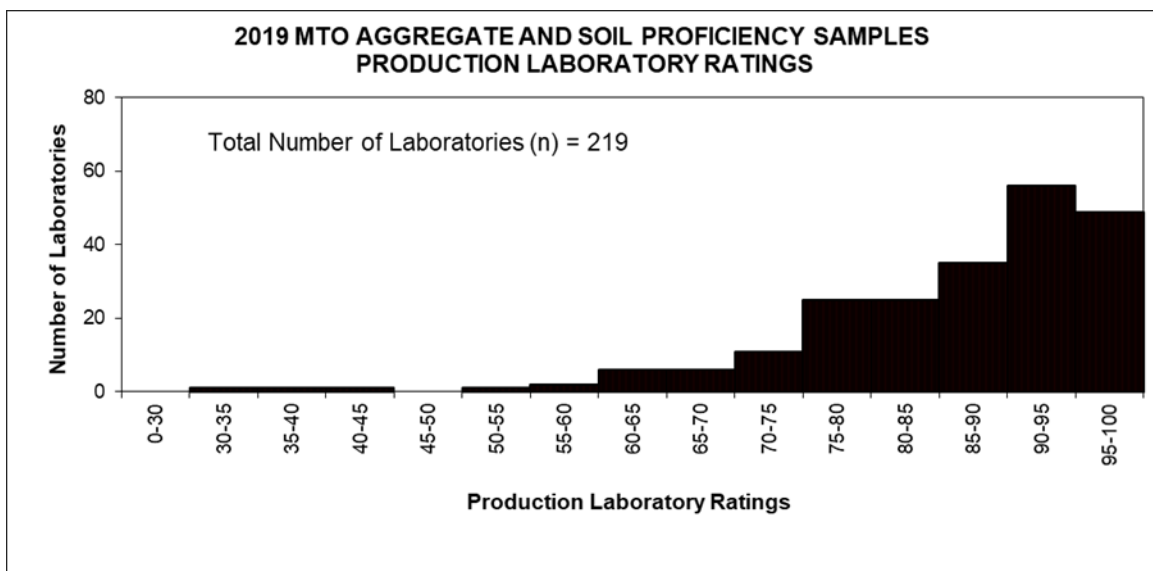


Figure 5. Production Laboratory Ratings.

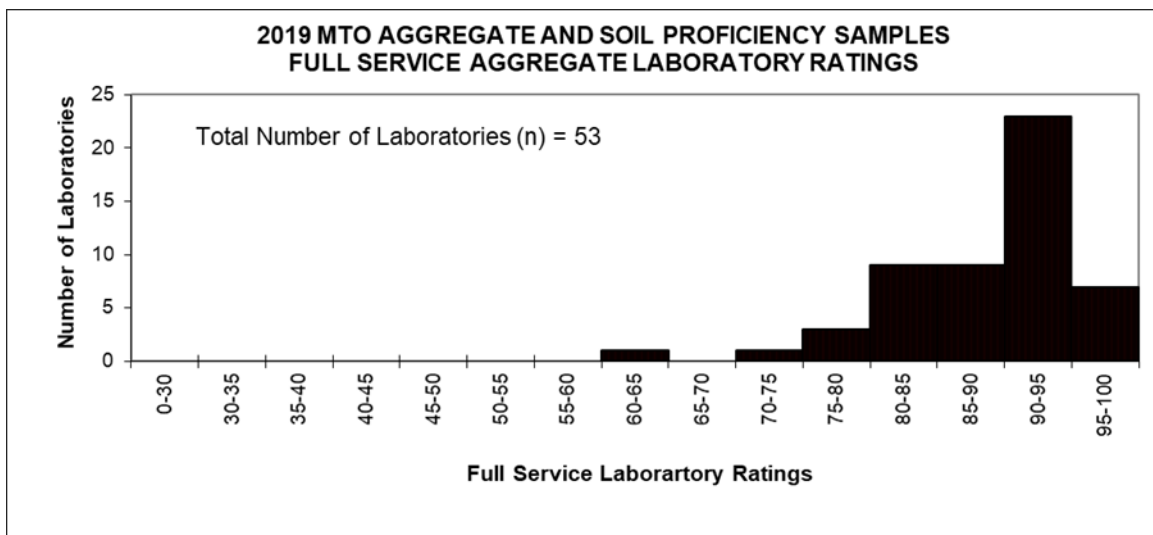


Figure 6. Full Service Laboratory Ratings.

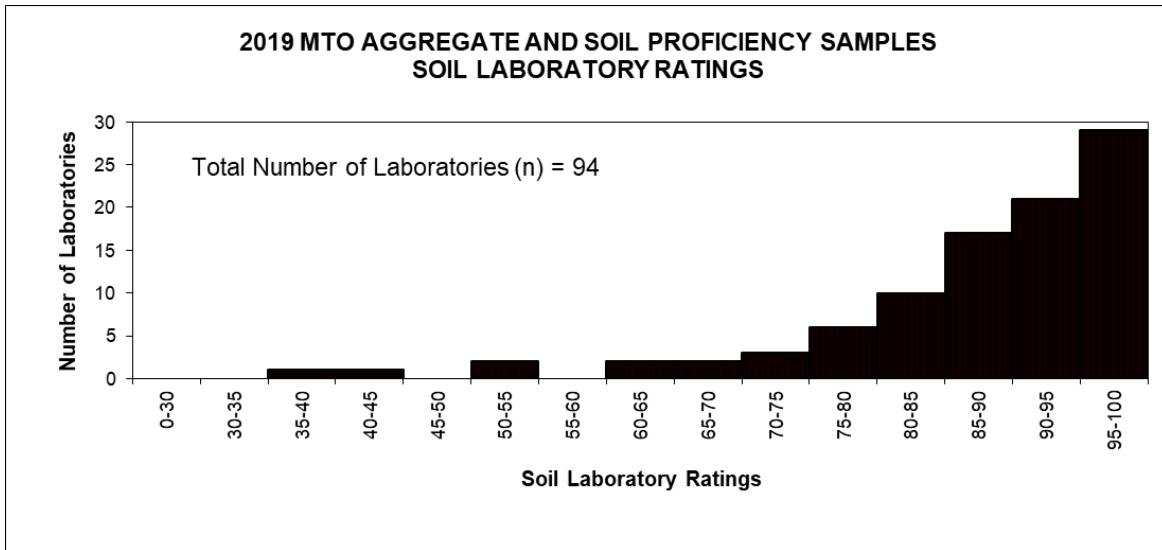


Figure 7. Soil Laboratory Ratings.

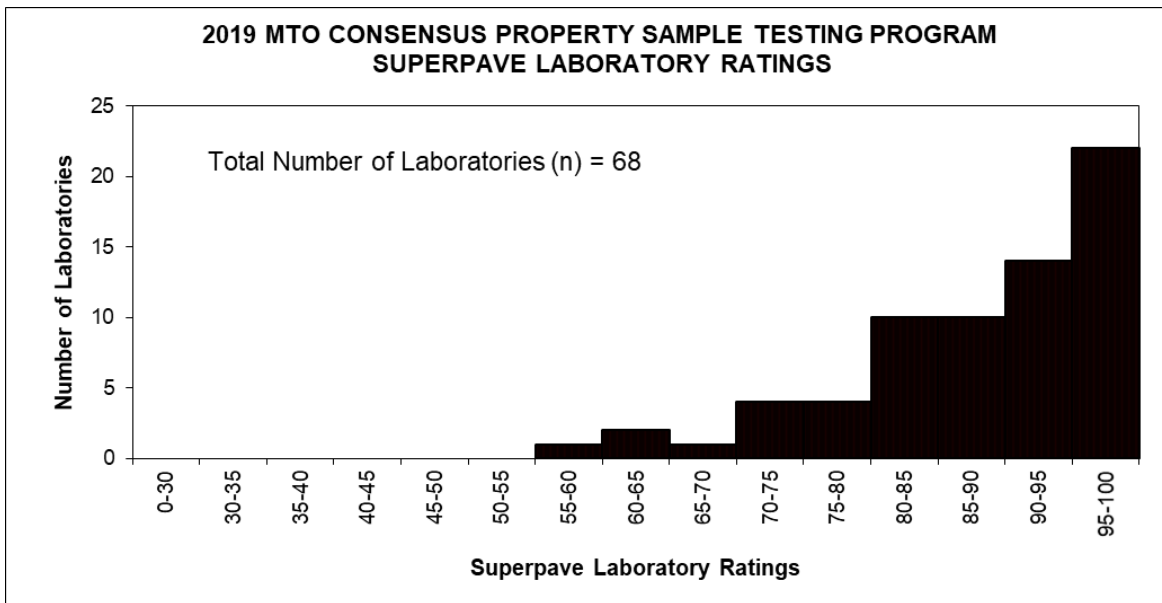


Figure 8. Superpave Laboratory Ratings.

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in almost identical mean gradation values for samples 1.19 and 2.19. The differences in mean, as well as in the standard deviations between pairs of samples for both coarse and fine sieves are almost negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform and nearly identical material at reasonable cost.

The majority of the aggregate and soil test results of the 2019 Aggregate and Soil Proficiency Sample Testing Program compare favourably with the results of previous studies. In some cases, the variations show noticeable improvement over previous years' results and the precision estimates of those tests where MTO, ASTM, AASHTO or CSA precision statements are available. The scatter diagrams for the majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories.

Two hundred and nineteen of the laboratories that participated in the aggregate tests are CCIL Type C (Production) certified, and fifty three of those are also CCIL Type D (Full Service) certified. CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about two year intervals. The performance of laboratories in most of the aggregate tests (Type C and Type D) is consistent with the results in the past and a large number of these tests show improvement in multi-laboratory variation over the established precision estimates. The improvements noted may be due to the on-site laboratory inspection by CCIL at regular intervals, proficiency sample testing, and due to an increased awareness of the importance of proper testing and quality control procedures implemented by CCIL.

Ninety-four laboratories participated in all three soil tests. For particle size analysis of soil and Atterberg limits of soils, the variations found in 2019 are consistent with the variations reported in 2017 where the classification of the clay was Cl. The proficiency sample testing program for Soil and Rock Including Testing for Foundation Engineering was introduced in 2019. Fifteen laboratories participated in the medium complexity soil testing and ten in the high complexity testing. There is no precision statement for consolidation properties of soils and direct shear test of soils. The multi-laboratory variations of hydraulic conductivity of saturated soils show noticeable improvements over the precision estimates published by ASTM D5084. However, the precision estimates in ASTM D5084 may not be typical of the reconstituted soil specimens that were used in the 2019 testing program. The scatter diagrams of the soil tests show either strong laboratory biases or a combination of random variation and laboratory bias

for some laboratories. The results of soil tests are significantly influenced by operator skills, testing environment, and the condition and calibration of the equipment.

Sixty-eight laboratories participated in all four Superpave consensus property tests. The results of 2019 compare favourably with the results of past three years. The multi-laboratory variations of Uncompacted Void Content of Fine Aggregate (AASHTO T 304) show noticeable improvements over the values reported in the past three years. The multi-laboratory variations of sand equivalent value of fine aggregate (D2419) show noticeable improvements over the precision estimates published by ASTM. Another improvement over the past is that only the scatter diagrams for ASTM D 2419 shows strong laboratory biases. The other three consensus property tests show a combination of random variation and laboratory bias for some laboratories. The quality control program implemented by CCIL is expected to bring about improvements in the multi-laboratory variations.

6. Recommendations

Although there are improvements in the multi-laboratory variations over the precision estimates established by MTO, AASHTO, ASTM standards or CSA, strong laboratory biases remain in a few of the aggregate tests, two of the Superpave property test procedures and two of the six soil tests in 2019. The laboratories that were identified as outliers should examine their quality control practices, the condition and calibration of equipment, testing procedures and skills of their technicians. Laboratories that receive a rating of less than 3 for an individual sample in a test should investigate the probable cause and prepare corrective action reports as required by the Quality System implemented by CCIL.

The results of the 2019 MTO Aggregate and Soil Proficiency Sample Testing Program suggest that most laboratories have performed satisfactorily. Laboratories that obtained relatively low ratings must focus on quality control practices, operator training, standardization and calibration of equipment and improvements to laboratory environments in order to improve their performance.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of equipment maintenance, repair and correct calibration is required in order to achieve improvements. It is expected that the CCIL Quality System will encourage laboratories to conduct a review of their internal quality control practices to ensure that they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal lab audit, calibration and testing of control or reference samples is beneficial to maintaining a high level of confidence in their results.

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Appendix A. Glossary of Terms

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s) by the factor $2\sqrt{2}$ (2.83).

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value'. This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process and an accepted reference value of the property being measured. For the majority of aggregate and soil tests, there is no acceptable reference material, so bias is impossible to compute.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$C.V = \frac{\text{std dev}}{\text{mean}} \times 100$$

Critical Value is that value of the sample criterion which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

MAIDB refers to Mineral Aggregate Inventory Data Bank of the Ministry of Transportation.

Median is synonymous with the middle and the sample median is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the sample median is the single middle value in the ordered list, if n is odd, or the average of the two middle values in the ordered list, if n is even, where n equals the number of observations.

Multi-laboratory precision is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances, the estimates of the one-sigma limit (1s) for

multi-laboratory precision are usually larger than those for single-operator precision because different operators and different equipment are being used in different laboratories.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier, it means that something went wrong either with the sample or in the laboratory.

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Sample mean or average is the sum of all observations divided by the total number of observations.

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Appendix B. Test Results for Laboratory 47

Table 1. Summary of Results for Laboratory 47.

Lab 47	Samples 1.19 and 2.19	Lab Data	Lab Data	Lab Mean	Lab Mean	Std. Dev.	Std. Dev	Rating	Rating
Standard	Test Method:	1.19	2.19	1.19	2.19	1.19	2.19	1.19	2.19
LS-601	Wash Pass 75 μ m (Coarse Aggregate)	0.450	0.430	0.465	0.461	-0.152	-0.332	-5	-5
LS-602 (CA)	% Passing 19.0mm	95.000	96.100	95.282	95.282	-0.294	0.798	-5	5
LS-602 (CA)	% Passing 16.0mm	88.000	90.600	88.352	88.331	-0.213	1.291	-5	4
LS-602 (CA)	% Passing 13.2mm	81.100	84.200	81.429	81.454	-0.157	1.255	-5	4
LS-602 (CA)	% Passing 9.5mm	69.300	72.800	70.017	70.173	-0.308	1.073	-5	4
LS-602 (CA)	% Passing 4.75mm	52.800	55.000	52.949	53.162	-0.073	0.801	-5	5
LS-603	LA Abrasion, %	26.900	26.600	24.683	25.011	1.202	1.042	4	4
LS-606 (CA)	Coarse Aggregate MgSO ₄ , Soundness Loss, %	7.200	7.600	6.826	6.753	0.176	0.501	5	5
LS-607	% Crushed Particles	78.200	79.500	77.716	77.691	0.104	0.400	5	5
LS-608	% Flat & Elongated Particles	10.600	9.800	6.885	6.800	2.012	1.506	2	3
LS-609	Petrographic Number CA	290.000	294.000	223.000	232.438	1.146	1.176	N/A	N/A
LS-614	Freeze-Thaw Loss, %	4.900	5.700	6.323	6.216	-0.780	-0.394	-5	-5
LS-618	Micro-Deval Abrasion Loss (Coarse Aggregate)	10.900	10.600	11.074	10.974	-0.193	-0.446	-5	-5
LS-620	Accelerated Mortar Bar (14 Days)	0.092	0.102	0.095	0.095	-0.043	0.098	-5	5
LS-706	Maximum Wet Density (t/cm ³)	2.500	2.459	2.457	2.458	1.535	0.022	3	5
LS-706	Maximum Dry Density (t/cm ³)	2.606	2.608	2.331	2.336	8.572	8.278	0*	0*
LS-706	Optimum Moisture, %	5.626	5.870	6.052	6.011	-0.671	-0.254	-5	-5
LS-604 (CA)	Relative Density (O.D.)	2.661	2.661	2.665	2.664	-0.633	-0.515	-5	-5
LS-604 (CA)	Absorption	1.440	1.460	1.438	1.427	0.016	0.293	5	5

Lab 47	Samples 1.19 and 2.19	Lab Data	Lab Data	Lab Mean	Lab Mean	Std. Dev.	Std. Dev.	Rating	Rating
Standard	Test Method:	1.19	2.19	1.19	2.19	1.19	2.19	1.19	2.19
LS-621	Asphalt Coated Particles, %	34.700	41.400	38.403	37.403	-1.652	1.421	-3	4
LS-605 (FA)	Relative Density (O.D.)	2.697	2.719	2.687	2.687	1.163	3.330	4	0*
LS-605 (FA)	Absorption	1.280	0.959	1.222	1.210	0.386	-1.661	5	-3
LS-619 (FA)	Micro-Deval Abrasion	20.800	19.300	19.565	19.997	0.699	-0.451	5	-5
LS-602 (FA)	% Passing 2.36 mm	44.000	44.300	42.352	42.495	0.668	0.758	5	5
LS-602 (FA)	% Passing 1.18 mm	35.900	36.400	34.774	34.739	0.522	0.780	5	5
LS-602 (FA)	% Passing 600 µm	28.900	29.800	28.428	28.247	0.270	0.785	5	5
LS-602 (FA)	% Passing 300 µm	21.500	22.400	21.537	21.537	-0.027	0.566	-5	5
LS-602 (FA)	% Passing 150 µm	13.700	14.400	14.037	14.047	-0.371	0.362	-5	5
LS-602 (FA)	% Passing 75 µm	8.870	9.350	9.214	9.273	-0.584	0.121	-5	5
LS-702	% Passing 2.00mm	99.880	99.600	99.984	99.984	-2.052	-6.335	N/A	N/A
LS-702	% Passing 425 µm	97.700	97.600	97.588	97.345	0.374	0.956	5	5
LS-702	% Passing 75 µm	90.400	90.500	90.493	89.196	-0.086	1.215	-5	4
LS-702	% Passing 20 µm	79.970	80.800	81.826	79.978	-0.552	0.239	-5	5
LS-702	% Passing 5 µm	53.810	54.430	56.234	54.209	-0.709	0.061	-5	5
LS-702	% Passing 2 µm	34.860	35.160	36.531	35.737	-0.524	-0.171	-5	-5
LS-703	Liquid Limit, %	31.120	33.320	32.376	31.485	-0.753	0.972	-5	5
LS-704	Plastic Limit, %	16.860	18.420	17.523	17.120	-0.519	1.114	-5	4
LS-704	Plasticity Index, %	14.260	13.890	14.920	14.540	-0.351	-0.361	-5	-5
LS-705	Specific Gravity of Soil	2.780	2.754	2.771	2.766	0.387	-0.437	5	-5
Superpave	Uncompacted Void Content	43.800	44.800	44.390	44.390	-0.913	0.536	-5	5
Superpave	Sand Equivalent Value	39.100	36.100	38.851	38.851	0.054	-0.534	5	-5
Superpave	% Fractured Particles	76.000	73.800	77.871	77.378	-0.431	-0.855	-5	-5
Superpave	% Flat and Elongated	3.400	3.100	2.298	2.311	1.075	0.723	4	5

Blank spaces represent not tested.

* - Calculation considered outlier

∅ - Outliers by Manual Deletion

Appendix C. List of Participants – Aggregates

Table 2. List of Participants – Aggregates.

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
A. L. Blair Construction Limited Moose Creek, Ontario Mr. Justin Blair Tel: (613) 538-2271	✓	✓				✓	✓										✓		
AECOM Canada Ltd. Toronto, Ontario Venkata Ramana Mullapudi Tel: (416) 527-1824	✓	✓				✓	✓										✓	✓	
AME - Materials Engineering Mobile 24-384 Caledon, Ontario Mr. Scott Crowley Tel: (905) 840-5914	✓	✓				✓	✓										✓		
AME - Materials Engineering Caledon, Ontario Mr. Scott Crowley Tel: 905 840-5914	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
AME - Materials Engineering Mobile 24-271 Caledon, Ontario Mr. Scott Crowley Tel: (905) 840-5914	✓	✓				✓	✓										✓		
AME - Materials Engineering Mobile 24-297 Caledon, Ontario Mr. Scott Crowley Tel: (905) 840-5914	✓	✓				✓	✓										✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm																		
	LS-602 Sieve Analysis	✓	✓																
	LS-603 Los Angeles Abrasion																		
	LS-604/5 Relative Density																		
	LS-606 Sulphate Soundness																		
	LS-607 Percent Crushed Particles					✓													
	LS-608 Percent Flat and Elongated					✓													
	LS-609 Petrographic Number -																		
	LS-616 Petrographic Analysis – Fine																		
	LS-614 Freeze-Thaw																		
	LS-613 Insoluble Residue																		
	LS-618 Micro-Deval CA																		
	LS-619 Micro-Deval FA																		
	LS-615 Alkali- Carbonate Reactivity																		
	LS-620 Accelerated Mortar Bar																		
	CSA A23.2-14A Concrete Prism																		
	LS-621 Asphalt Coated Particles														✓				
	LS-706 Standard Proctor Density															✓			
	LS-709 Granular Permeability																		
AME - Materials Engineering Mobile 24-298 Caledon, Ontario Mr. Scott Crowley Tel: (905) 840-5914		✓	✓																
AME - Materials Engineering Ottawa, Ontario Mr. Harrison Smith Tel: (613) 726-3039		✓	✓															✓	
AME Materials Engineering Mobile 24-001 Caledon, Ontario Mr. Scott Crowley Tel: (905) 840-5914		✓	✓															✓	
AME Materials Engineering Mobile 24-002 Caledon, Ontario Mr. Scott Crowley Tel: (905) 840-5914		✓	✓															✓	
Bare Contracting Services Ltd Mississauga, Ontario Mr. Adam Costello Tel: (416) 677-1782		✓	✓															✓	✓
Beamish Construction Inc. Hanmer, Ontario Mr. Louise Moreau Tel: (705) 669-7331		✓	✓															✓	✓

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm																		
	LS-602 Sieve Analysis	✓	✓																
	LS-603 Los Angeles Abrasion																		
	LS-604/5 Relative Density																		
	LS-606 Sulphate Soundness																		
	LS-607 Percent Crushed Particles					✓													
	LS-608 Percent Flat and Elongated					✓													
	LS-609 Petrographic Number -																		
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	LS-615 Alkali- Carbonate Reactivity																		
	LS-620 Accelerated Mortar Bar																		
	CSA A23.2-14A Concrete Prism																		
	LS-621 Asphalt Coated Particles					✓													
	LS-706 Standard Proctor Density																		
	LS-709 Granular Permeability																		
	Bruno's Contracting (Thunder Bay) Thunder Bay, Ontario Mr. Dante DiGregorio Tel: (807) 623-1855	✓	✓					✓	✓									✓	
	C. Villeneuve Construction - Mobile 1 Hearst, Ontario Mr. Charles Harris Tel: (705) 372-1838	✓	✓		✓			✓	✓									✓	✓
	C. Villeneuve Construction - Mobile 2 Hearst, Ontario Mr. Charles Harris Tel: (705) 372-1838	✓	✓					✓	✓									✓	✓
	C. Villeneuve Construction - Mobile 25 Hearst, Ontario Mr. Charles Harris Tel: (705) 372-1838	✓	✓					✓	✓									✓	✓
	C. Villeneuve Construction - Mobile 5 Hearst, Ontario Mr. Charles Harris Tel: (705) 372-1838	✓	✓					✓	✓									✓	✓
	C.T. Soil & Materials Testing Inc. Windsor, Ontario Mr. Thomas J. O'Dwyer Tel: (519) 966-8863	✓	✓		✓			✓	✓			✓	✓					✓	✓

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Caledon Sand & Gravel Limited Caledon, Ontario Mr. Leigh Mugford Tel: (416) 579-9426	✓	✓				✓	✓										✓		
Cambium Inc. Peterborough, Ontario Mr. Stuart Baird Tel: (705) 741-4109	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	
Capital Paving Inc. Guelph, Ontario Mr. Mark Latyn Tel: (519) 822-4511	✓	✓		✓		✓	✓										✓	✓	
CBM Aggregates - Aberfoyle Cambridge, Ontario Mr. Dan Roth Tel: (519) 239-4743	✓	✓				✓	✓										✓		
CBM Aggregates - Codrington Codrington, Ontario Mr. Dale Covert Tel: (613) 475-4595	✓	✓				✓	✓										✓		
CBM Aggregates - London St Mary's, Ontario Mr. Michael Smith Tel: (519) 240-8410	✓	✓				✓	✓												
CBM Aggregates - Osprey Lab Cambridge, Ontario Hashim Anwar Tel: (519) 496-5346	✓	✓				✓	✓					✓	✓				✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
CBM Aggregates Sunderland, Ontario Mr. John Mceachern Tel: (705) 357-3147	✓	✓				✓	✓										✓		
CBM Aggregates Westwood, Ontario Mr. Robert Loeters Tel: (226) 237-6644	✓	✓				✓	✓										✓		
Central Earth Engineering Inc. Barrie, Ontario Mr. Alexander Winkelmann Tel: (705) 719-7994	✓	✓				✓	✓										✓	✓	
Chung & Vander Dollen Engineering Kitchener, Ontario Mr. William Evans Tel: (519) 742-8979	✓	✓				✓	✓										✓		
CMT Engineering Inc. St. Clements, Ontario Marci Smith Tel: (519) 699-5775	✓	✓				✓	✓										✓		
COCO GROUP - Mobile Lab # 2 Kingston, Ontario Tim Bilton Tel: (613) 536-9112	✓	✓				✓	✓										✓		
COCO GROUP Kingston, Ontario Mr. Tim Bilton Tel: (613) 536-9112	✓	✓		✓	✓	✓	✓					✓	✓				✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
COCO Paving Inc. Belleville, Ontario, Mr. Michael Haisma Tel: (613) 962-3461	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
COCO Paving Inc. Ottawa, Ontario Mr. Brad G. Gooderham Tel: (613) 907-7283	✓	✓		✓		✓	✓					✓	✓				✓		
COCO Paving Inc. Tecumseh, Ontario Mr. Harbal Dhaliwal Tel: (519) 727-3838	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
COCO Paving Inc. Toronto, Ontario Mr. Oussama Ibrahim Tel: (416) 633-9670	✓	✓		✓		✓	✓					✓	✓				✓	✓	
Colacem Canada L'Original, Ontario Mr. Shu Yang Tel: (819) 242-4312	✓	✓				✓	✓					✓	✓				✓		
Construction Testing Asphalt Lab Ltd. Cambridge, Ontario Mr. Peter Lung Tel: (519) 622-7023	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	
Cornwall Gravel Company Ltd. Cornwall, Ontario Ms. Billie-Gail Macfarlane Tel: (613) 930-3530	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Cox Construction Limited Guelph, Ontario Ms. Alana Smith Tel: (519) 824-6570	✓	✓				✓	✓										✓		
CRH Canada Group Inc. Etobicoke, Ontario Mylene Ite-hughes Tel: (416) 903-5783	✓	✓		✓	✓	✓	✓	✓		✓		✓	✓		✓		✓		
D. Crupi & Sons Limited Toronto, Ontario Mr. Pracash Kandasaami Tel: (416) 677-3037	✓	✓		✓		✓	✓										✓		
Danford Construction Limited Madoc, Ontario Mr. Al Danford Tel: (613) 473-2468	✓	✓				✓	✓										✓		
Davroc Testing Laboratories Inc. Brampton, Ontario Mr. Sal Fasullo Tel: (905) 792-7792	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
District Municipality of Muskoka Bracebridge, Ontario Mr. Dave Wood Tel: (705) 645-6764	✓	✓				✓	✓										✓	✓	
Doughty Aggregates (Peterborough) Lakefield, Ontario Mr. Wayne Rayfuse Tel: (705) 652-3016	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
For further information, contact: Soils-Aggregates@ontario.ca																			
Drain Bros. Excavating Limited Norwood, Ontario Mr. Elton Neuman Tel: (705) 639-2301	✓	✓		✓		✓	✓					✓	✓				✓	✓	
DS Consultants Ltd Vaughan, Ontario Mr. Jordan Gadjanov Tel: (905) 265-9393	✓	✓		✓	✓	✓	✓	✓				✓	✓				✓	✓	
DST Consulting Engineers Inc. Kenora, Ontario Mr. Neil Johnson Tel: (807) 548-2383	✓	✓				✓	✓										✓	✓	
DST Consulting Engineers Inc. Ottawa, Ontario Mr. Amer Mohammed Tel: (613) 222-4081	✓	✓				✓	✓										✓		
DST Consulting Engineers Inc. Sudbury, Ontario Lynne Brazeau Tel: 705 523-6680	✓	✓				✓	✓										✓	✓	
DST Consulting Engineers Inc. Thunder Bay, Ontario Syed Ahmed Tel: (807) 623-2929	✓	✓	✓	✓		✓	✓			✓		✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm																		
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	LS-603 Los Angeles Abrasion																		
	LS-604/5 Relative Density																		
	LS-606 Sulphate Soundness																		
	LS-607 Percent Crushed Particles					✓													
	LS-608 Percent Flat and Elongated					✓													
	LS-609 Petrographic Number -																		
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	LS-615 Alkali- Carbonate Reactivity																		
	LS-620 Accelerated Mortar Bar																		
	CSA A23.2-14A Concrete Prism																		
	LS-621 Asphalt Coated Particles					✓													
	LS-706 Standard Proctor Density					✓													
	LS-709 Granular Permeability																		
DST Consulting Engineers Waterloo, Ontario Hugh Arthur Tel: (519) 772-4521		✓																	
Dufferin Aggregates - Flamborough Dundas, Ontario Mr. Gord Taylor Tel: (905) 308-5324		✓	✓					✓										✓	
Dufferin Aggregates - Mill Creek Cambridge, Ontario Mr. Gord Taylor Tel: (905) 308-5324		✓	✓					✓										✓	
Dufferin Aggregates - Milton Milton, Ontario Ms. Kelly Mercer Tel: (416) 453-3268		✓	✓					✓										✓	
Dufferin Aggregates - Mosport Orono, Ontario Ms. Kelly Mercer Tel: (416) 453-3268		✓	✓					✓										✓	
Dufferin Construction (QC) - Bronte Oakville, Ontario Mr. Ronald Abdul Tel: (905) 827-5757		✓	✓		✓			✓				✓		✓				✓	✓

[illegible]

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Duncor Enterprises Inc. Barrie, Ontario Mr. Peter Smith Tel: (705) 730-1999	✓	✓				✓	✓										✓		
E.C. King Contracting Owen Sound, Ontario Mr. Lance Elliott Tel: (519) 376-6140	✓	✓				✓	✓										✓		
EnGlobe Corp - Kitchener Kitchener, Ontario Mr. Olton Rexha Tel: (519) 741-1313	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
EnGlobe Corp. Branford, Ontario Mr. Thom Staples Tel: (519) 720-0078	✓	✓				✓	✓										✓		
EnGlobe Corp. North Bay, Ontario Mr. J. P. Duhaime. Tel: (705) 476-2550	✓	✓		✓		✓	✓										✓	✓	
EnGlobe Corp. Toronto, Ontario Mr. Dawit Amar Tel: (416) 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
EnGlobe Corp. London, Ontario Mr. David Mcbay Tel: (519) 685-6400	✓	✓				✓	✓										✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Engtec Consulting Inc. Vaughan, Ontario Mr. Salman Bhutta Tel: (905) 856-2988	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	
exp Services Inc. Barrie, Ontario Mr. Leigh Knecht Tel: (705) 716-1100	✓	✓				✓	✓										✓	✓	
exp Services Inc. Brampton, Ontario Mickey Misra Tel: (905) 793-9800	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
exp Services Inc. Hamilton, Ontario Mr. Ashraf Abass Tel: (905) 573-4000	✓	✓				✓	✓										✓	✓	
exp Services Inc. London, Ontario Mr. David Speller Tel: (519) 963-3000	✓	✓		✓		✓	✓	✓	✓	✓		✓	✓				✓	✓	
exp Services Inc. Oldcastle, Ontario Mr. David G. Speller Tel: (519) 737-0588	✓	✓				✓	✓										✓	✓	
exp Services Inc. Ottawa, Ontario Mr. Ismail M. Taki Tel: (613) 723-2886	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	

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exp Services Inc. Sudbury, Ontario Mr. Robert Ferguson Tel: (705) 674-9681	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
exp Services Inc. Thunder Bay, Ontario Mr. Jason Goodman Tel: (807) 623-9495	✓	✓				✓	✓			✓		✓	✓				✓	✓	
exp Services Inc. Timmins, Ontario Mr. Jason Ferrigan Tel: (705) 363-6828	✓	✓				✓	✓										✓	✓	
Fermar Construction Limited Etobicoke, Ontario Mr. Ramon Meza Tel: (416) 657-3554	✓	✓		✓		✓	✓										✓	✓	
Four Corners Engineering Inc Markham, Ontario Ming Zhu Tel: (905) 475-1004	✓	✓		✓		✓	✓					✓	✓				✓	✓	
Fowler Construction Company Bracebridge, Ontario Mr. Ross Elliott Tel: (705) 644-4037	✓	✓		✓		✓	✓					✓	✓				✓	✓	
G. Tackaberry & Sons Construction Athens, Ontario Mr. Paul Rodgers Tel: (613) 924-2634	✓	✓				✓	✓										✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Gazzola Paving Etobicoke, Ontario Mr. Solomon Anduaem Tel: (416) 675-7007	✓	✓				✓	✓										✓		
GECAN Materials Analyses Lab Vaughan, Ontario Narayan Hanasoge Tel: (905) 760-2023	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
GEMTEC Consulting Engineers & Scientists Petawawa, Ontario Allan Brotton Tel: (613) 585-3626	✓	✓				✓	✓										✓		
GEMTEC Consulting Engineers & Scientists Ottawa, Ontario Mrs. Krystle Smith Tel: (613) 836-1422	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
Geo Terre Limited Brampton, Ontario Mr. Ivan Corbett Tel: (905) 455-5666	✓	✓				✓	✓										✓	✓	
GeoPro Consulting Limited Richmond Hill, Ontario James Chen Tel: (905) 237-8336	✓	✓		✓		✓	✓										✓	✓	
GHD Limited Waterloo, Ontario Mr. Abdul H. Khan Tel: (519) 884-0510	✓	✓		✓		✓	✓										✓	✓	✓

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
GHD Limited Ottawa, Ontario Mr. Eric Bennett Tel: (613) 727-0510	✓	✓				✓	✓										✓		
GHD Limited St. Catharines, Ontario Mr. Wayne Russell Tel: (905) 682-0510	✓	✓				✓	✓										✓	✓	
GHD Limited Peterborough, Ontario Mr. Matt Rawlings Tel: (705) 749-3317	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	
GHD Limited Whitby, Ontario Mr. Matt Rawlings Tel: (705) 761-9047	✓	✓		✓		✓	✓					✓	✓				✓	✓	
GHD Limited Pembroke, Ontario Ms. Heather Kuisma Tel: (613) 735-8361	✓	✓				✓	✓										✓	✓	
GHD Limited Mississauga, Ontario Mr. Raj Kadia Tel: (905) 712-0510	✓	✓				✓	✓										✓	✓	
GM BluePlan Engineering Limited Owen Sound, Ontario Mr. Derek Brewster Tel: (519) 376-1805	✓	✓				✓	✓										✓	✓	

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Golder Associates Limited Burnaby, British Columbia Mr. Fred Shrimer Tel: (604) 412-6719	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	✓	
Golder Associates Limited Mississauga, Ontario Ms. Mariana Manojlovic Tel: (905) 567-6100	✓	✓				✓	✓										✓	✓	✓
Golder Associates Limited Ottawa, Ontario Mr. Chris Mangione Tel: (613) 592-9600	✓	✓		✓		✓	✓										✓	✓	
Golder Associates Limited Sudbury, Ontario Ms. Tina Gauthier Tel: (705) 524-6861	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
Golder Associates Limited Whitby, Ontario Mr. Jeremy Rose Tel: 905 723-2727	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Golder Associates Limited Windsor, Ontario Mr. Laura Zarlenga Tel: (519) 250-3733	✓	✓		✓		✓	✓										✓	✓	
Golder Associates Limited. London, Ontario Mr. Laura Pryla Tel: (519) 652-0099	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Graham Bros. Construction Ltd. Brampton, Ontario Mr. Greg Thompson Tel: (905) 866-3093	✓	✓		✓		✓	✓					✓	✓				✓		
Greenwood Aggregates Amaranth, Ontario Mr. Andrew Raymond Tel: (519) 941-0732	✓	✓		✓		✓	✓					✓	✓				✓		
H & H Construction Inc. Petawawa, Ontario Mr. Kevin Hoffman Tel: (613) 687-8154	✓	✓				✓	✓										✓	✓	
Harold Sutherland Construction Ltd. Kemble, Ontario Mr. Roland Leigh Tel: (519) 376-3506	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
HATCH Ltd. Niagara Falls, Ontario Mr. Ralph Serluca Tel: (905) 374-5200	✓	✓				✓	✓								✓		✓	✓	✓
HLV2K Engineering Limited Mississauga, Ontario Irfan Ahmad Khokhar Tel: (647) 447-7641	✓	✓				✓	✓										✓	✓	
Interpaving Asphalt & Aggregate Supply Ltd. Garson, Ontario Ms. Ashley Edwards Tel: (705) 694-6210	✓	✓		✓		✓	✓	✓				✓	✓				✓	✓	

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	LS-602 Sieve Analysis	✓	✓																
	LS-603 Los Angeles Abrasion																		
	LS-604/5 Relative Density																		
	LS-606 Sulphate Soundness																		
	LS-607 Percent Crushed Particles					✓													
	LS-608 Percent Flat and Elongated					✓													
	LS-609 Petrographic Number -																		
	LS-616 Petrographic Analysis – Fine																		
	LS-614 Freeze-Thaw						✓												
	LS-613 Insoluble Residue																		
	LS-618 Micro-Deval CA									✓									
	LS-619 Micro-Deval FA									✓									
	LS-615 Alkali- Carbonate Reactivity																		
	LS-620 Accelerated Mortar Bar																		
	CSA A23.2-14A Concrete Prism																		
	LS-621 Asphalt Coated Particles						✓												
	LS-706 Standard Proctor Density						✓												
	LS-709 Granular Permeability																		
Interpaving Asphalt and Aggregate Supply Ltd. Garson, Ontario Ashley Edwards Tel: (705) 694-6210		✓	✓					✓		✓								✓	✓
Intratech Engineering Laboratories Scarborough, Ontario Mr. Frank Miles Tel: (416) 754-2077		✓	✓			✓		✓				✓						✓	✓
J & P Leveque Bros. Ltd. - Mobile 617 Bancroft, Ontario Mr. Shawn Franksy Tel: (613) 332-5533		✓	✓					✓		✓				✓				✓	✓
J & P Leveque Bros. Ltd.- Mobile 616 Bancroft, Ontario Mr. Shawn Franksy Tel: (613) 332-5533		✓	✓					✓		✓				✓				✓	✓
John D. Paterson & Associates Ltd. Nepean, Ontario Mr. Stephen Walker Tel: (613) 226-7381		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓				✓	✓
John D. Paterson & Associates North Bay, Ontario Mr. Shawn Nelson Tel: (705) 472-5331		✓	✓		✓	✓	✓	✓	✓		✓	✓	✓					✓	✓

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Klohn Crippen Berger Lively, Ontario Mr. Alex Niesing Tel: (705) 522-1367	✓	✓															✓	✓	
Lafarge Canada - Caledon Pit Caledon, Ontario Mr. Chris Thomas Tel: (905) 977-7363	✓	✓				✓	✓										✓		
Lafarge Canada - Mobile 434 Oro Station, Ontario Mrs. Christine Crumbie Tel: (705) 623-2744	✓	✓				✓	✓										✓		
Lafarge Canada Inc. - Brechtin Brechtin, Ontario Ms. Christine Crumbie Tel: (705) 484-5225	✓	✓				✓	✓										✓		
Lafarge Canada Inc. - Dundas Quarry Dundas, Ontario Mr. Chris Thomas Tel: (905) 977-7363	✓	✓		✓	✓	✓	✓			✓		✓	✓		✓		✓	✓	
Lafarge Canada Inc. - London London, Ontario Ms. Kaitlyn Souter Tel: (519) 537-0999	✓	✓				✓	✓										✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Lafarge Canada Inc. - Pt. Anne Quarry Belleville, Ontario Mr. Jason Malcolm Tel: (613) 813-4857	✓	✓				✓	✓										✓		
Lafarge Canada Inc. Woodstock Quarry Embrow, Ontario Kaitlyn Misale Tel: (519) 537-0999	✓	✓				✓	✓										✓		
Lafarge Canada Inc. Cambridge, Ontario Ms. Kaitlyn Souter Tel: (519) 537-0999	✓	✓				✓	✓										✓		
Lafarge Canada Inc. Fonthill, Ontario Ms. Kaitlyn Souter Tel: (519) 537-0999	✓	✓				✓	✓										✓		
Lafarge Canada Inc. Meldrum Bay, Ontario Mr. Jeff Middleton Tel: (705) 283-3011	✓	✓				✓	✓										✓		
Lafarge Canada Inc. Orono, Ontario Mr. Frances Clements Tel: (905) 983-9260	✓	✓				✓	✓										✓		
Lafarge Canada Inc. Ottawa, Ontario Mr. Gustavo Imoberdorf Tel: (613) 834-4223	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Lafarge Canada Inc. St-Laurent, Québec Arsenio Gonzalez Tel: (438) 265-1084														✓	✓	✓			
Lafarge Canada Inc. Stouffville, Ontario Ms. Christine Crumbie Tel: (905) 640-5883	✓	✓				✓	✓										✓		
Lafarge Canada Inc. - West Paris Paris, Ontario Mr. Kaitlyn Souter Tel: (905) 537-0999	✓	✓				✓	✓										✓		
Lafarge Construction Materials Ltd. Brockville, Ontario Mr. Paul Arkeveld Tel: (613) 349-7422	✓	✓				✓	✓			✓		✓	✓				✓		
Lafarge McAdoo Lab Kingston, Ontario Mr. Paul Arkeveld Tel: (613) 349-7422	✓	✓				✓	✓										✓		
Landtek Limited Hamilton, Ontario Mr. Ralph Di Cienzo Tel: (905) 383-3733	✓	✓		✓		✓	✓					✓	✓				✓	✓	
Lavis Contracting Co. Limited Clinton, Ontario Mr. George Brown Tel: (519) 482-3694	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓				✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
LRL Associates Ltd. Ottawa, Ontario Ms. Wendy McLaughlin Tel: (613) 842-3434	✓	✓				✓	✓										✓	✓	
Malroz Engineering Inc. Kingston, Ontario Mr. Dylan Hill Tel: (613) 548-3446	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	
McAsphalt Engineering Services Toronto, Ontario Mr. Michael Esenwa Tel: (416) 281-8181	✓	✓		✓		✓	✓										✓		
McIntosh Perry - CCI Group Inc. Concord, Ontario Ms. Liliana Fevga Tel: (905) 856-5200	✓	✓		✓		✓	✓										✓	✓	
McIntosh Perry Nepean, Ontario Harrison Smith Tel: (613) 266-0535	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	
Mill-Am Corporation - Mobile 890901 Windsor, Ontario Mr. Abdul R. Saifan Tel: (519) 791-2753	✓	✓				✓	✓										✓		
Miller Northwest - Mobile 942012 Dryden, Ontario Ms. Kim Finlayson Tel: (807) 223-2844	✓	✓				✓	✓											✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Miller Northwest Limited Mobile 120601 Dryden, Ontario Ms. Kin Finlayson Tel: (807) 223-2844	✓	✓				✓	✓											✓	
Miller Paving - Mobile 8660 Arnprior, Ontario Ms. Michelle Baumhour Tel: (613) 623-3144	✓	✓				✓	✓										✓		
Miller Paving Limited Markham, Ontario Ms. Carla Hariprashad Tel: (905) 475-6660	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	
Miller Paving Limited Whitby, Ontario Mr. John Straub Tel: (905) 655-3889	✓	✓				✓	✓										✓		
Miller Paving Ltd. - Mobile 1084 North Bay, Ontario Mr. Herb Villneff Tel: (705) 472-3312	✓	✓				✓	✓										✓	✓	
Miller Paving Northern - Lab 160622 New Liskeard, Ontario Amanda Swan Tel: (705) 648-0145	✓	✓				✓	✓										✓		
Miller Paving Northern - Mobile 1254 North Bay, Ontario Mr. Herb Villneff Tel: (705) 472-3312	✓	✓		✓		✓	✓										✓	✓	

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Miller Paving Northern - Mobile 8661 North Bay, Ontario Mr. Herb Villneff Tel: (705) 472-3312	✓	✓				✓	✓										✓	✓	
Miller Paving Northern New Liskeard, Ontario Doreen Passenier Tel: (705) 647-2948	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
MNA Engineering Limited Scarborough, Ontario Mr. Peter Balendran Tel: (416) 757-8882	✓	✓		✓	✓	✓	✓										✓	✓	
MTE Consultants Inc. Stratford, Ontario Montana Wilson Tel: (519) 271-7952	✓	✓				✓	✓										✓	✓	
MTO Downsview Downsview, Ontario Ms. Anne Holt Tel: (416) 235-3543	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓		✓		✓	✓	
Nasiruddin Engineering Limited Mississauga, Ontario Mr. Shakeel Nasiruddin Tel: (416) 882-5136	✓	✓		✓		✓	✓										✓	✓	
National Testing Laboratories Limited Winnipeg, Manitoba Mr. Jason Thompson Tel: 204 488-6999	✓	✓		✓	✓	✓	✓					✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Nelson Aggregate Co. - Lincoln Beamsville, Ontario Mr. Shawn Warkholdt Tel: (905) 563-8226	✓	✓				✓	✓					✓	✓				✓		
Nelson Aggregate Co. Burlington, Ontario Mr. Mike Rook Tel: (905) 335-5250	✓	✓				✓	✓										✓		
Nelson Aggregate Co. Orillia, Ontario Mr. Mike Roote Tel: (705) 352-2264	✓	✓				✓	✓										✓		
Orbit Engineering Limited Brampton, Ontario Dr. Aly Ahmed Tel: (905) 494-0074	✓	✓		✓		✓	✓										✓	✓	
Peto MacCallum Limited Barrie, Ontario Mr. Andrew Jones Tel: (705) 734-3900	✓	✓		✓		✓	✓										✓	✓	
Peto MacCallum Limited Hamilton, Ontario Mr. Amjad Khan Tel: (905) 561-2231	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Peto MacCallum Limited Kitchener, Ontario Mr. Sean Jerry Tel: (519) 893-7500	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Peto MacCallum Limited Toronto, Ontario Mr. Geoffrey Uwimana Tel: (416) 785-5110	✓	✓		✓		✓	✓										✓	✓	✓
Pioneer Construction Inc. Garson, Ontario Mr. David Pilkey Tel: (705) 693-1363	✓	✓		✓		✓	✓			✓		✓	✓				✓		
Pioneer Construction Inc. Sault Ste. Marie, Ontario Mrs. Shelley Geiling Tel: (705) 541-2280	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
Pioneer Construction Inc. Thunder Bay, Ontario Mr. Tony Fazio Tel: (807) 768-6008	✓	✓		✓		✓	✓										✓		
Port Colborne Quarries Inc. Port Colborne, Ontario Mr. Tim Cassibo Tel: (905) 834-3647	✓	✓				✓	✓										✓		
Precision Concrete Testing Sault Ste. Marie, Ontario Mr. Steven Hoffman Tel: (807) 355-5955	✓	✓				✓	✓										✓	✓	
Preston Sand & Gravel Cambridge, Ontario Mr. Matthew Bell Tel: (519) 242-0902	✓	✓				✓	✓										✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
R. W. Tomlinson Limited Ottawa, Ontario Mr. Paul Charbonneau Tel: (613) 822-0543	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
Regional Municipality of Durham Whitby, Ontario Mr. Joeman Ng Tel: (905) 655-3340	✓	✓				✓	✓										✓		
Saffa Engineering Inc. Markham, Ontario Fawad Khan Tel: (905) 604-8194	✓	✓		✓		✓	✓										✓	✓	
Sarafinchin Associates Ltd. Rexdale, Ontario Mr. Scott Jeffrey Tel: (416) 674-1770	✓	✓				✓	✓										✓		
Shaba Testing Services Limited Kirkland Lake, Ontario Mr. Lad Shaba Tel: (705) 567-4187	✓	✓				✓	✓										✓	✓	
Sirati & Partners Consultants Ltd. Vaughan, Ontario Andrew Mendonca Tel: (905) 669-4477	✓	✓				✓	✓										✓	✓	
Smelter Bay Aggregates Inc. Thessalon, Ontario Mr. Jacob King Tel: (705) 842-2597	✓	✓				✓	✓										✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
SNC Lavalin GEM Ontario Inc. Kingston, Ontario Mr. Jon Ubdegrove Tel: (613) 389-1781	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	
SNC-Lavalin Gem Ontario Inc. Vaughan, Ontario Mr. Zlatko Brcic Tel: (905) 851-0090	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
SNC-Lavalin GEM Québec inc. Montréal, Quebec Simon Grenier Tel: (514) 393-8000	✓	✓				✓	✓										✓	✓	
SNC-Lavalin Gatineau, Quebec Ms. Isabelle Chaîné Tel: (819) 669-1225	✓	✓				✓	✓										✓	✓	
Soil Engineers Limited Scarborough, Ontario Mr. S. Sanjeevan Tel: (416) 754-8515	✓	✓				✓	✓										✓	✓	
Soil-Mat Engineers & Consultants Ltd. Hamilton, Ontario Matt Livecchi Tel: (905) 318-7440		✓				✓	✓										✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Sola Engineering Vaughan, Ontario Mr. Kanthavanam I. Pooranan Tel: (905) 760-9501	✓	✓				✓	✓										✓	✓	
St. Lawrence Testing & Inspection Co. Cornwall, Ontario Mr. Gib McIntee Tel: (613) 938-2521	✓	✓		✓		✓	✓			✓		✓	✓				✓	✓	
St. Marys Leaside Lab Toronto, Ontario Mr. Stephen Parkes Tel: (416) 423-2439	✓	✓		✓	✓	✓	✓			✓		✓	✓		✓		✓		
Stantec Consulting Ltd. Dartmouth, NS Ms. Jessica Waite Tel: (902) 468-0444	✓	✓				✓	✓								✓	✓			
Stantec Consulting Ltd. Markham, Ontario Ms. Eric Fron Tel: (905) 479-9345	✓	✓		✓		✓	✓										✓	✓	✓
Stantec Consulting Ltd. Ottawa, Ontario Mr. Jeff Weng Tel: (613) 722-4420	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	
Steed and Evans Ltd. St. Jacobs, Ontario Mr. Richard Marco Tel: (519) 699-4646	✓	✓		✓		✓	✓										✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm																		
	LS-602 Sieve Analysis	✓	✓																
	LS-603 Los Angeles Abrasion																		
	LS-604/5 Relative Density																		
	LS-606 Sulphate Soundness																		
	LS-607 Percent Crushed Particles					✓													
	LS-608 Percent Flat and Elongated					✓													
	LS-609 Petrographic Number -																		
	LS-616 Petrographic Analysis – Fine																		
	LS-614 Freeze-Thaw																		
	LS-613 Insoluble Residue																		
	LS-618 Micro-Deval CA																		
	LS-619 Micro-Deval FA																		
	LS-615 Alkali- Carbonate Reactivity																		
	LS-620 Accelerated Mortar Bar																		
	CSA A23.2-14A Concrete Prism																		
	LS-621 Asphalt Coated Particles					✓													
	LS-706 Standard Proctor Density																		
	LS-709 Granular Permeability																		
Taranis Contracting Group Thunder Bay, Ontario Ms. Cheryl Thompson Tel: (807) 631-6169		✓	✓				✓	✓											
TBT Engineering Limited Mobile Lab 4 Thunder Bay, Ontario Tim Fummerton Tel: (807) 624-5162		✓	✓				✓	✓									✓		
TBT Engineering Ltd. Thunder Bay, Ontario Mr. Tim Fummerton Tel: (807) 624-5162		✓	✓		✓		✓	✓	✓	✓	✓	✓					✓	✓	✓
Teranorth Construction & Engineering Sudbury, Ontario Mr. Edward Carriere Tel: (705) 523-1540		✓	✓				✓	✓									✓		
Terrapex Environmental Ltd. Toronto, Ontario Mr. Demetra Matthews Tel: (905) 474-5265		✓	✓				✓	✓									✓	✓	
Terraprobe Inc. Barrie, Ontario Mr. Jerry Duguid Tel: (705) 739-8355		✓	✓		✓		✓	✓									✓	✓	
Terraprobe Inc. Brampton, Ontario Mr. Vishnu Goswami Tel: (905) 796-2650		✓	✓		✓		✓	✓					✓	✓			✓	✓	✓

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Terraprobe Inc. Stoney Creek, Ontario Mr. Patrick Cannon Tel: (905) 643-7560	✓	✓		✓		✓	✓										✓	✓	
Terraprobe Inc. Sudbury, Ontario Mr. Denis Paquette Tel: (705) 670-0460	✓	✓				✓	✓										✓	✓	
Terraspec Engineering Inc. Peterborough, Ontario Mr. Shane Galloway Tel: (705) 743-7880	✓	✓				✓	✓										✓		
The Karson Aggregates Carp, Ontario Mr. Cameron MacDonald Tel: (613) 880-1164	✓	✓		✓	✓	✓	✓			✓		✓	✓		✓		✓		
The Miller Group - Materials Research Lab Gormley, Ontario Mr. Justin Baxter Tel: (905) 726-9518	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	
The Murray Group Limited Harriston, Ontario Mr. Jerry Dunham Tel: (519) 501-0776	✓	✓				✓	✓										✓		
Thomas Cavanagh Construction Ltd. Ashton, Ontario Mr. Phil White Tel: (613) 257-2918	✓	✓		✓	✓	✓	✓			✓		✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Thurber Engineering Limited Oakville, Ontario Mr. Weiss Mehdawi Tel: (905) 829-8666	✓	✓				✓	✓										✓	✓	✓
Thurber Engineering Ltd. Ottawa, Ontario Mr. Fred Griffiths Tel: (613) 247-2121	✓	✓				✓	✓										✓	✓	
Tom Veert Contracting Ltd. – Mobile 001 Fort Frances, Ontario Mr. Tyler Gaspar Tel: (807) 274-6898	✓	✓				✓	✓										✓	✓	
Tri City Materials Petersburg, Ontario Mr. Ron Shantz Tel: (519) 634-5110	✓	✓				✓	✓										✓		
True Grit Consulting Ltd. Thunder Bay, Ontario Mr. Cliff Long Tel: (807) 626-5640	✓	✓				✓	✓										✓	✓	
Tulloch Engineering Inc. Sault Ste. Marie, Ontario Mr. Adam Byers Tel: (705) 949-1457	✓	✓		✓		✓	✓					✓	✓				✓	✓	
Vicdom Sand and Gravel Limited Uxbridge, Ontario Mr. Bruno Giordano Tel: (905) 649-2193	✓	✓				✓	✓										✓		

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
For further information, contact: Soils-Aggregates@ontario.ca																			
Walker Aggregates Inc. Duntroon Lab Duntroon, Ontario Mr. Tom Risi Tel: (705) 445-2300	✓	✓				✓	✓										✓		
Walker Aggregates Inc. McGregor Lab Amherstburg, Ontario Tom Risi Tel: (519) 726-6882	✓	✓				✓	✓										✓		
Walker Aggregates Inc. WBQ Lab Niagara Falls, Ontario Mr. Tom Risi Tel: (905) 227-4142	✓	✓		✓	✓	✓	✓					✓	✓				✓		
Waynco Ltd. Cambridge, Ontario Ms. Valerie Snowdon Tel: (905) 335-5250	✓	✓				✓	✓										✓		
Wood Environment & Infrastructure Burlington, Ontario Mr. Ognienko Lazic Tel: (905) 335-2353	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Wood Environment & Infrastructure Cambridge, Ontario Ms. Jason Taylor Tel: (519) 650-7116	✓	✓	✓			✓	✓					✓	✓				✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number -	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-615 Alkali- Carbonate Reactivity	LS-620 Accelerated Mortar Bar	CSA A23.2-14A Concrete Prism	LS-621 Asphalt Coated Particles	LS-706 Standard Proctor Density	LS-709 Granular Permeability
Wood Environment & Infrastructure Lively, Ontario David M Brown Tel: (705) 682-2632	✓	✓				✓	✓										✓		
Wood Environment & Infrastructure Richmond Hill, Ontario Mr. S. Baskaran Tel: (905) 415-2632	✓	✓	✓	✓	✓	✓	✓			✓		✓	✓				✓	✓	✓
Wood Environment & Infrastructure Sarnia, Ontario Mr. Geoff Collier Tel: (519) 337-5409	✓	✓		✓		✓	✓										✓	✓	
Wood Environment & Infrastructure Tecumseh, Ontario Mr. Justin Palmer Tel: (519) 735-2499	✓	✓		✓		✓	✓										✓	✓	
Wood Environment & Infrastructure Thorold, Ontario Mr. Andrew Markov Tel: (905) 687-6616	✓	✓				✓	✓										✓	✓	
WSP - Ottawa Nepean, Ontario Mr. Nick Krebs Tel: (613) 228-0065	✓	✓				✓	✓										✓	✓	

2019 Participants List Ministry of Transportation Aggregate Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-601 Wash Pass 75µm																		
	LS-602 Sieve Analysis	✓	✓																
	LS-603 Los Angeles Abrasion																		
	LS-604/5 Relative Density																		
	LS-606 Sulphate Soundness																		
	LS-607 Percent Crushed Particles		✓																
	LS-608 Percent Flat and Elongated		✓																
	LS-609 Petrographic Number -																		
	LS-616 Petrographic Analysis – Fine																		
	LS-614 Freeze-Thaw		✓																
	LS-613 Insoluble Residue		✓																
	LS-618 Micro-Deval CA		✓																
	LS-619 Micro-Deval FA		✓																
	LS-615 Alkali- Carbonate Reactivity																		
	LS-620 Accelerated Mortar Bar																		
	CSA A23.2-14A Concrete Prism																		
	LS-621 Asphalt Coated Particles		✓																
	LS-706 Standard Proctor Density		✓																
	LS-709 Granular Permeability																		

Appendix D. List of Participants – Soils

Table 3. List of Participants – Soils.

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
AECOM Canada Ltd. Toronto, Ontario Venkata Ramana Mullapudi, Tel: (416) 527-1824	✓	✓	✓			
AME - Materials Engineering Caledon, Ontario Mr. Scott Crowley, Tel: 905 840-5914	✓	✓	✓			
AME - Materials Engineering Ottawa, Ontario Mr. Harrison Smith, Tel: (613) 726-3039	✓	✓	✓			
C.T. Soil & Materials Testing Inc. Windsor, Ontario Mr. Thomas J. O'Dwyer, Tel: (519) 966-8863	✓	✓	✓			
Cambium Inc. Peterborough, Ontario Mr. Stuart Baird, Tel: (705) 741-4109	✓	✓	✓			
Central Earth Engineering Inc. Barrie, Ontario, Mr. Alexander Winkelmann, Tel: (705) 719-7994	✓	✓				
Construction Testing Asphalt Lab Ltd. Cambridge, Ontario Mr. Peter Lung, Tel: (519) 622-7023	✓	✓	✓			
Cornwall Gravel Company Ltd. Cornwall, Ontario Ms. Billie-Gail Macfarlane, Tel: (613) 930-3530		✓				

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
CRH Canada Group Inc. Etobicoke, Ontario Mylene Ite-hughes, Tel: (416) 903-5783		✓				
Davroc Testing Laboratories Inc. Brampton, Ontario Mr. Sal Fasullo, Tel: (905) 792-7792	✓	✓	✓			
Doughty Aggregates (Peterborough) Ltd. Lakefield, Ontario Mr. Wayne Rayfuse, Tel: (705) 652-3016	✓	✓	✓			
DS Consultants Ltd. Vaughan, Ontario Mr. Jordan Gadjanov, Tel: (905) 265-9393	✓	✓	✓			
DST Consulting Engineers Inc. Thunder Bay, Ontario Syed Ahmed, Tel: (807) 623-2929	✓	✓	✓			
DST Consulting Engineers Waterloo, Ontario Hugh Arthur, Tel: (519) 772-4521	✓	✓	✓			
Dufferin Construction (QC) - Bronte Oakville, Ontario Mr. Ronald Abdul, Tel: (905) 827-5757	✓	✓	✓			
Dufferin Construction Company - North Main King City, Ontario Mr. Chad Henderson, Tel: (905) 833-4666		✓				
EnGlobe Corp - Kitchener Kitchener, Ontario Mr. Oltion Rexha, Tel: (519) 741-1313	✓	✓	✓			
EnGlobe Corp. North Bay, Ontario Mr. J. P. Duhaime., Tel: (705) 476-2550	✓	✓	✓			

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
EnGlobe Corp. Toronto, Ontario Mr. Dawit Amar, Tel: (416) 213-1060	✓	✓	✓			
EnGlobe Corp. London, Ontario Mr. David Mcbay, Tel: (519) 685-6400	✓	✓	✓			
Engtec Consulting Inc. Vaughan, Ontario Mr. Salman Bhutta, Tel: (905) 856-2988	✓	✓	✓			
exp Services Inc. Barrie, Ontario Mr. Leigh Knecht, Tel: (705) 716-1100	✓	✓	✓			
exp Services Inc. Brampton, Ontario Mickey Misra, Tel: (905) 793-9800	✓	✓	✓	✓	✓	✓
exp Services Inc. Hamilton, Ontario Mr. Ashraf Abass, Tel: (905) 573-4000	✓	✓	✓			
exp Services Inc. London, Ontario Mr. David Speller, Tel: (519) 963-3000	✓	✓	✓			
exp Services Inc. Ottawa, Ontario Mr. Ismail M. Taki, Tel: (613) 723-2886	✓	✓	✓			
exp Services Inc. Sudbury, Ontario Mr. Robert Ferguson, Tel: (705) 674-9681	✓	✓	✓			
exp Services Inc. Thunder Bay, Ontario Mr. Jason Goodman, Tel: (807) 623-9495		✓				

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Four Corners Engineering Inc Markham, Ontario Ming Zhu, Tel: (905) 475-1004	✓	✓	✓			
GEMTEC Consulting Engineers and Scientists Ltd. Ottawa, Ontario Mrs. Krystle Smith, Tel: (613) 836-1422	✓	✓	✓			
Geo Terre Limited Brampton, Ontario Mr. Ivan Corbett, Tel: (905) 455-5666	✓	✓	✓			
GeoPro Consulting Limited Richmond Hill, Ontario, James Chen, Tel: (905) 237-8336	✓	✓	✓			
GHD Limited Waterloo, Ontario Mr. Abdul H. Khan, Tel: (519) 884-0510	✓	✓	✓	✓	✓	✓
GHD Limited St. Catharines, Ontario Mr. Wayne Russell, Tel: (905) 682-0510	✓	✓	✓			
GHD Limited Peterborough, Ontario Mr. Matt Rawlings, Tel: (705) 749-3317	✓	✓	✓			
GHD Limited Whitby, Ontario, Mr. Matt Rawlings, Tel: (705) 761-9047	✓	✓	✓			
GHD Limited Pembroke, Ontario, Ms. Heather Kuisma, Tel: (613) 735-8361	✓	✓	✓			
GHD Limited Mississauga, Ontario, Mr. Raj Kadia, Tel: (905) 712-0510	✓	✓	✓			

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Golder Associates Limited Burnaby, British Columbia Mr. Fred Shrimmer, Tel: (604) 412-6719	✓	✓	✓			
Golder Associates Limited Mississauga, Ontario Ms. Mariana Manojlovic, Tel: (905) 567-6100	✓	✓	✓	✓	✓	✓
Golder Associates Limited Ottawa, Ontario Mr. Chris Mangione, Tel: (613) 592-9600	✓	✓	✓			
Golder Associates Limited Sudbury, Ontario Ms. Tina Gauthier, Tel: (705) 524-6861	✓	✓	✓	✓		
Golder Associates Limited Whitby, Ontario Mr. Jeremy Rose, Tel: 905 723-2727	✓	✓	✓			
Golder Associates Limited Windsor, Ontario Mr. Laura Zarlenga, Tel: (519) 250-3733	✓	✓	✓			
Golder Associates Limited. London, Ontario Mr. Laura Pryla, Tel: (519) 652-0099	✓	✓	✓			
HATCH Ltd. Niagara Falls, Ontario Mr. Ralph Serluca, Tel: (905) 374-5200	✓	✓	✓	✓	✓	
HLV2K Engineering Limited Mississauga, Ontario Irfan Ahmad Khokhar, Tel: (647) 447-7641	✓	✓	✓			
Interpaving Asphalt & Aggregate Supply Ltd. Garson, Ontario Ms. Ashley Edwards, Tel: (705) 694-6210		✓				

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Intratech Engineering Laboratories Inc. Scarborough, Ontario Mr. Frank Miles, Tel: (416) 754-2077	✓	✓	✓			
J & P Leveque Bros. Ltd. - Mobile 617 Bancroft, Ontario Mr. Shawn Fransky, Tel: (613) 332-5533		✓				
J & P Leveque Bros. Ltd.- Mobile 616 Bancroft, Ontario Mr. Shawn Fransky, Tel: (613) 332-5533		✓				
John D. Paterson & Associates Ltd. Nepean, Ontario Mr. Stephen Walker, Tel: (613) 226-7381	✓	✓	✓			
John D. Paterson & Associates North Bay, Ontario Mr. Shawn Nelson, Tel: (705) 472-5331	✓	✓	✓			
Klohn Crippen Berger Lively, Ontario Mr. Alex Niesing, Tel: (705) 522-1367	✓	✓	✓			
Lafarge Canada Inc. - Dundas Quarry Dundas, Ontario Mr. Chris Thomas, Tel: (905) 977-7363		✓				
Lafarge Canada Inc. Ottawa, Ontario Mr. Gustavo Imoberdorf, Tel: (613) 834-4223		✓				
Landtek Limited Hamilton, Ontario Mr. Ralph Di Cienzo, Tel: (905) 383-3733	✓	✓	✓			
LRL Associates Ltd. Ottawa, Ontario Ms. Wendy McLaughlin, Tel: (613) 842-3434	✓	✓	✓			

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Malroz Engineering Inc. Kingston, Ontario Mr. Dylan Hill, Tel: (613) 548-3446	✓	✓	✓			
McIntosh Perry - CCI Group Inc. Concord, Ontario Ms. Liliana Fevga, Tel: (905) 856-5200	✓	✓	✓			
McIntosh Perry Nepean, Ontario Harrison Smith, Tel: (613) 266-0535	✓	✓	✓	✓		
Miller Paving Northern New Liskeard, Ontario Doreen Passenier, Tel: (705) 647-2948		✓				
MNA Engineering Limited Scarborough, Ontario Mr. Peter Balendran, Tel: (416) 757-8882	✓	✓	✓			
MTE Consultants Inc. Stratford, Ontario Montana Wilson, Tel: (519) 271-7952	✓	✓	✓			
MTO Downsview Downsview, Ontario Mr. Anne Holt, Tel: (416) 235-4901	✓	✓	✓			
Nasiruddin Engineering Limited Mississauga, Ontario Mr. Shakeel Nasiruddin, Tel: (416) 882-5136	✓	✓	✓			
National Testing Laboratories Limited Winnipeg, Manitoba Mr. Jason Thompson, Tel: 204 488-6999	✓	✓	✓			
Orbit Engineering Limited Brampton, Ontario Dr. Aly Ahmed, Tel: (905) 494-0074	✓	✓	✓			

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Peto MacCallum Limited Barrie, Ontario Mr. Andrew Jones, Tel: (705) 734-3900	✓	✓	✓			
Peto MacCallum Limited Hamilton, Ontario Mr. Amjad Khan, Tel: (905) 561-2231	✓	✓	✓			
Peto MacCallum Limited Kitchener, Ontario Mr. Sean Jerry, Tel: (519) 893-7500	✓	✓	✓			
Peto MacCallum Limited Toronto, Ontario Mr. Geoffrey Uwimana, Tel: (416) 785-5110	✓	✓	✓	✓	✓	✓
Precision Concrete Testing Sault Ste. Marie, Ontario Mr. Steven Hoffman, Tel: (807) 355-5955	✓	✓	✓			
R. W. Tomlinson Limited Ottawa, Ontario Mr. Paul Charbonneau, Tel: (613) 822-0543		✓	✓			
Saffa Engineering Inc. Markham, Ontario Fawad Khan, Tel: (905) 604-8194		✓				
Sarafinchin Associates Ltd. Rexdale, Ontario Mr. Scott Jeffrey, Tel: (416) 674-1770	✓	✓	✓			
Sirati & Partners Consultants Ltd. Vaughan, Ontario Andrew Mendonca, Tel: (905) 669-4477	✓	✓	✓			
SNC Lavalin GEM (DBA Engineering Limited) Kingston, Ontario Mr. Jon Ubdegrove, Tel: (613) 389-1781	✓	✓	✓			

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
SNC-Lavalin Gem Ontario Inc. (DBA) Vaughan, Ontario Mr. Zlatko Brcic, Tel: (905) 851-0090	✓	✓	✓			
SNC-Lavalin GEM Québec inc. Montréal, Quebec Simon Grenier, Tel: (514) 393-8000	✓	✓	✓			
SNC-Lavalin Gatineau, Quebec Ms. Isabelle Chaîné, Tel: (819) 669-1225	✓	✓	✓			
Soil Engineers Limited Scarborough, Ontario Mr. S. Sanjeevan, Tel: (416) 754-8515	✓	✓	✓			
Sola Engineering Vaughan, Ontario Mr. Kanthavanam I. Pooranan, Tel: (905) 760-9501	✓	✓	✓			
St. Lawrence Testing & Inspection Co. Ltd Cornwall, Ontario Mr. Gib McIntee, Tel: (613) 938-2521	✓	✓	✓			
Stantec Consulting Ltd. Markham, Ontario Ms. Eric Fron, Tel: (905) 479-9345	✓	✓	✓			
Stantec Consulting Ltd. Ottawa, Ontario Mr. Jeff Weng, Tel: (613) 722-4420	✓	✓	✓	✓	✓	✓
TBT Engineering Ltd. Thunder Bay, Ontario Mr. Tim Fummerton Tel: (807) 624-5162	✓	✓	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Terrapex Environmental Ltd. Toronto, Ontario Mr. Demetra Matthews and Mr. Sam Chow, Tel: (905) 474-5265	✓	✓	✓			
Terraprobe Inc. Barrie, Ontario Mr. Jerry Duguid, Tel: (705) 739-8355	✓	✓	✓			
Terraprobe Inc. Brampton, Ontario Mr. Vishnu Goswami, Tel: (905) 796-2650	✓	✓	✓	✓	✓	✓
Terraprobe Inc. Stoney Creek, Ontario Mr. Patrick Cannon, Tel: (905) 643-7560	✓	✓	✓			
Terraprobe Inc. Sudbury, Ontario Mr. Denis Paquette, Tel: (705) 670-0460	✓	✓	✓			
Terraspec Engineering Inc. Peterborough, Ontario Mr. Shane Galloway, Tel: (705) 743-7880	✓	✓	✓			
The Miller Group - Materials Research Lab Gormley, Ontario Mr. Justin Baxter, Tel: (905) 726-9518		✓				
Thomas Cavanagh Construction Ltd. Ashton, Ontario Mr. Phil White, Tel: (613) 257-2918		✓				
Thurber Engineering Limited Oakville, Ontario Mr. Weiss Mehdawi, Tel: (905) 829-8666	✓	✓	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
Thurber Engineering Ltd. Ottawa, Ontario Mr. Fred Griffiths, Tel: (613) 247-2121	✓	✓	✓	✓		
True Grit Consulting Ltd. Thunder Bay, Ontario Mr. Cliff Long, Tel: (807) 626-5640	✓	✓	✓			
Tulloch Engineering Inc. Sault Ste. Marie, Ontario Mr. Adam Byers, Tel: (705) 949-1457	✓	✓	✓	✓		
Wood Environment & Infrastructure Solutions Burlington, Ontario Mr. Ognienko Lazic, Tel: (905) 335-2353	✓	✓	✓			
Wood Environment & Infrastructure Solutions Cambridge, Ontario Ms. Jason Taylor, Tel: (519) 650-7116	✓	✓	✓			
Wood Environment & Infrastructure Solutions Richmond Hill, Ontario Mr. S. Baskaran, Tel: (905) 415-2632	✓	✓	✓	✓	✓	
Wood Environment & Infrastructure Solutions Sarnia, Ontario Mr. Geoff Collier, Tel: (519) 337-5409	✓	✓	✓			
Wood Environment & Infrastructure Solutions Tecumseh, Ontario Mr. Justin Palmer, Tel: (519) 735-2499	✓	✓	✓			
Wood Environment & Infrastructure Solutions Thorold, Ontario Mr. Andrew Markov, Tel: (905) 687-6616	✓	✓	✓			
WSP Canada Inc. Nepean, Ontario Mr. Nick Krebs, Tel: (613) 228-0065	✓	✓	✓			

2019 Participants List Ministry of Transportation Soil Proficiency Sample Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	ASTM D2435 Consolidation Properties	ASTM D3080 Direct Shear Test	ASTM D5084 Hydraulic Conductivity
WSP Canada Inc. Toronto, Ontario Mr. Harun Rashid, Tel: (416) 679-9410	☑	☑	☑	☑		
WSP Canada Inc. Markham, Ontario Marjan Darnahal, Tel: (905) 475-0065	☑	☑	☑			
WSP Canada Inc. Peterborough, Ontario Ms. Kasey Conlon, Tel: (705) 743-6850	☑	☑	☑			

Appendix E. List of Participants – Superpave

Table 4. List of Participants – Superpave.

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
AME - Materials Engineering Caledon, Ontario Mr. Scott Crowley, Tel: 905 840-5914	✓	✓	✓	✓
C. Villeneuve Construction - Mobile 1 Hearst, Ontario, Mr. Charles Harris, Tel: (705) 372-1838	✓	✓	✓	✓
Cambium Inc. Peterborough, Ontario, Mr. Stuart Baird, Tel: (705) 741-4109	✓	✓	✓	✓
Capital Paving Inc. Guelph, Ontario, Mr. Mark Latyn, Tel: (519) 822-4511	✓	✓	✓	✓
COCO GROUP Kingston, Ontario, Mr. Tim Bilton, Tel: (613) 536-9112	✓	✓	✓	✓
COCO Paving Inc. Belleville, Ontario, Mr. Michael Haisma, Tel: (613) 962-3461	✓	✓	✓	✓
COCO Paving Inc. Ottawa, Ontario, Mr. Brad G. Gooderham, Tel: (613) 907-7283	✓	✓	✓	✓
COCO Paving Inc. Tecumseh, Ontario, Mr. Harbal Dhaliwal, Tel: (519) 727-3838	✓	✓	✓	✓
COCO Paving Inc. Toronto, Ontario, Mr. Oussama Ibrahim, Tel: (416) 633-9670	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Construction Testing Asphalt Lab Ltd. Cambridge, Ontario, Mr. Peter Lung, Tel: (519) 622-7023	✓	✓	✓	✓
Cornwall Gravel Company Ltd. Cornwall, Ontario, Ms. Billie-Gail Macfarlane, Tel: (613) 930-3530	✓	✓	✓	✓
Cox Construction Limited Guelph, Ontario, Ms. Alana Smith, Tel: (519) 824-6570			✓	✓
D. Crupi & Sons Limited Toronto, Ontario, Mr. Prakash Kandasaami, Tel: (416) 677-3037	✓	✓	✓	✓
Davroc Testing Laboratories Inc. Brampton, Ontario, Mr. Sal Fasullo, Tel: (905) 792-7792	✓	✓	✓	✓
DS Consultants Ltd. Vaughan, Ontario, Mr. Jordan Gadjanov, Tel: (905) 265-9393	✓	✓	✓	✓
DST Consulting Engineers Inc. Thunder Bay, Ontario, Syed Ahmed, Tel: (807) 623-2929		✓	✓	✓
Dufferin Construction (QC) - Bronte Oakville, Ontario, Mr. Ronald Abdul, Tel: (905) 827-5757	✓	✓	✓	✓
Dufferin Construction Company - North Main King City, Ontario, Mr. Chad Henderson, Tel: (905) 833-4666	✓	✓	✓	✓
Duncor Enterprises Inc. Barrie, Ontario, Mr. Peter Smith, Tel: (705) 730-1999	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
EnGlobe Corp. - LVM Toronto, Ontario, Mr. Dawit Amar or Ms. Jingyun Yao (PN), Tel: (416) 213-1060	✓	✓	✓	✓
Engtec Consulting Inc. Vaughan, Ontario, Mr. Salman Bhutta, Tel: (905) 856-2988	✓	✓	✓	✓
exp Services Inc. Brampton, Ontario, Mickey Misra, Tel: (905) 793-9800	✓	✓	✓	✓
exp Services Inc. Ottawa, Ontario, Mr. Ismail M. Taki, Tel: (613) 723-2886	✓	✓	✓	✓
exp Services Inc. Sudbury, Ontario, Mr. Robert Ferguson, Tel: (705) 674-9681	✓	✓	✓	✓
Fermar Construction Limited Etobicoke, Ontario, Mr. Ramon Meza, Tel: (416) 657-3554	✓	✓	✓	✓
Fowler Construction Company Bracebridge, Ontario, Mr. Ross Elliott, Tel: (705) 644-4037	✓	✓	✓	✓
GECAN Materials Analyses Laboratory Vaughan, Ontario, Narayan Hanasoge, Tel: (905) 760-2023	✓	✓	✓	✓
GEMTEC Consulting Engineers and Scientists Ltd. Ottawa, Ontario, Mrs. Krystle Smith, Tel: (613) 836-1422	✓	✓	✓	✓
GeoPro Consulting Limited Richmond Hill, Ontario, James Chen, Tel: (905) 237-8336	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
GHD (Geo-Logic Inc.) Peterborough, Ontario, Mr. Matt Rawlings, Tel: (705) 749-3317	✓	✓	✓	✓
GHD (Geo-Logic Inc.) Whitby, Ontario, Mr. Matt Rawlings, Tel: (705) 761-9047	✓	✓	✓	✓
Golder Associates Limited Burnaby, British Columbia, Mr. Fred Shrimmer or Ms. Lily Hu, Tel: (604) 412-6719	✓	✓	✓	✓
Golder Associates Limited Sudbury, Ontario, Ms. Tina Gauthier, Tel: (705) 524-6861	✓	✓	✓	✓
Golder Associates Limited Whitby, Ontario, Mr. Jeremy Rose, Tel: 905 723-2727	✓	✓	✓	✓
Golder Associates Limited. London, Ontario, Mr. Laura Pryla, Tel: (519) 652-0099	✓	✓	✓	✓
Graham Bros. Construction Ltd. Brampton, Ontario, Mr. Greg Thompson, Tel: (905) 866-3093	✓	✓	✓	✓
Greenwood Aggregates Amaranth, Ontario, Mr. Andrew Raymond, Tel: (519) 941-0732	✓	✓	✓	✓
Harold Sutherland Construction Ltd. Kemble, Ontario, Mr. Roland Leigh, Tel: (519) 376-3506	✓	✓	✓	✓
Interpaving Asphalt & Aggregate Supply Ltd. Garson, Ontario, Ms. Ashley Edwards, Tel: (705) 694-6210	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
John D. Paterson & Associates Ltd. Nepean, Ontario, Mr. Stephen Walker, Tel: (613) 226-7381	✓	✓	✓	✓
John D. Paterson & Associates North Bay, Ontario, Mr. Shawn Nelson, Tel: (705) 472-5331	✓	✓	✓	✓
Lafarge Canada Inc. - Dundas Quarry Dundas, Ontario, Mr. Chris Thomas, Tel: (905) 977-7363	✓		✓	✓
Landtek Limited Hamilton, Ontario, Mr. Ralph Di Cienzo, Tel: (905) 383-3733	✓	✓	✓	✓
Lavis Contracting Co. Limited Clinton, Ontario, Mr. George Brown, Tel: (519) 482-3694	✓	✓	✓	✓
McAsphalt Engineering Services Toronto, Ontario, Mr. Michael Esenwa, Tel: (416) 281-8181	✓	✓	✓	✓
Miller Northwest - Mobile 942012 Dryden, Ontario, Ms. Kim Finlayson, Tel: (807) 223-2844			✓	
Miller Northwest Limited - Mobile 120601 Dryden, Ontario, Ms. Kin Finlayson, Tel: (807) 223-2844			✓	
Miller Paving Limited Markham, Ontario, Ms. Carla Hariprashad, Tel: (905) 475-6660	✓	✓	✓	✓
Miller Paving Northern - Mobile 1254 North Bay, Ontario, Mr. Herb Villneff, Tel: (705) 472-3312			✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Miller Paving Northern New Liskeard, Ontario, Doreen Passenier, Tel: (705) 647-2948	✓	✓	✓	✓
MNA Engineering Limited Scarborough, Ontario, Mr. Peter Balendran, Tel: (416) 757-8882	✓	✓	✓	✓
MTO Downsview Downsview, Ontario, Mr. Zhiyong Jiang, Tel: (416) 235-4901	✓	✓	✓	✓
Nasiruddin Engineering Limited Mississauga, Ontario, Mr. Shakeel Nasiruddin, Tel: (416) 882-5136	✓	✓	✓	✓
National Testing Laboratories Limited Winnipeg, Manitoba, Mr. Jason Thompson, Tel: 204 488-6999	✓	✓	✓	✓
Peto MacCallum Limited Hamilton, Ontario, Mr. Amjad Khan, Tel: (905) 561-2231	✓	✓	✓	✓
Peto MacCallum Limited Kitchener, Ontario, Mr. Sean Jerry, Tel: (519) 893-7500	✓	✓	✓	✓
Peto MacCallum Limited Toronto, Ontario, Mr. Geoffrey Uwimana, Tel: (416) 785-5110	✓	✓	✓	✓
Pioneer Construction Inc. Garson, Ontario, Mr. David Pilkey, Tel: (705) 693-1363	✓	✓	✓	✓
Pioneer Construction Inc. Sault Ste. Marie, Ontario, Mrs. Shelley Geiling, Tel: (705) 541-2280	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
Pioneer Construction Inc. Thunder Bay, Ontario, Mr. Tony Fazio, Tel: (807) 768-6008	✓	✓	✓	✓
R. W. Tomlinson Limited Ottawa, Ontario, Mr. Paul Charbonneau, Tel: (613) 822-0543	✓	✓	✓	✓
SNC Lavalin GEM (DBA Engineering Limited) Kingston, Ontario, Mr. Jon Ubdegrove, Tel: (613) 389-1781	✓	✓	✓	✓
SNC-Lavalin Gem Ontario Inc. (DBA) Vaughan, Ontario, Mr. Zlatko Brcic, Tel: (905) 851-0090	✓	✓	✓	✓
St. Lawrence Testing & Inspection Co. Ltd Cornwall, Ontario, Mr. Gib McIntee, Tel: (613) 938-2521	✓	✓	✓	✓
Stantec Consulting Ltd. Ottawa, Ontario, Mr. Jeff Weng, Tel: (613) 722-4420	✓	✓	✓	✓
Steed and Evans Ltd. St. Jacobs, Ontario, Mr. Richard Marco, Tel: (519) 699-4646	✓		✓	✓
TBT Engineering Ltd. Thunder Bay, Ontario, Mr. Tim Fummerton, Tel: (807) 624-5162	✓	✓	✓	✓
Terraprobe Inc. Brampton, Ontario, Mr. Vishnu Goswami, Tel: (905) 796-2650	✓	✓	✓	✓
The Karson Aggregates Carp, Ontario, Mr. Cameron MacDonald, Tel: (613) 880-1164	✓	✓	✓	✓

2019 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information, contact: Soils-Aggregates@ontario.ca	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
The Miller Group - Materials Research Lab Gormley, Ontario, Mr. Justin Baxter, Tel: (905) 726-9518	✓	✓	✓	✓
Thomas Cavanagh Construction Ltd. Ashton, Ontario, Mr. Phil White, Tel: (613) 257-2918	✓	✓	✓	✓
Wood Environment & Infrastructure Solutions Burlington, Ontario, Mr. Ognienko Lazic, Tel: (905) 335-2353	✓	✓	✓	✓
Wood Environment & Infrastructure Solutions Cambridge, Ontario, Ms. Jason Taylor, Tel: (519) 650-7116	✓	✓	✓	✓
Wood Environment & Infrastructure Solutions Richmond Hill, Ontario, Mr. S. Baskaran, Tel: (905) 415-2632	✓	✓	✓	✓
Wood Environment & Infrastructure Solutions Sarnia, Ontario, Mr. Geoff Collier, Tel: (519) 337-5409	✓	✓	✓	✓
WSP Canada Inc. Markham, Ontario, Marjan Darnahal, Tel: (905) 475-0065	✓	✓	✓	✓

Appendix F. Multi-Laboratory Precision

Table 5. Multi-Laboratory Precision for Proficiency Tests.

Test 1:	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
WP 75µm	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	MTO LS-601
Mean	0.86	0.96	0.73	0.73	0.88	0.88	0.46	0.46	< 2.5
1S	0.16	0.19	0.12	0.12	0.15	0.14	0.09	0.09	0.20
D2S	0.45	0.53	0.33	0.33	0.42	0.40	0.25	0.25	0.58
Test 2:	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 19.0mm	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM C136 ^A
Mean	92.0	92.9	98.6	98.3	91.3	91.1	95.3	95.3	100 - 95
1S	1.0	1.1	0.38	0.45	1.8	1.7	0.9	0.9	0.35
D2S	2.8	3.0	1.08	1.27	5.09	4.81	2.5	2.5	1.0
Test 3	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 16.0 mm	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM C136 ^A
Mean	82.8	84.5	90.0	88.6	80.0	79.5	88.4	88.4	95 - 85
1S	1.3	1.6	1.38	1.26	3.2	3.2	1.5	1.6	1.37
D2S	3.7	4.4	3.91	3.57	9.05	9.05	4.2	4.5	3.9
Test 4	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 13.2 mm	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM C136 ^A
Mean	74.7	77.0	78.9	76.4	68.7	68.0	81.5	81.5	85 – 80
1S	1.5	1.9	1.78	1.89	3.8	3.8	2.0	2.1	1.92
D2S	4.1	5.4	5.03	5.33	10.75	10.75	9.6	17.5	5.4
Test 5	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 9.5 mm	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM C136 ^A
Mean	63.1	65.6	62.8	60.2	53.0	52.2	70.1	70.2	80 – 60
1S	1.4	2.1	2.22	1.94	3.8	3.9	2.2	2.3	2.82
D2S	4.0	6.0	6.27	5.48	10.75	11.03	3.4	6.2	8.0
Test 6	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 4.75 mm	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM C136 ^A
Mean	48.0	50.2	45.1	43.1	38.2	37.8	53.0	53.2	60 – 20

1S	1.4	2.3	1.94	1.62	3.1	3.4	1.9	2.2	1.97	
D2S	4.0	6.4	5.49	4.58	8.77	9.62	0.0	0.0	5.6	
Test 8	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	ASTM C131
L. A	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	C of V	σ^*
Mean	25.5	25.7	22.3	22.3	26.7	26.7	24.8	25.1	10-45	25.0
1S	0.7	0.7	0.73	0.78	1.1	0.6	1.9	1.5	4.5%	1.1
D2S	1.9	1.8	2.06	2.21	3.11	1.70	5710.59	5710.59	12.7%	3.1
Test 9	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
RD (O.D.)	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	MTO LS-604	
Mean	2.694	2.696	2.648	2.650	2.708	2.707	2.665	2.664	N/A	
1S	0.007	0.007	0.006	0.007	0.007	0.007	0.007	0.007	0.006	
D2S	0.020	0.020	0.020	0.010	0.020	0.020	0.255	0.255	0.016	
Test 10	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
ABS	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	MTO LS-604	
Mean	1.061	1.038	1.067	1.052	1.213	1.216	1.446	1.434	< 2%	
1S	0.080	0.075	0.070	0.077	0.094	0.092	0.091	0.086	0.09	
D2S	0.226	0.212	0.197	0.22	0.266	0.260	5710.594	5710.594	0.25	
Test 11	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	ASTM C88
MgSO ₄	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	C of V	σ^*
Mean	2.5	2.4	2.300	2.335	4.2	4.1	6.8	6.8	9-20%	2.3
1S	0.9	0.8	0.766	0.823	1.3	1.3	2.2	1.7	25%	0.6
D2S	2.6	2.4	2.166	2.327	3.7	3.7	230.5	230.5	71%	1.7
Test 12	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
% Crush	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	MTO LS-607	
Mean	73.0	73.8	64.79	65.42	96.9	97.0	77.6	77.6	55% - 85%	
1S	4.4	4.2	5.471	5.572	2.0	2.0	4.5	4.3	4.7	
D2S	12.6	11.8	15.474	15.759	5.7	5.7	9.6	17.5	13.2	
Test 13	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
% F & E	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	MTO LS-608	
Mean	8.0	8.2	4.188	4.067	4.2	4.1	6.9	6.8	2.0% - 9.5%	
1S	1.9	2.0	1.236	1.167	1.3	1.2	1.8	2.0	2.3	
D2S	5.3	5.8	3.49	3.30	3.7	3.4	3.37	6.19	6.4	

Test 16 MDA, CA	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	MTO LS-618
	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	C of V	σ^*
Mean	9.8	9.8	11.024	11.059	10.5	10.4	11.1	11.0	5-23%	8.8
1S	0.56	0.55	0.633	0.700	0.66	0.74	0.85	0.80	5.4%	0.48
D2S	1.58	1.57	1.79	1.98	1.87	2.09	0.02	0.02	15.2%	1.34
Test 17 Freeze/thaw	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	MTO LS-614
	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	C of V	σ^*
Mean	2.54	2.60	5.147	4.966	2.80	2.76	6.39	6.28	3-18%	1.73
1S	0.84	1.01	1.328	5.400	0.86	0.79	1.78	1.23	21.6%	0.37
D2S	2.39	2.86	3.76	3.45	2.43	2.23	5710.59	5710.59	61.0%	1.06
Test 20 P 2.36 mm	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM C136 ^A	
Mean	38.2	40.0	35.52	34.14	30.9	30.5	42.6	45.2	60 - 20	
1S	1.7	2.2	1.955	1.489	2.7	2.7	2.2	2.4	1.41	
D2S	4.7	6.3	5.53	4.21	7.6	7.6	0.3	0.25	4.0	
Test 21 P 1.18 mm	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM C136 ^A	
Mean	29.4	30.7	28.51	27.57	24.9	24.6	34.8	34.8	60 - 20	
1S	1.6	2.1	1.874	1.419	2.4	2.2	2.1	2.1	1.41	
D2S	4.6	5.8	5.30	1.01	6.8	6.2	5710.6	5710.6	4.0	
Test 22 P 600 μm	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM C136 ^A	
Mean	21.8	22.7	21.62	21.12	19.0	18.8	28.5	28.3	60 - 20	
1S	1.3	1.7	1.612	1.220	1.8	1.8	1.7	1.9	1.41	
D2S	3.8	4.7	4.56	3.45	5.1	5.1	230.5	230.5	4.0	
Test 23 P 300 μm	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM C136 ^A	
Mean	15.6	16.2	11.02	10.73	12.9	12.9	21.6	21.6	60 - 20	
1S	1.0	1.2	0.764	0.653	1.2	1.2	1.2	1.4	1.41	
D2S	2.7	3.3	2.16	1.85	3.4	3.4	9.6	17.5	4.0	
Test 24	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	

P 150 µm	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM C136 ^A
Mean	11.8	12.3	6.12	5.99	9.0	9.0	14.1	14.1	15 - 10
1S	0.8	0.9	0.447	0.362	0.9	0.8	0.8	0.9	0.73
D2S	2.1	2.5	1.26	1.02	2.5	2.3	3.37	6.19	2.1
Test 25	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 75 µm	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM C136 ^A
Mean	8.4	8.6	4.85	4.73	6.1	6.1	9.2	9.3	10 - 2
1S	0.5	0.6	0.355	0.281	0.5	0.5	0.5	0.6	0.65
D2S	1.3	1.6	1.00	0.79	1.4	1.4	0.02	0.02	1.8
Test 27	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
RD (O.D.)	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	MTO LS-605
Mean	2.692	2.692	2.631	2.631	2.696	2.696	2.687	2.687	N/A
1S	0.013	0.012	0.011	0.010	0.011	0.009	0.009	0.010	0.012
D2S	0.037	0.034	0.03	0.03	0.031	0.025	5710.594	5710.594	0.034
Test 28	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
ABS	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	MTO LS-605
Mean	1.058	1.043	1.365	1.349	0.969	0.986	1.225	1.213	< 2.0%
1S	0.127	0.134	0.116	0.120	0.123	0.147	0.148	0.148	0.16
D2S	0.36	0.38	0.33	0.34	0.35	0.42	219.49	219.49	0.44
Test 30	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
% ACP	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	MTO LS-621
Mean	33.4	32.6	59.3	61.8	44.1	43.8	38.4	37.2	25% - 55%
1S	3.0	3.3	4.852	4.404	2.841	2.616	2.123	2.838	3.9
D2S	8.5	9.2	13.72	12.46	8.0	7.4	0.3	0.3	11.1
Test 31	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
MWD	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM D698
Mean	2.456	2.454	2.384	2.386	2.451	2.449	2.457	2.458	N/A
1S	0.033	0.029	0.034	0.041	0.035	0.038	0.028	0.030	N/A
D2S	0.093	0.082	0.09	0.12	0.099	0.107	5710.594	5710.6	N/A
Test 32	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
MDD	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM D698
Mean	22.936	22.984	2.228	2.230	2.333	2.338	2.330	2.335	106.2 (pcf)

1S	0.425	0.345	0.031	0.036	0.033	0.031	0.032	0.033	1.0	
D2S	1.203	0.976	0.09	0.10	0.093	0.088	230.5	230.5	2.9	
Test 33	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
OMC	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM D698	
Mean	5.80	5.75	6.91	6.90	5.88	5.83	6.05	6.02	16.7	
1S	0.49	0.50	0.79	0.77	0.71	0.71	0.64	0.56	1.0	
D2S	1.38	1.42	2.22	2.19	2.01	2.01	9.62	17.5	2.9	
Test 34	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	MTO LS-619
MDA, FA3	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	C of V	σ^*
Mean	15.3	15.3	15.0	15.1	13.7	13.8	19.6	20.1	7-18%	15.8
1S	1.2	1.3	1.0	1.0	1.1	1.2	1.7	1.4	7.6%	1.2
D2S	3.4	3.7	2.80	2.9	3.1	3.4	3.37	6.2	21.4%	3.4
Test 40	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
P 2.0 mm	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702	
Mean	99.9	99.9	100.0	99.9	100.0	100.0	100.0	100.0	No Precision Statements	
1S	0.1	0.1	0.07	0.06	0.07	0.06	0.05	0.06	No Precision Statements	
D2S	0.4	0.3	0.19	0.16	0.2	0.2	0.02	0.02	No Precision Statements	
Test 41	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
P 425 μ m	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702	
Mean	98.2	98.1	99.0	99.0	98.6	98.6	97.6	97.3	No Precision Statements	
1S	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	No Precision Statements	
D2S	0.7	0.8	0.6	0.6	0.6	0.8	5710.6	5710.6	No Precision Statements	
Test 42	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
P 75 μ m	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702	
Mean	94.7	94.0	97.5	97.6	95.3	95.3	90.4	89.1	No Precision Statements	
1S	0.5	0.4	0.3	0.2	0.4	0.6	1.0	0.9	No Precision Statements	
D2S	1.3	1.2	0.8	0.5	1.1	1.7	219.5	219.5	No Precision Statements	
Test 43	2016	2016	2017	2017	2018	2018	2019	2019	Standard:	
P 20 μ m	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702	
Mean	86.9	86.3	92.4	92.6	89.1	89.2	81.7	79.9	No Precision Statements	
1S	3.4	3.1	3.5	3.1	2.6	3.0	3.2	3.2	No Precision Statements	
D2S	9.5	8.6	10.0	8.8	7.4	8.5	0.25	0.3	No Precision Statements	

Test 44	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 5 μm	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702
Mean	76.8	75.8	66.4	66.4	79.5	80.3	56.1	54.1	No Precision Statements
1S	3.5	3.2	3.8	3.4	3.3	3.5	3.3	3.4	No Precision Statements
D2S	10.0	9.1	10.9	9.6	9.3	9.9	5710.6	5710.6	No Precision Statements
Test 45	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P 2 μm	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702
Mean	65.9	64.8	43.7	43.7	68.9	69.5	34.4	35.6	No Precision Statements
1S	3.7	3.4	3.7	3.2	3.5	3.5	3.0	3.1	No Precision Statements
D2S	10.3	9.5	10.5	9.1	9.9	9.9	230.5	230.5	No Precision Statements
Test 46	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
L. L	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	MTO LS-702
Mean	50.2	49.2	39.0	39.0	51.4	51.6	32.2	31.4	No Precision Statements
1S	2.1	2.2	1.3	1.4	2.4	2.4	1.6	1.8	No Precision Statements
D2S	6.0	6.1	3.6	3.9	6.8	6.8	9.6	17.5	No Precision Statements
Test 47	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P. L	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	ASTM D4318
Mean	21.7	21.4	20.5	20.7	22.2	22.3	17.5	17.1	20.6
1S	1.4	1.5	1.3	1.4	1.9	1.9	1.3	1.2	2.0
D2S	3.9	4.3	3.8	4.0	5.4	5.4	3.37	6.19	6
Test 48	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
P. I	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	ASTM D4318
Mean	28.5	27.9	18.453	18.164	29.2	29.5	14.9	14.5	39.2
1S	2.5	2.3	1.811	1.950	2.3	2.1	1.8	1.6	2.5
D2S	7.1	6.5	5.12	5.52	6.5	5.9	0.02	0.02	7
Test 49	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
SG of Soils	5.16	6.16	5.17	6.17	5.18	6.18	5.19	6.19	ASTM D4318
Mean	2.752	2.754	2.775	2.775	2.767	2.764	2.771	2.766	N/A
1S	0.035	0.030	0.030	0.028	0.018	0.022	0.024	0.028	0.04
D2S	0.099	0.085	0.08	0.07	0.051	0.062	5710.6	5710.6	0.11
Test 50	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
Consolidation	N/A	N/A	N/A	N/A	N/A	N/A	5.19	6.19	ASTM D4318

Mean	No Data	No Data	No Data	No Data	No Data	No Data	7.70E-4	8.61E-4	No Precision Statements
1S	No Data	No Data	No Data	No Data	No Data	No Data	3.15E-4	3.44E-4	No Precision Statements
D2S	No Data	No Data	No Data	No Data	No Data	No Data	8.88E-4	9.70E-4	No Precision Statements
Test 51 Direct Shear	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
	N/A	N/A	N/A	N/A	N/A	N/A	5.19	6.19	ASTM D3080
Mean	No Data	No Data	No Data	No Data	No Data	No Data	219.703	224.407	No Precision Statements
1S	No Data	No Data	No Data	No Data	No Data	No Data	7.985	11.294	No Precision Statements
D2S	No Data	No Data	No Data	No Data	No Data	No Data	22.518	31.850	No Precision Statements
Test 52 Conductivity	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
	N/A	N/A	N/A	N/A	N/A	N/A	5.19	6.19	ASTM D5084
Mean	No Data	No Data	No Data	No Data	No Data	No Data	4.8E-11	5.1E-11	3.8E-8
1S	No Data	No Data	No Data	No Data	No Data	No Data	1.2E-11	6.7E-12	6.2E-9
D2S	No Data	No Data	No Data	No Data	No Data	No Data	3.4E-11	1.9E-11	1.8E-8
Test 53 Permeability	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
	N/A	N/A	N/A	N/A	N/A	N/A	5.19	6.19	LS-709
Mean	No Data	No Data	No Data	No Data	No Data	No Data	0.0095	0.0088	No Precision Statements
1S	No Data	No Data	No Data	No Data	No Data	No Data	0.0086	0.0084	No Precision Statements
D2S	No Data	No Data	No Data	No Data	No Data	No Data	0.024	0.024	No Precision Statements
Test 95 UC Void	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	AASHTO T 304

Mean	43.3	43.4	42.4	42.5	42.9	43.0	44.4	44.5	N/A
1S	0.48	0.48	0.49	0.48	0.48	0.44	0.59	0.57	0.33%
D2S	1.35	1.35	1.39	1.35	1.36	1.24	0.25	0.25	0.93%
Test 96	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
SE Value	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM D2419
Mean	42.1	42.2	58.1	57.5	47.9	47.5	39.0	38.5	< 80
1S	5.5	5.0	6.6	6.2	7.2	7.2	4.6	4.2	8.0
D2S	15.5	14.0	18.8	17.7	20.4	20.4	5710.6	5710.6	22.6
Test 97	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
% Fractured	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM D5821
Mean	78.6	66.9	65.719	66.259	71.7	71.7	78.2	77.6	76.0%
1S	3.9	4.3	5.2	5.0	6.0	5.7	3.4	3.6	5.2%
D2S	11.0	12.2	14.8	14.1	17.0	16.1	230.5	230.5	14.7%
Test 99	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
% F & E	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	ASTM D4791
Mean	2.44	2.62	1.36	1.24	1.25	1.32	2.32	2.33	19.0 -12.5 mm
1S	0.93	0.93	0.47	0.46	0.52	0.53	1.02	1.09	88.5%
D2S	2.62	2.62	1.33	1.29	1.47	1.50	9.6	17.5	250.3%
Test 15	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
% Residue	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM D3042
Mean	74.7	74.6	26.9	26.6	29.7	28.9	10.3	10.4	4.7%
1S	1.2	2.2	1.4	1.1	2.3	1.9	0.5	0.7	0.9
D2S	3.5	6.2	4.0	3.1	6.5	5.4	3.37	6.2	2.7
Test 98	2016	2016	2017	2017	2018	2018	2019	2019	Standard:
% Retained	3.16	4.16	3.17	4.17	3.18	4.18	3.19	4.19	ASTM D3042
Mean	70.7	70.9	24.8	24.8	27.8	27.1	4.0	4.3	N/A
1S	1.3	1.3	0.9	1.0	1.7	1.6	2.2	2.4	3.1
D2S	3.7	3.8	2.61	2.79	4.8	4.5	0.25	0.25	8.9
Test 123	2016	2016	2017	2017	2018	2018	2019	2019	ASTM C1260 **
Mortar Bar	1.16	2.16	1.17	2.17	1.18	2.18	1.19	2.19	C of V
Mean	0.237	0.239	0.152	0.160	0.328	0.327	0.081	0.081	>0.1%
1S	0.034	0.036	0.037	0.031	0.056	0.051	0.008	0.009	15.2%

D2S	0.096	0.102	0.100	0.090	0.158	0.144	0.25	0.25	43%
Test 125	2016	2016	2017	2017	2018	2018	2019	2019	CSA A23.2-14A
Conc. Prism	N/A	N/A	1.17	2.17	1.18	2.18	1.19	2.19	C of V
Mean	No Data	No Data	0.026	0.027	0.033	0.036	0.184	0.187	>0.014%
1S	No Data	No Data	0.009	0.007	0.005	0.011	0.015	0.007	23%
D2S	No Data	No Data	1.39	1.35	0.014	0.031	0.25	0.255	65%

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix G. Number of Laboratories Excluding Outliers over Outliers

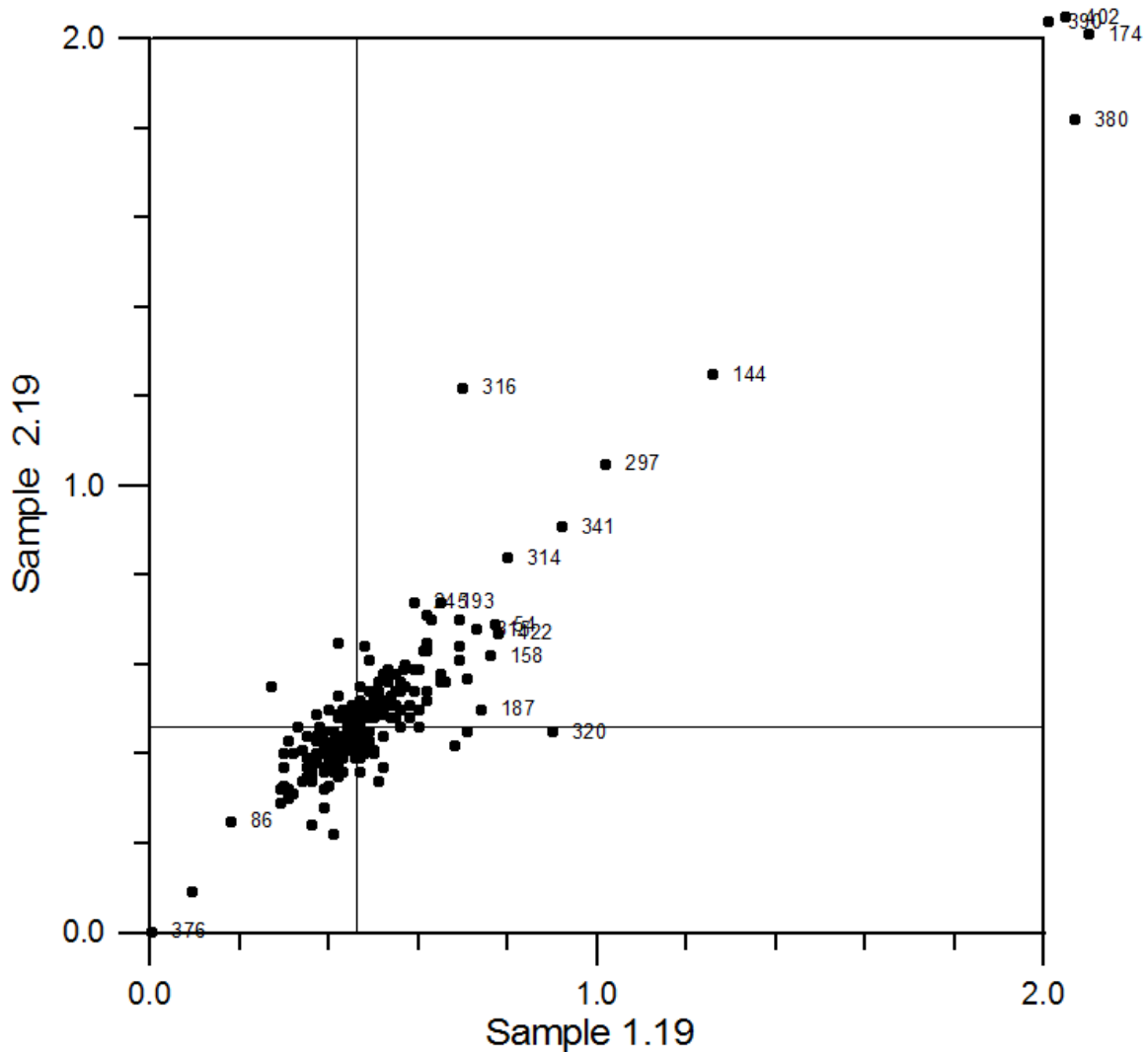
Table 6. Number of laboratories excluding outliers(n) over Outliers(Out); (n/Out).

Year	2016	2017	2018	2019
Test 1 WP 75 mm	208/17	220/20	219/18	208/19
Test 2 P 19.0 mm	214/10	229/11	230/7	221/8
Test 3 P 16.0 mm	211/12	233/7	234/3	222/7
Test 4 P 13.2 mm	212/12	227/13	235/2	225/4
Test 5 P 9.5 mm	211/13	233/7	234/3	221/8
Test 6 P 4.75 mm	212/12	230/10	235/2	214/15
Test 8 L. A	8/2	10/0	10/2	11/0
Test 9 RD (O.D.)	99/4	98/5	100/4	100/2
Test 10 ABS	98/5	91/12	100/4	98/4
Test 11 MgSO ₄	38/3	37/1	38/0	39/2
Test 12 % Crush	202/23	212/28	201/36	218/9
Test 13 % F & E	190/33	200/38	231/6	218/10
Test 16 MDA, CA	73/5	73/2	74/1	78/3
Test 17 Freeze/thaw	54/5	55/3	58/1	54/4
Test 20 P 2.36 mm	214/10	229/10	232/5	218/9
Test 21 P 1.18 mm	231/8	231/8	232/5	215/13
Test 22 P 600 µm	212/12	231/8	233/4	213/15
Test 23 P 300 µm	210/14	224/15	230/7	209/19
Test 24 P 150 µm	208/16	227/12	227/10	215/13
Test 25 P 75 µm	202/22	222/17	223/14	214/14
Test 27 RD (O.D.)	95/7	95/3	92/7	87/12
Test 28 ABS	94/8	92/6	93/5	94/5
Test 30 % ACP	213/10	214/24	220/16	204/21
Test 31 MWD	111/15	124/17	122/12	125/15
Test 32 MDD	103/23	125/15	120/14	135/5
Test 33 OMC	116/10	138/2	132/2	137/3
Test 34 MDA, FA3	76/1	72/3	75/0	75/5
Test 40 P 2.0 mm	79/11	97/0	95/0	95/0
Test 41 P 425 µm	82/8	87/10	90/5	87/8
Test 42 P 75 µm	85/5	90/7	92/3	88/7
Test 43 P 20 µm	85/5	92/5	90/5	91/4
Test 44 P 5 µm	86/4	92/5	91/4	92/3
Test 45 P 2 µm	85/3	90/7	91/4	92/3
Test 46 L. L	102/4	107/7	102/8	104/5
Test 47 P. L	100/6	111/3	106/4	107/2
Test 48 P. I	103/3	110/4	104/6	105/4
Test 49 SG of Soils	76/15	74/22	81/14	90/5

Year	2016	2017	2018	2019
Test 50 Consolidation	N/A	N/A	N/A	11/4
Test 51 Direct Shear	N/A	N/A	N/A	9/1
Test 52 Conductivity	N/A	N/A	N/A	7/1
Test 53 Permeability	N/A	N/A	N/A	9/1
Test 95 UC Void	58/7	58/7	66/2	65/5
Test 96 SE Value	61/2	63/1	66/0	66/3
Test 97 % Fractured	67/9	70/2	67/2	73/2
Test 99 % F & E	64/9	66/9	68/2	71/2
Test 15 % Residue	13/2	14/3	13/3	12/4
Test 98 % Retained	15/0	16/1	15/1	15/1
Test 123 Mortar Bar	24/2	24/1	22/1	21/0
Test 125 Conc. Prism	N/A	11/0	10/2	10/2

Appendix H. Scatter Diagrams – Soils and Aggregates

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 1: Wash Pass 75 um

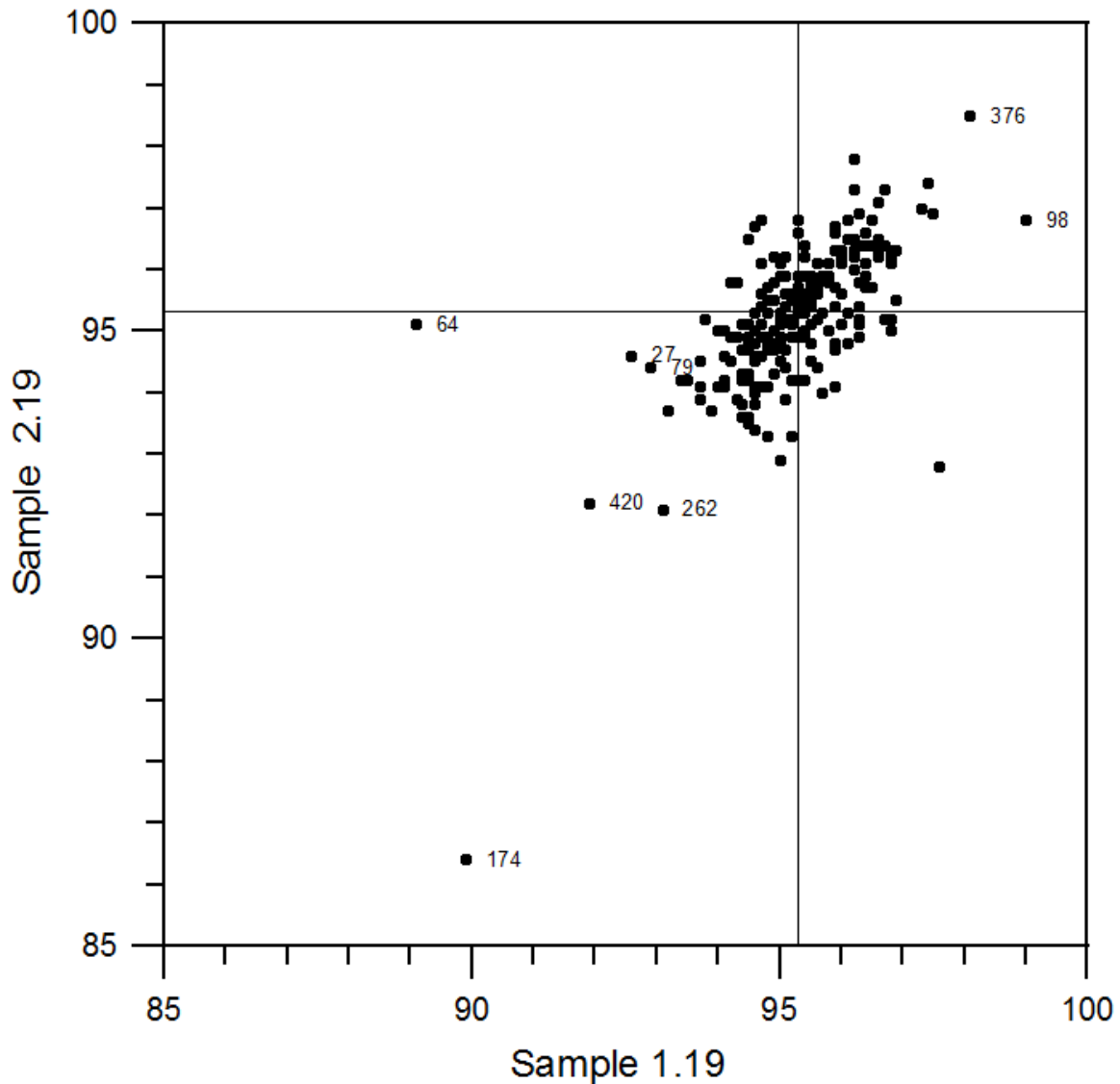
	Mat 1	Mat 2
Mean	0.463	0.460
Median	0.490	0.465
Std Dev	0.094	0.092

n = 208

Labs Eliminated: 54; 86; 144; 158; 174; 187; 193; 245; 297; 314; 315; 316;
320; 341; 376; 380; 390; 402; 422;

Figure 9. Scatter Diagram: Test 1 WP 75 mm.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 2: Percent Passing the 19.0 mm Sieve

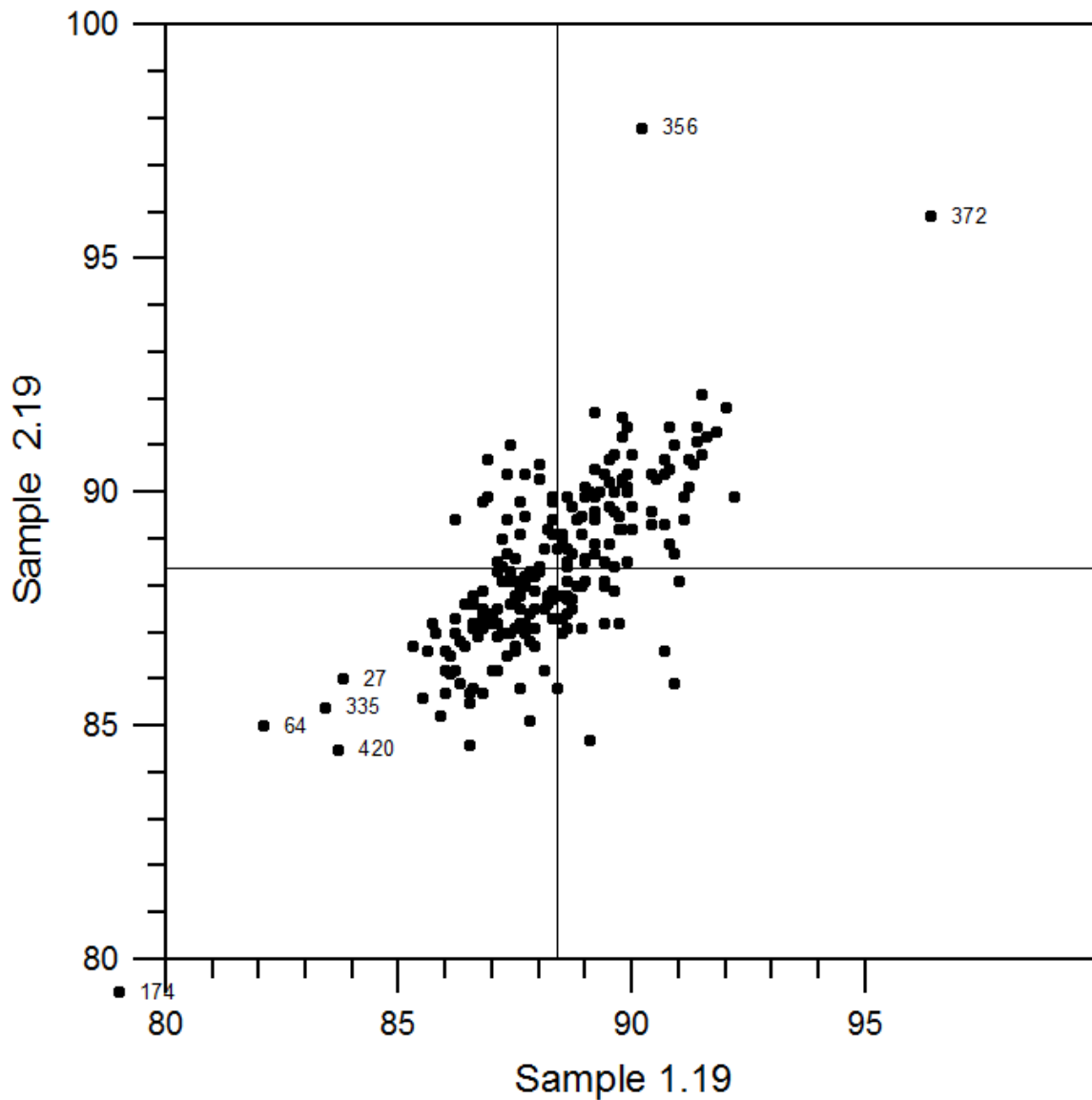
	Mat 1	Mat 2
Mean	95.311	95.311
Median	95.400	95.300
Std Dev	0.854	0.932

n = 221

Labs Eliminated: 27; 64; 79; 98; 174; 262; 376; 420;

Figure 10. Scatter Diagram: Test 2 P 19.0 mm.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 3: Percent Passing the 16.0 mm Sieve

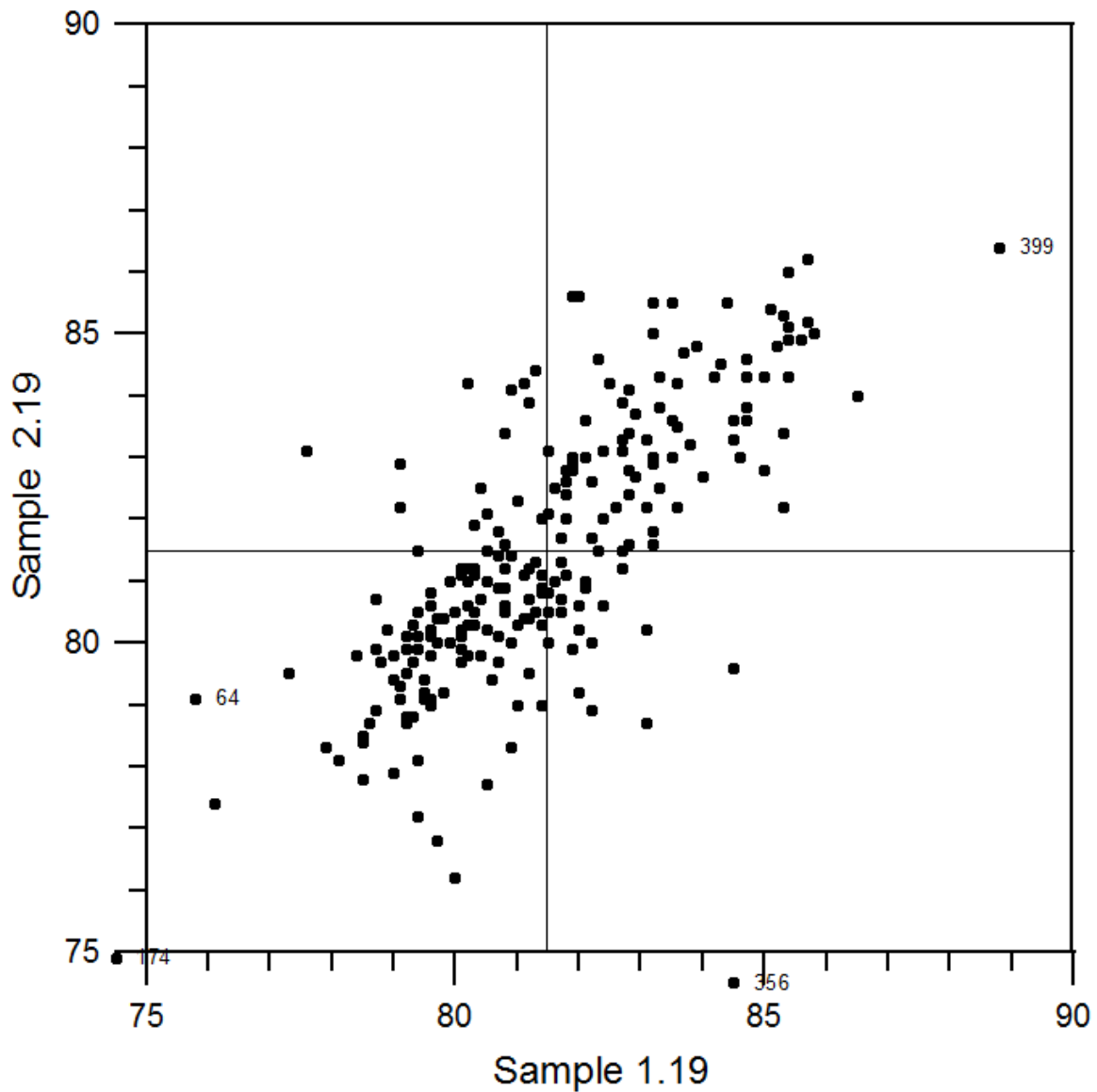
	Mat 1	Mat 2
Mean	88.398	88.376
Median	88.750	88.350
Std Dev	1.512	1.625

n = 222

Labs Eliminated: 27; 64; 174; 335; 356; 372; 420;

Figure 11. Scatter Diagram: Test 3 P 16.0 mm.

2019 MTO AGGREGATE AND SOIL
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Test 4: Percent Passing the 13.20 mm Sieve

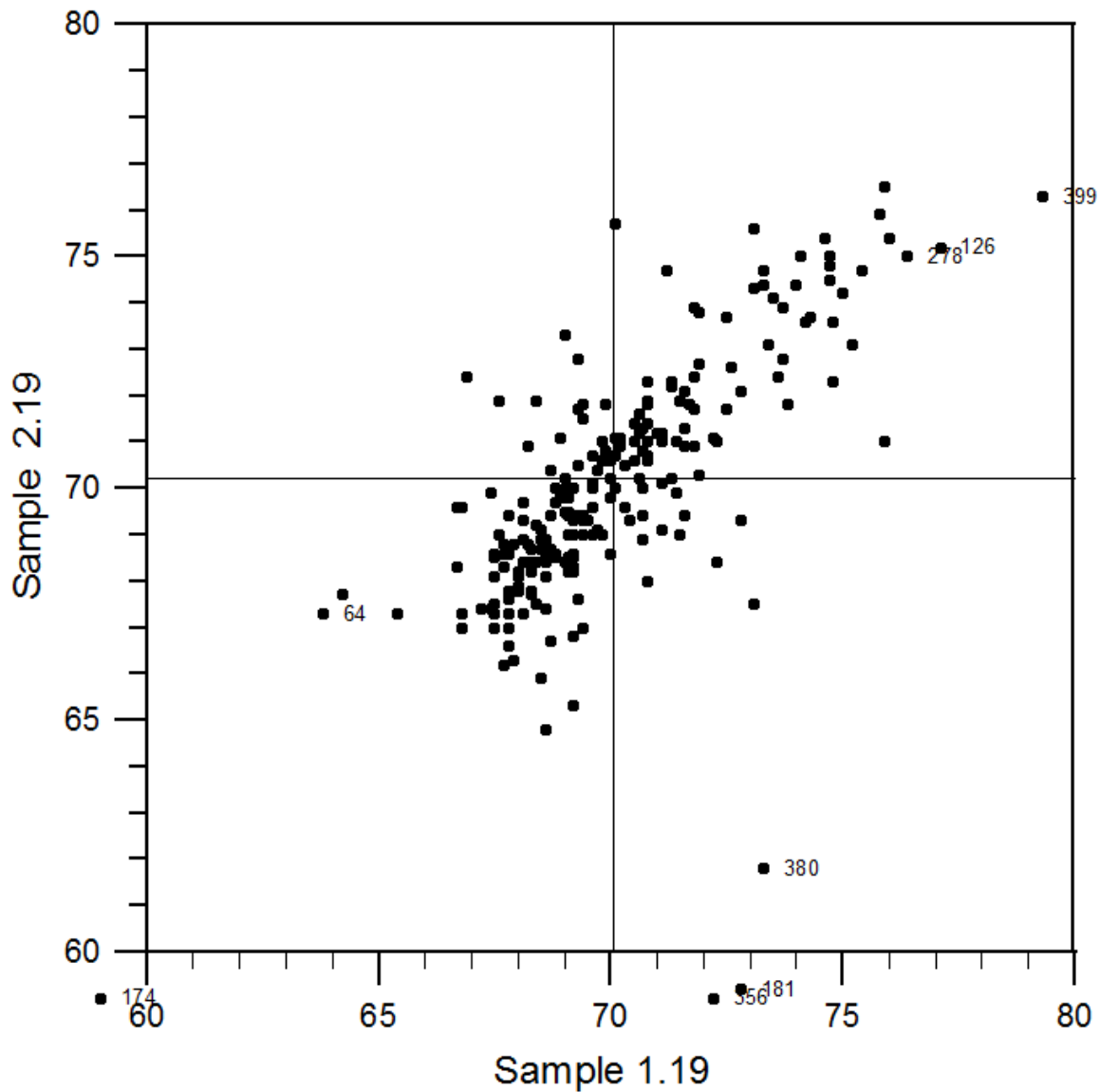
	Mat 1	Mat 2
Mean	81.475	81.502
Median	81.300	81.200
Std Dev	1.971	2.072

n = 225

Labs Eliminated: 67; 174; 356; 399;

Figure 12.Scatter Diagram: Test 4 P 13.2 mm.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 5: Percent Passing the 9.5 mm Sieve

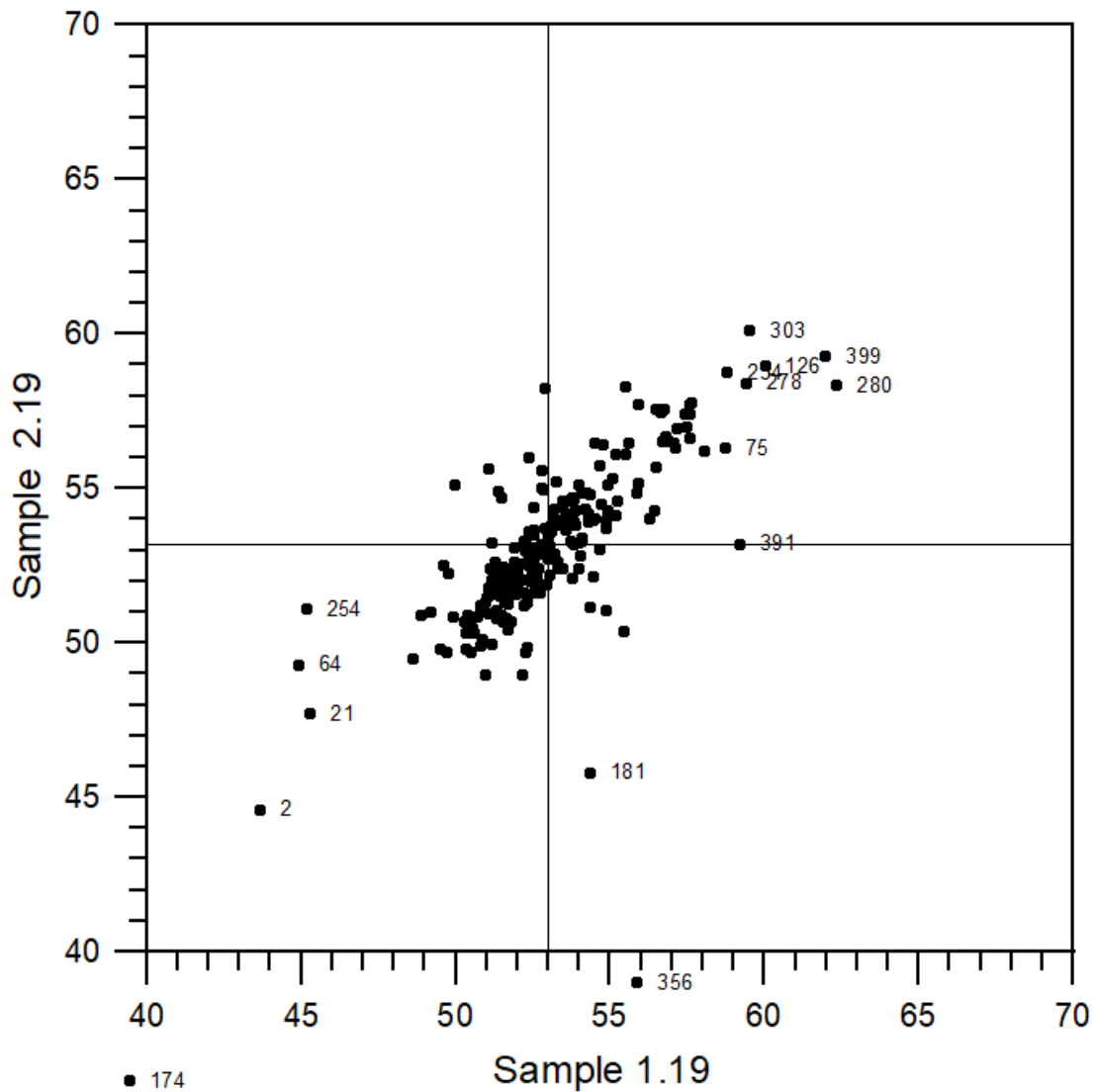
	Mat 1	Mat 2
Mean	70.068	70.223
Median	70.100	70.650
Std Dev	2.206	2.336

n = 221

Labs Eliminated: 64; 126; 174; 181; 278; 356; 380; 399;

Figure 13. Scatter Diagram: Test 5 P 9.5 mm.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 6: Percent Passing the 4.75 mm Sieve

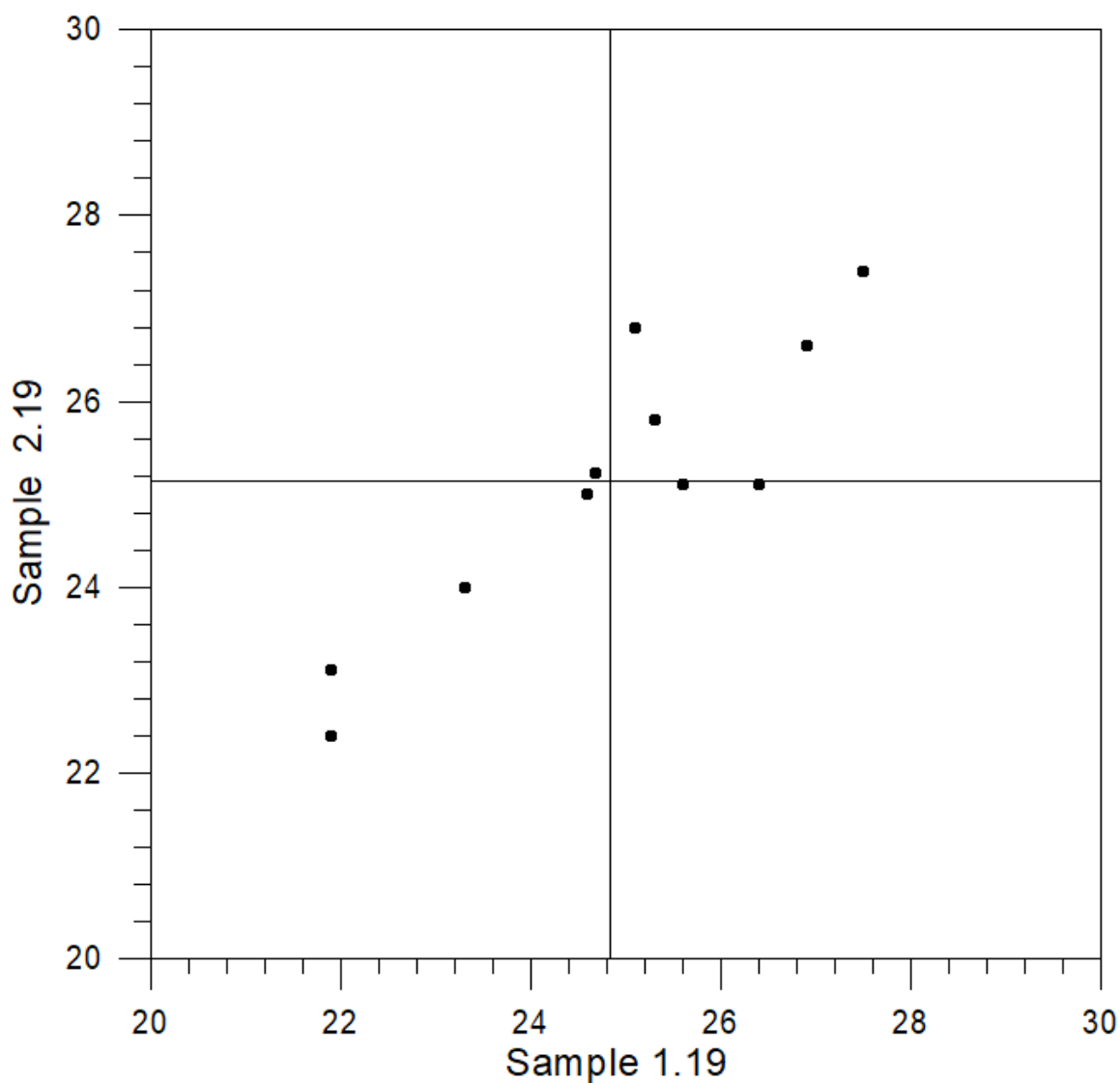
	Mat 1	Mat 2
Mean	52.991	53.202
Median	53.320	53.615
Std Dev	1.944	2.221

n = 214

Labs Eliminated: 2; 21; 64; 75; 126; 174; 181; 234; 254; 278; 280; 303; 356; 391; 399;

Figure 14. Scatter Diagram: Test 6 P4.75 mm.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 8: Los Angeles Abrasion Loss, %

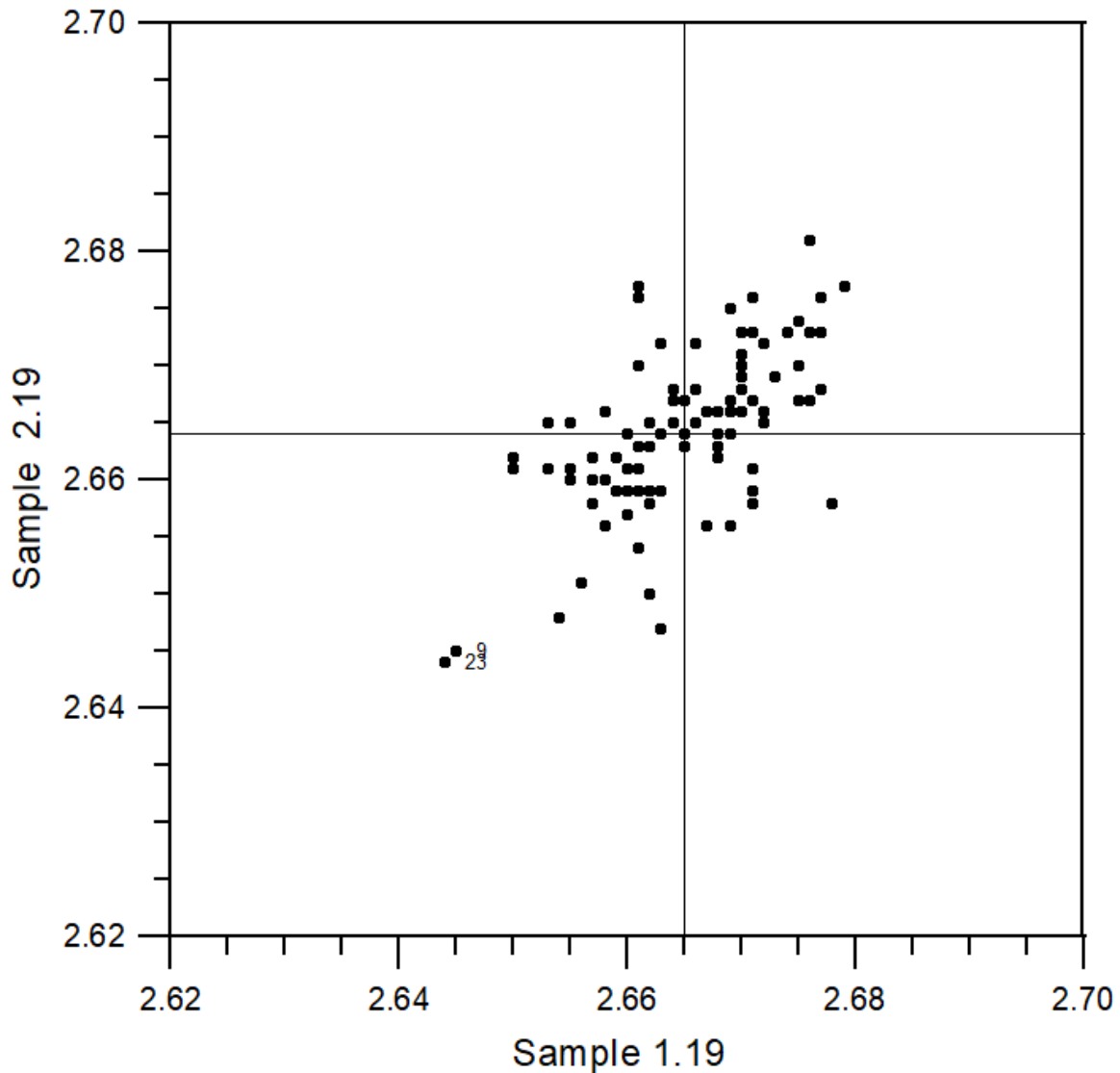
	Mat 1	Mat 2
Mean	24.835	25.139
Median	24.7	24.9
Std Dev	1.853	1.531

n = 11

Labs Eliminated: None

Figure 15. Scatter Diagram: Test 8 L.A.

2019 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 9: Relative Density of Coarse Aggregate (O. D)

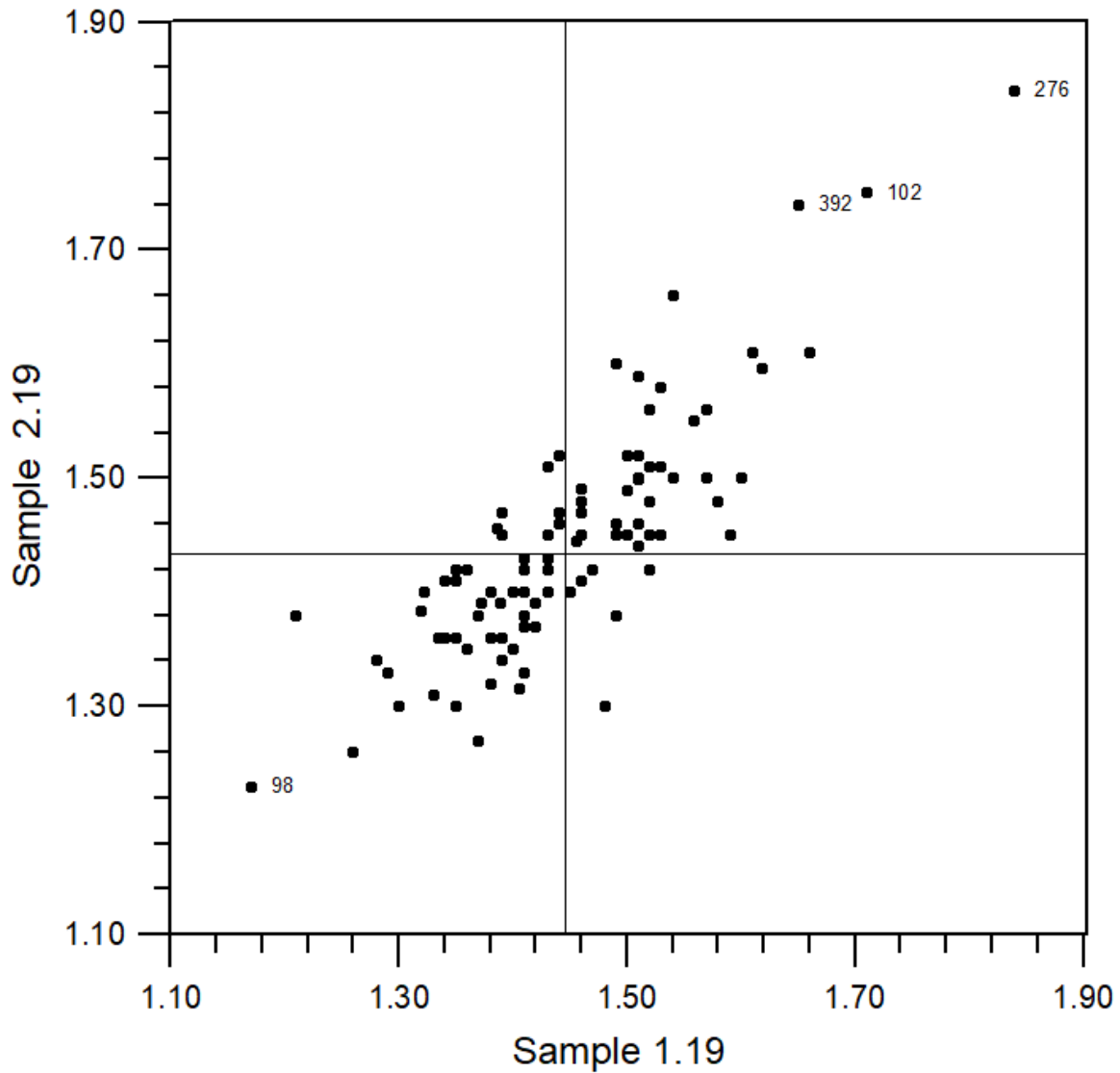
	Mat 1	Mat 2
Mean	2.665	2.664
Median	2.664	2.664
Std Dev	0.007	0.007

n = 100

Labs Eliminated: 9; 23;

Figure 16. Scatter Diagram: Test 9 RD of CA (O.D.).

2019 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 10: Absorption of Coarse Aggregate

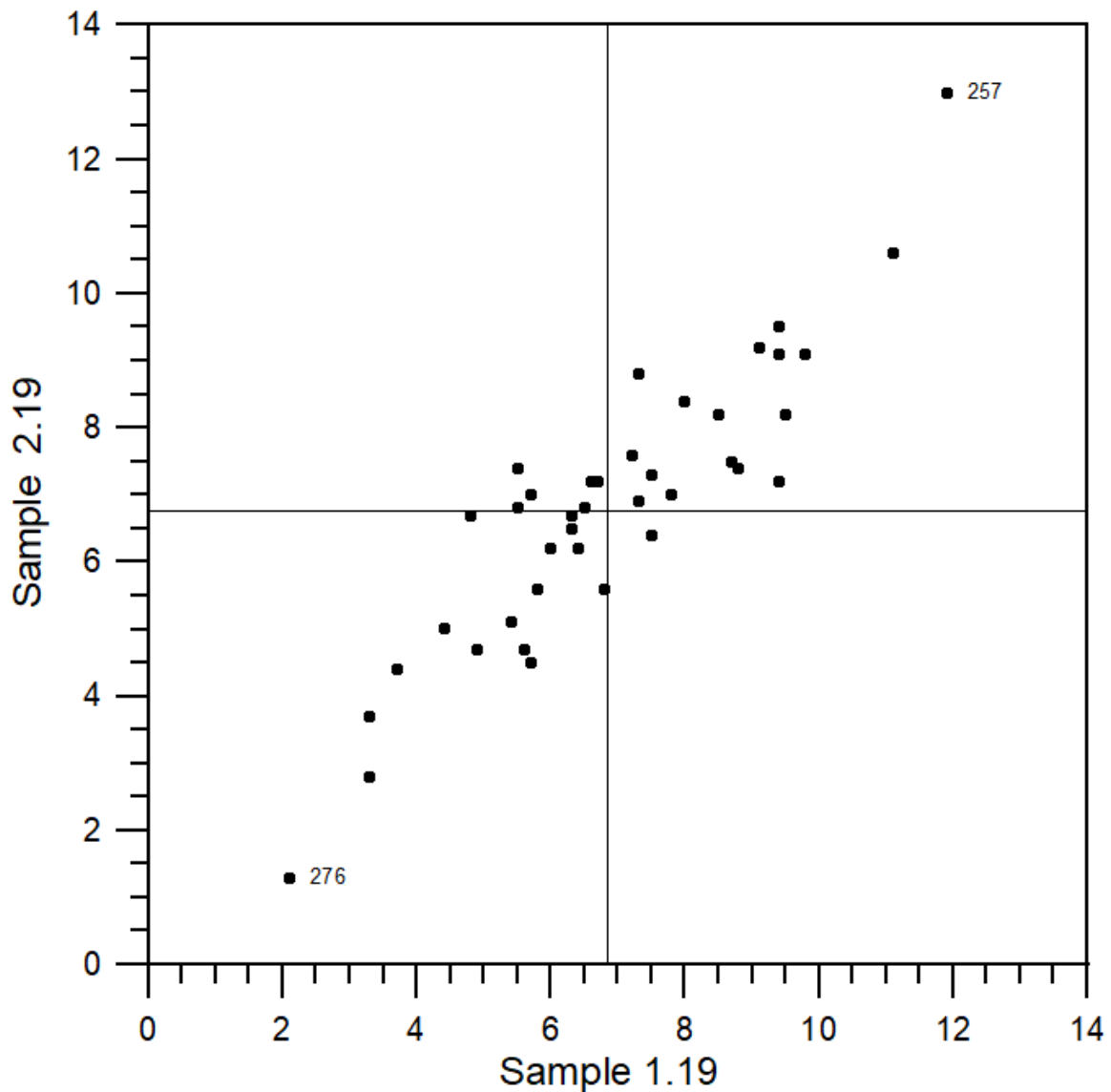
	Mat 1	Mat 2
Mean	1.446	1.434
Median	1.435	1.46
Std Dev	0.091	0.086

n = 98

Labs Eliminated: 98; 102; 276; 392;

Figure 17. Scatter Diagram: Test 10 Absorption of CA.

2019 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 11: MgSO₄ Soundness of Coarse Aggregate, % Loss

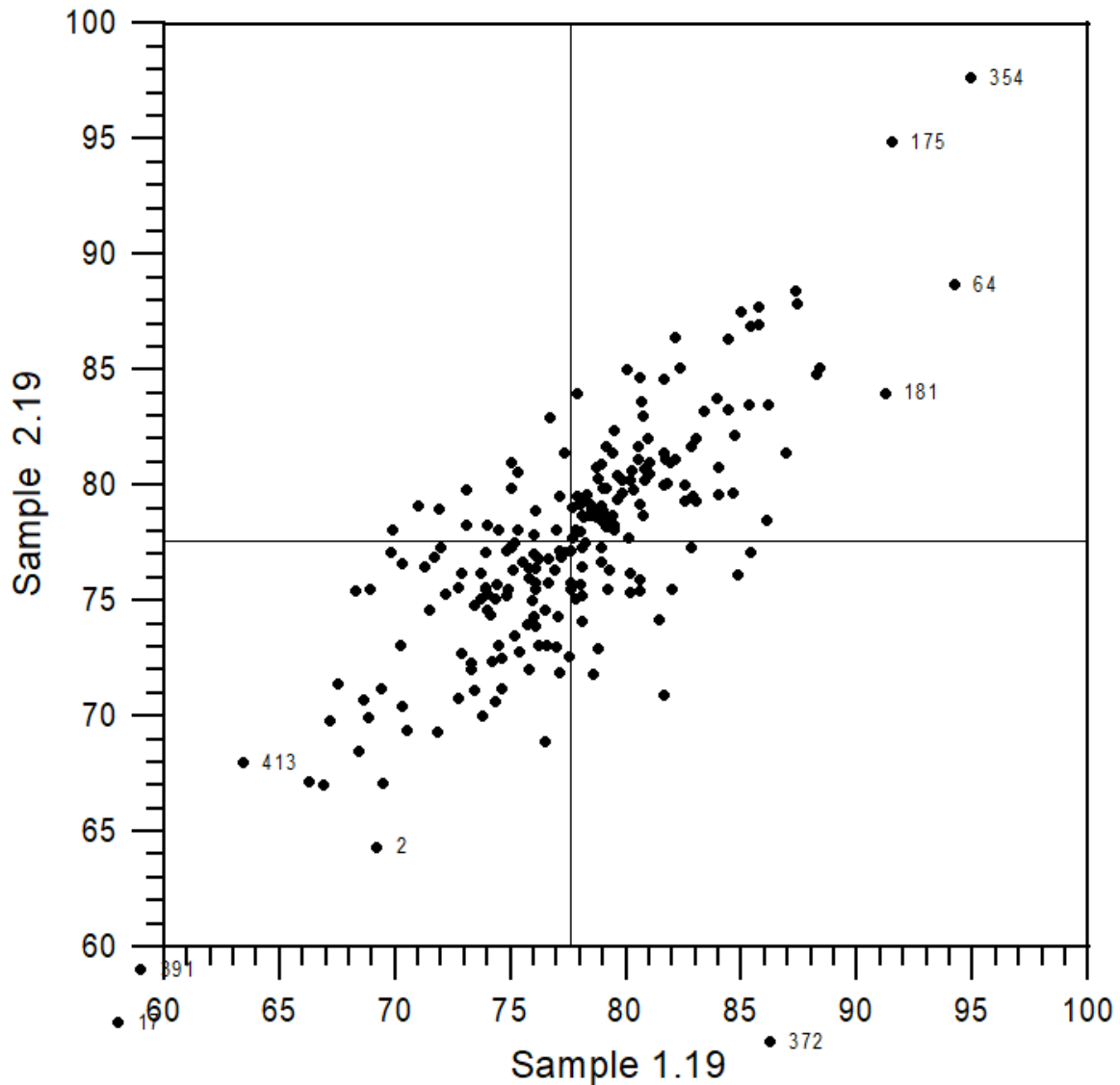
	Mat 1	Mat 2
Mean	6.839	6.767
Median	7.2	6.7
Std Dev	2.155	1.710

n = 39

Labs Eliminated: 257; 276;

Figure 18. Scatter Diagram: Test 11 MgSO₄.

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Test 12: Percent Crushed Particles

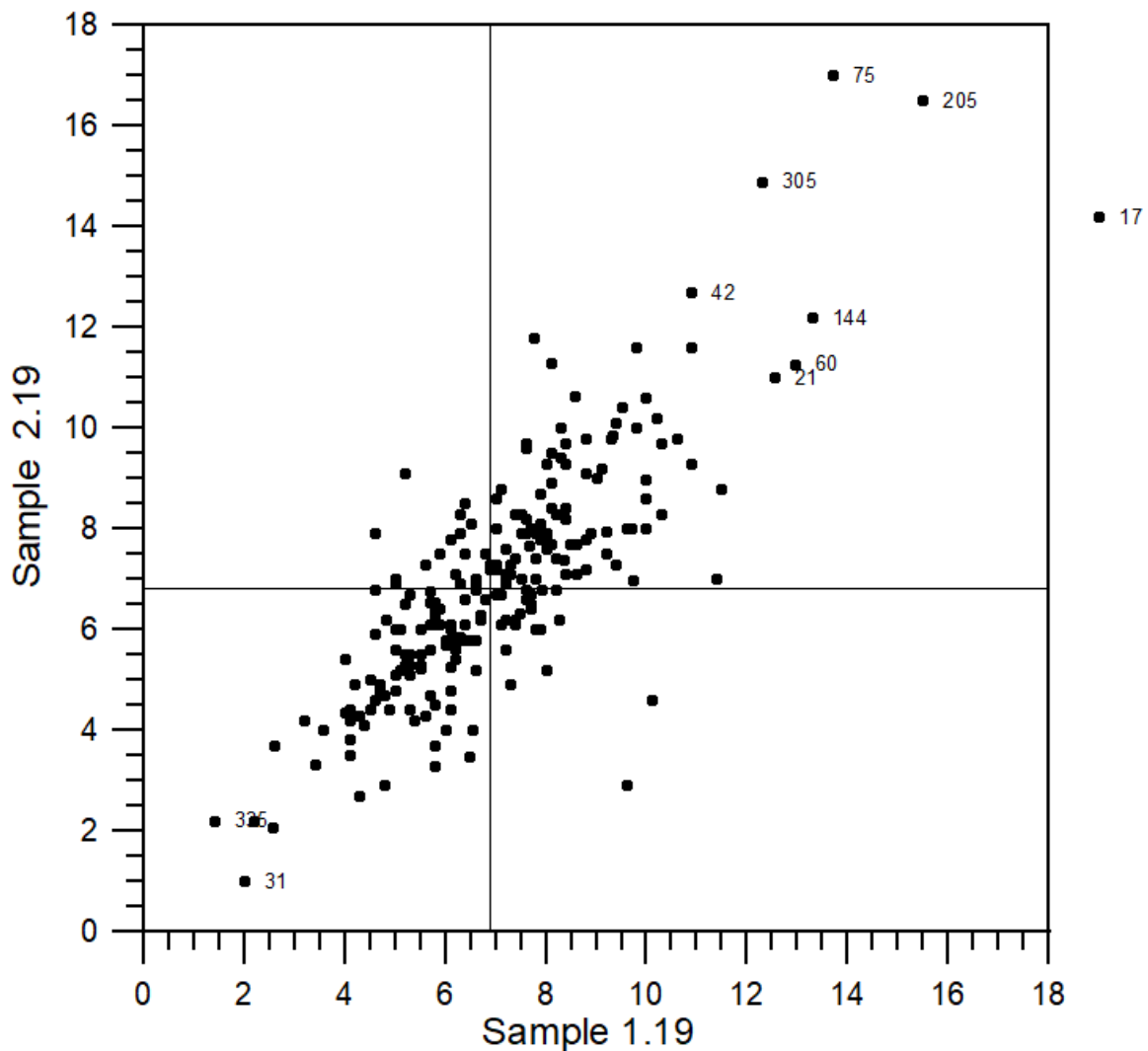
	Mat 1	Mat 2
Mean	77.628	77.598
Median	77.32	77.7
Std Dev	4.494	4.317

n = 218

Labs Eliminated: 2; 17; 64; 175; 181; 354; 372; 391; 413;

Figure 19. Scatter Diagram: Test 12 % Crush.

2019 MTO AGGREGATE AND SOIL
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Test 13: Percent Flat and Elongated Particles

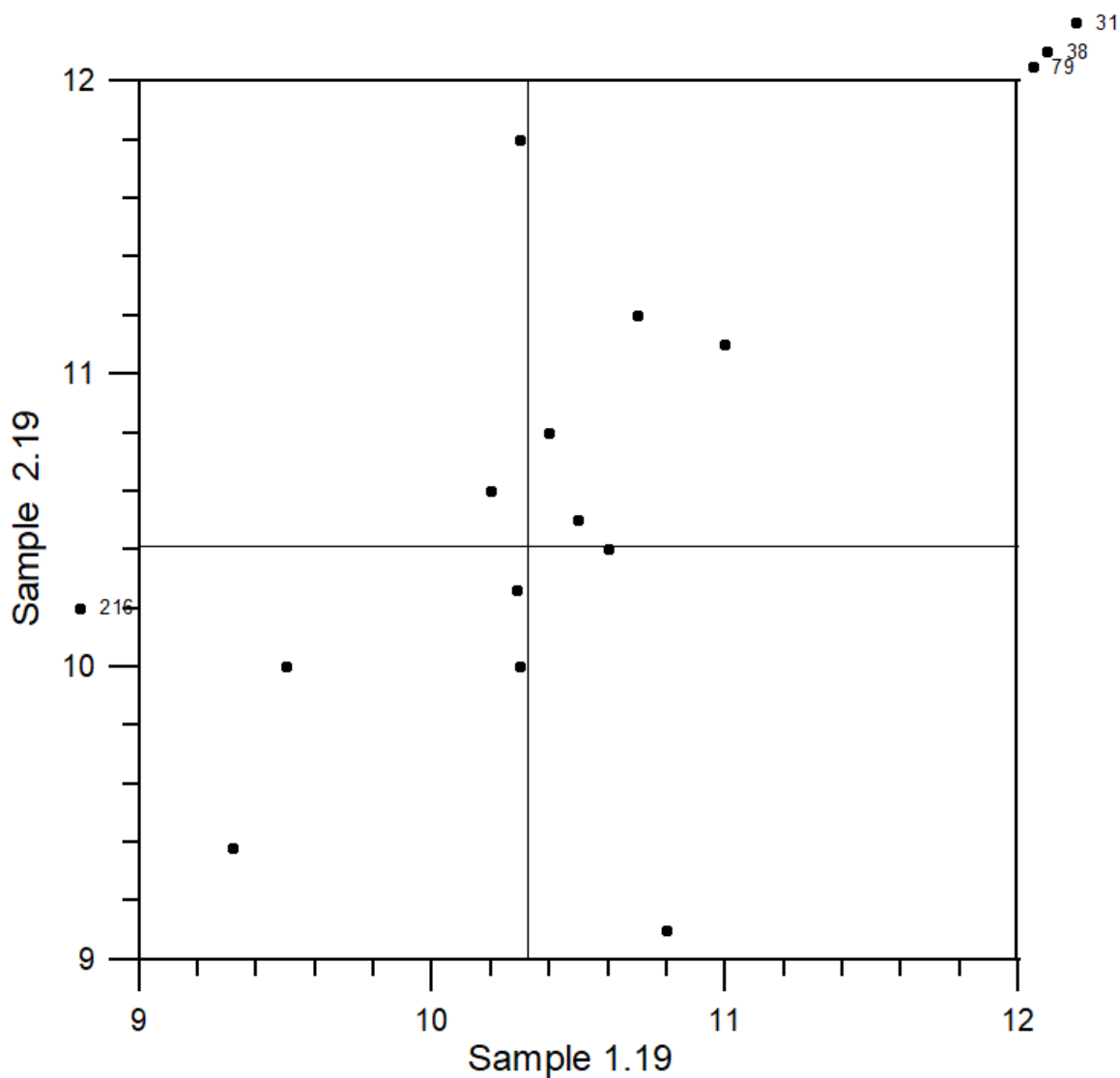
	Mat 1	Mat 2
Mean	6.904	6.824
Median	6.85	6.94
Std Dev	1.829	1.963

n = 218

Labs Eliminated: 17; 21; 31; 42; 60; 75; 144; 205; 305; 335;

Figure 20. Scatter Diagram: Test 13 % Flat & Elongated.

2019 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 15: Total Percentage of Insoluble Residue

	Mat 1	Mat 2
Mean	10.326	10.411
Median	10.16	10.45
Std Dev	0.490	0.731

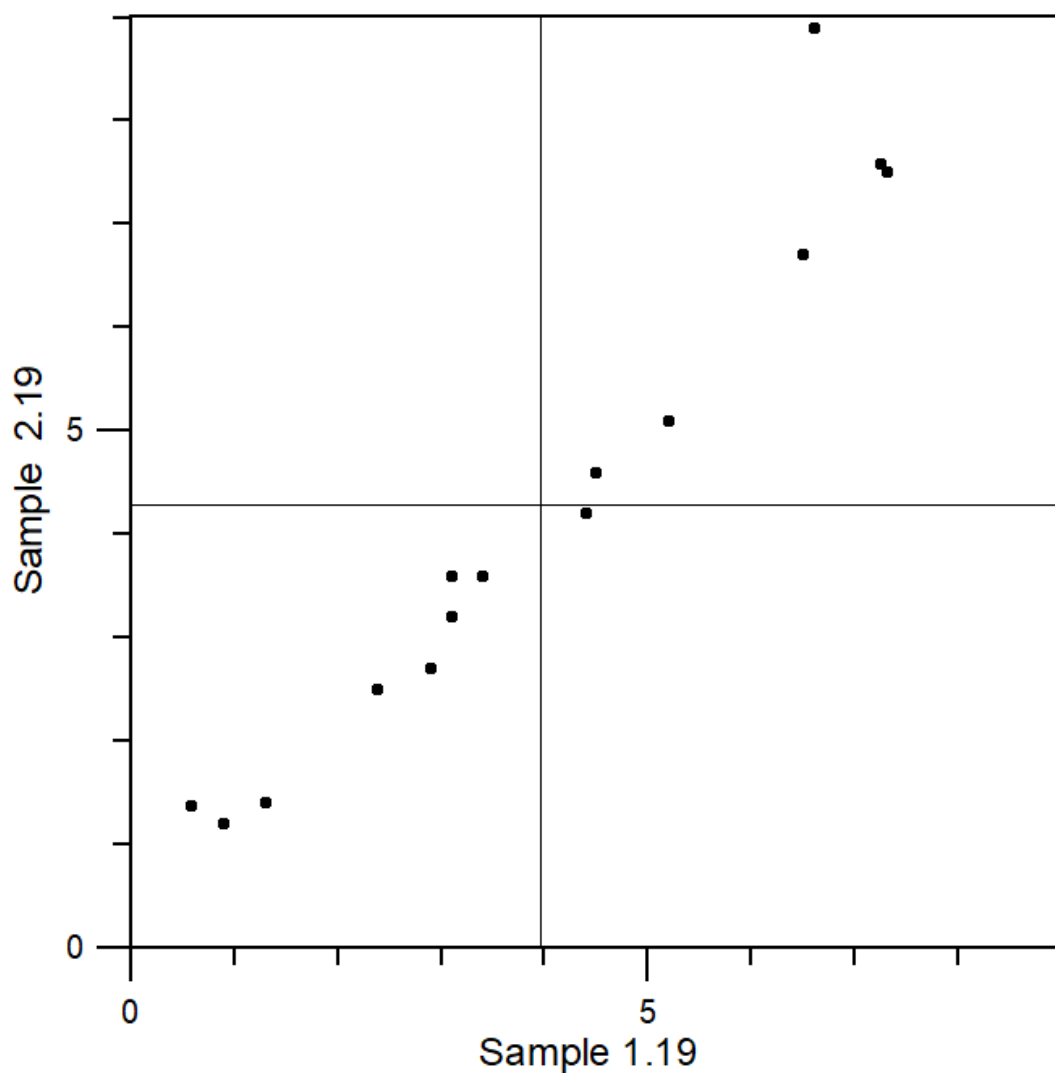
n = 12

Lab Eliminated: 31; 38; 79; 216;

Figure 21. Scatter Diagram: Test 15 Total % Insoluble Residue.

2019 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

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Test 98: Percentage of Insoluble Residue Retained 75 μ m

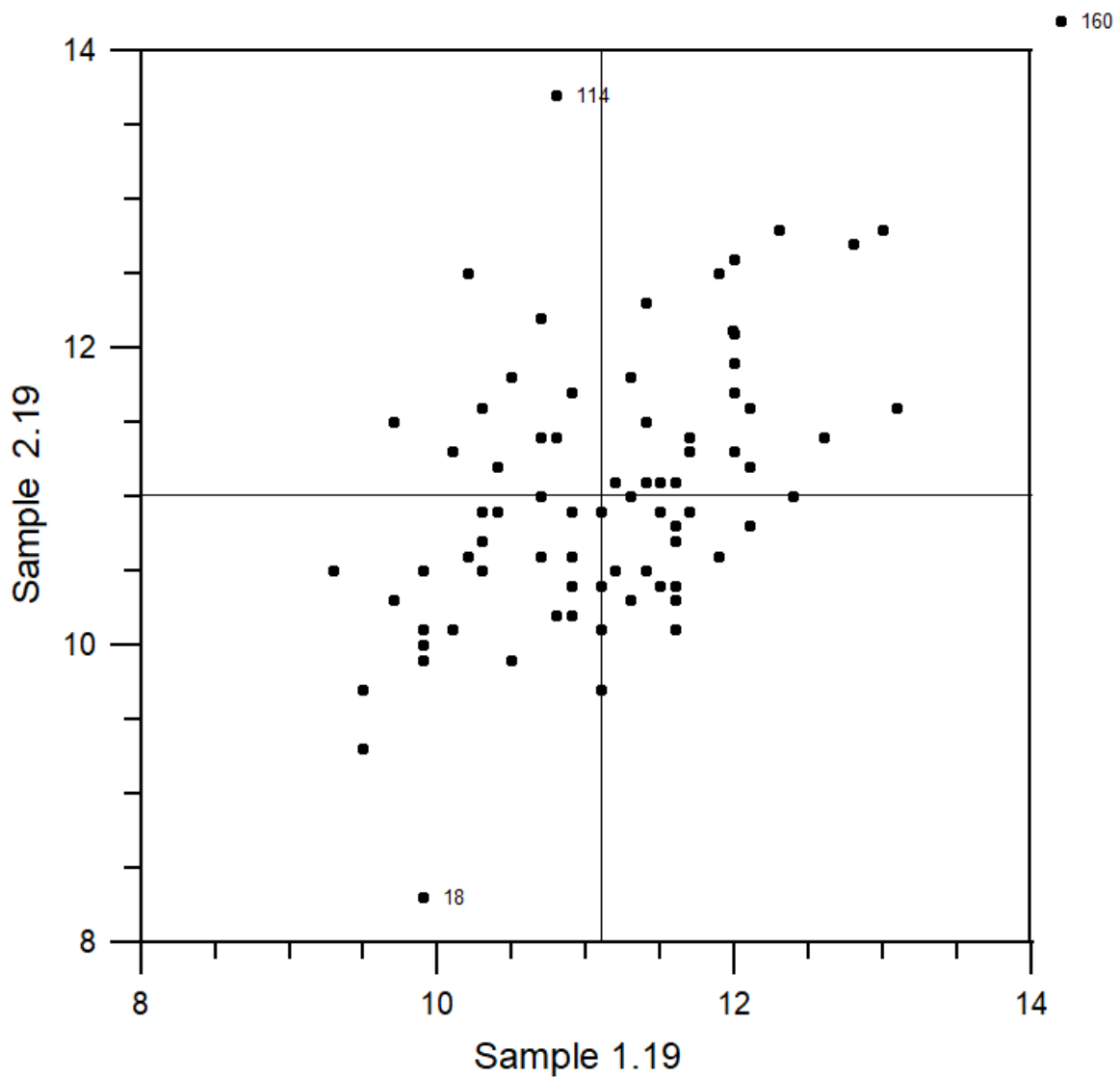
	Mat 1	Mat 2
Mean	3.961	4.278
Median	3.94	5.05
Std Dev	2.247	2.439

n = 15

Labs Eliminated: 31;

Figure 22.Scatter Diagram: Test 98 % Insoluble Residue.

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Test 16: Micro-Deval Abrasion Loss (CA), %

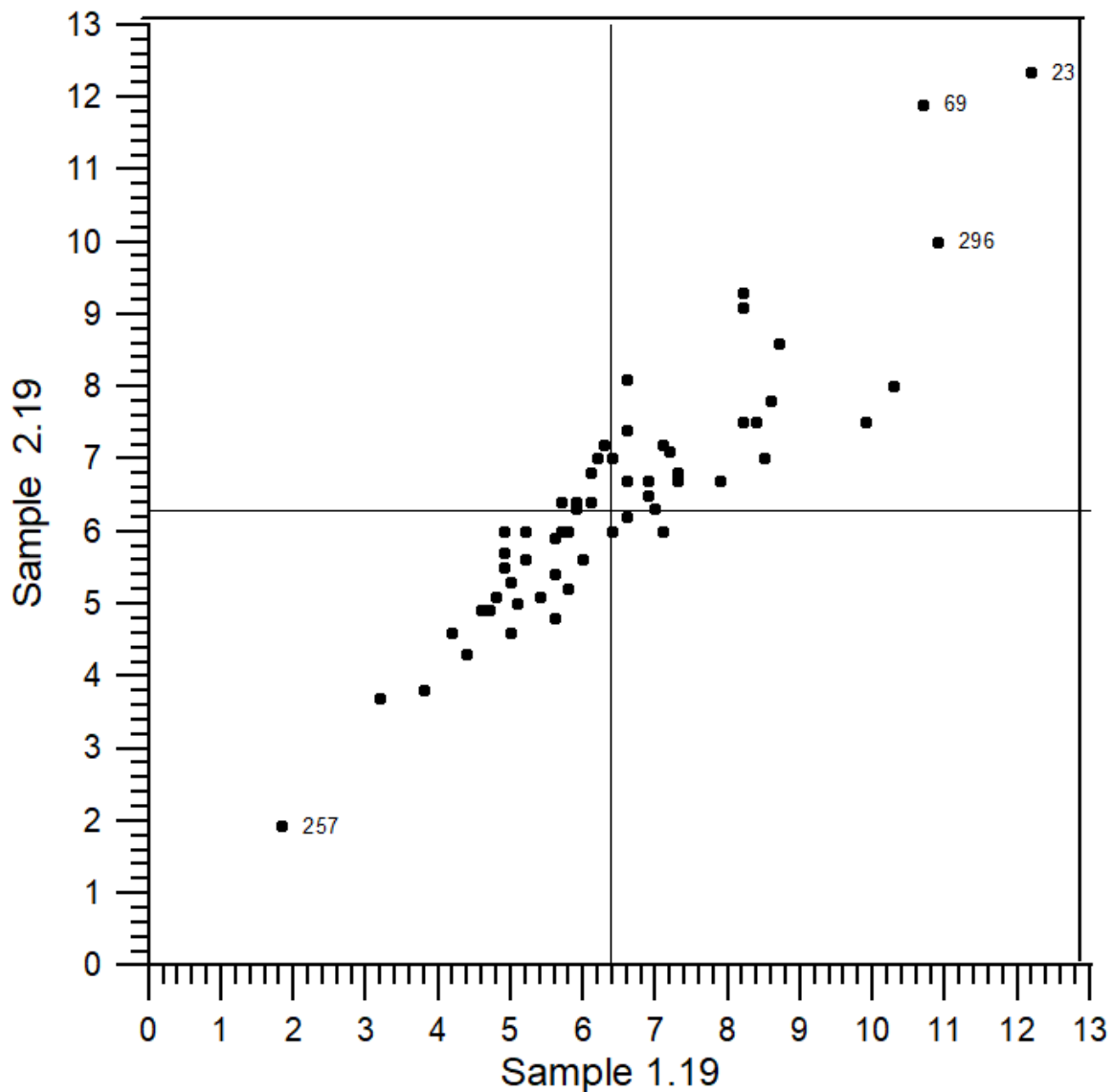
	Mat 1	Mat 2
Mean	11.107	11.007
Median	11.2	11.05
Std Dev	0.853	0.789

n = 78

Labs Eliminated: 18; 114; 160;

Figure 23. Scatter Diagram: Test 16 MDA, CA.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 17: Freeze-Thaw Loss, %

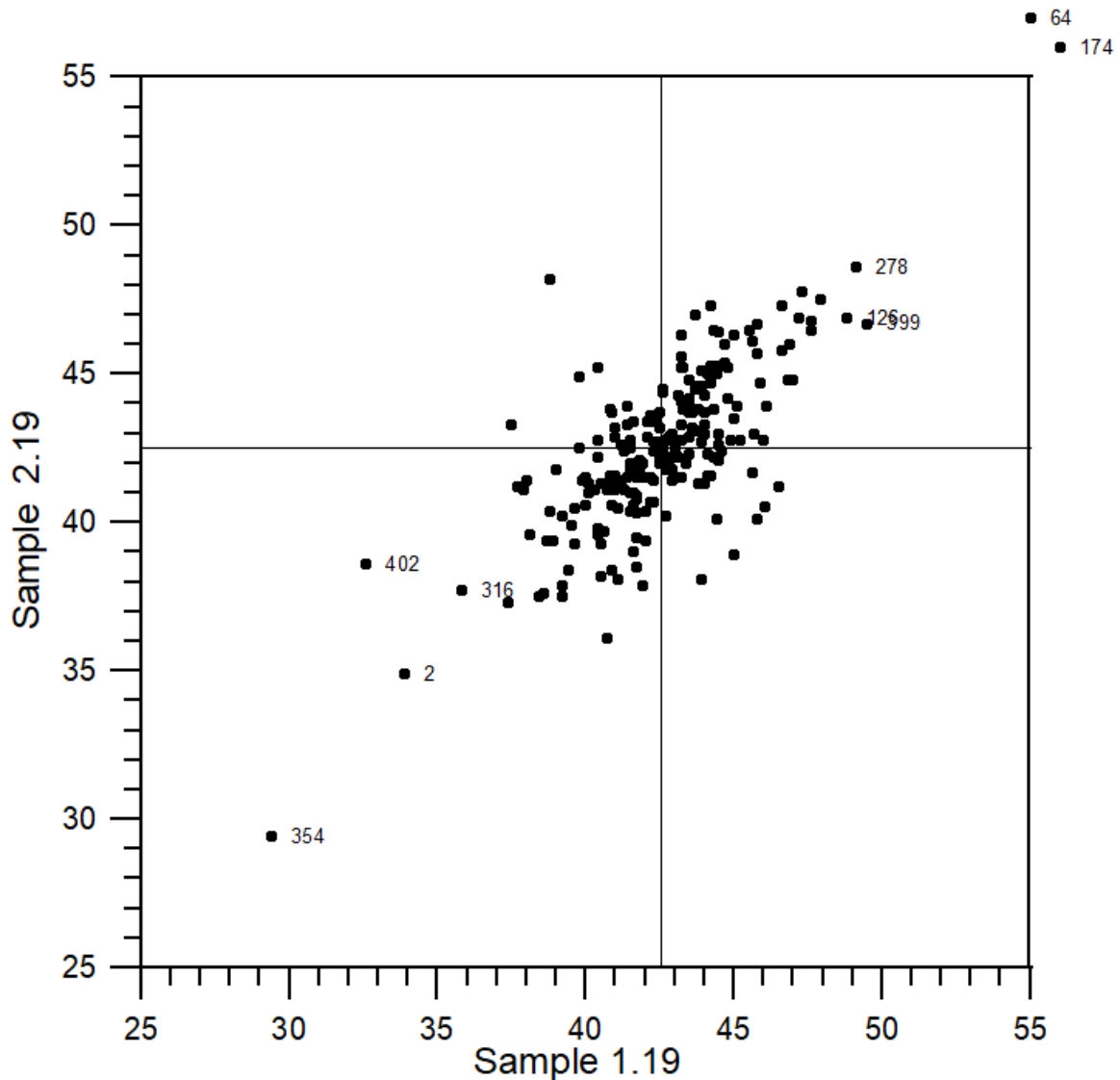
	Mat 1	Mat 2
Mean	6.385	6.281
Median	6.75	6.5
Std Dev	1.778	1.230

n = 54

Labs Eliminated: 23; 69; 257; 296;

Figure 24. Scatter Diagram: Test 17 Freeze-Thaw.

2019 MTO AGGREGATE AND SOIL
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Test 20: Percent Passing the 2.36 mm Sieve

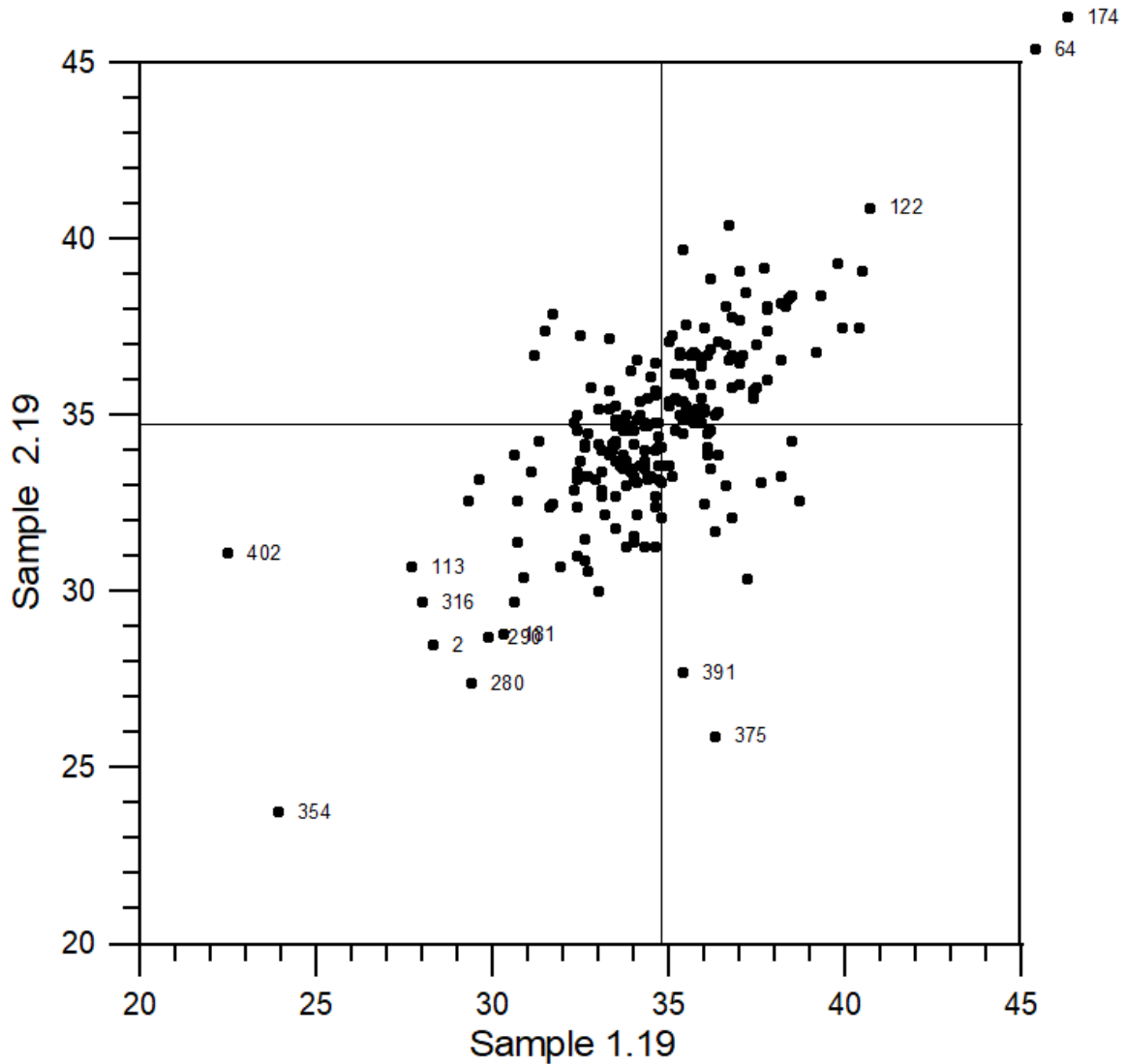
	Mat 1	Mat 2
Mean	42.560	42.522
Median	42.65	42.15
Std Dev	2.164	2.350

n = 218

Labs Eliminated: 2; 64; 126; 174; 278; 316; 354; 399; 402;

Figure 25. Scatter Diagram: Test 20 P2.36 mm.

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Test 21: Percent Passing the 1.18 mm Sieve

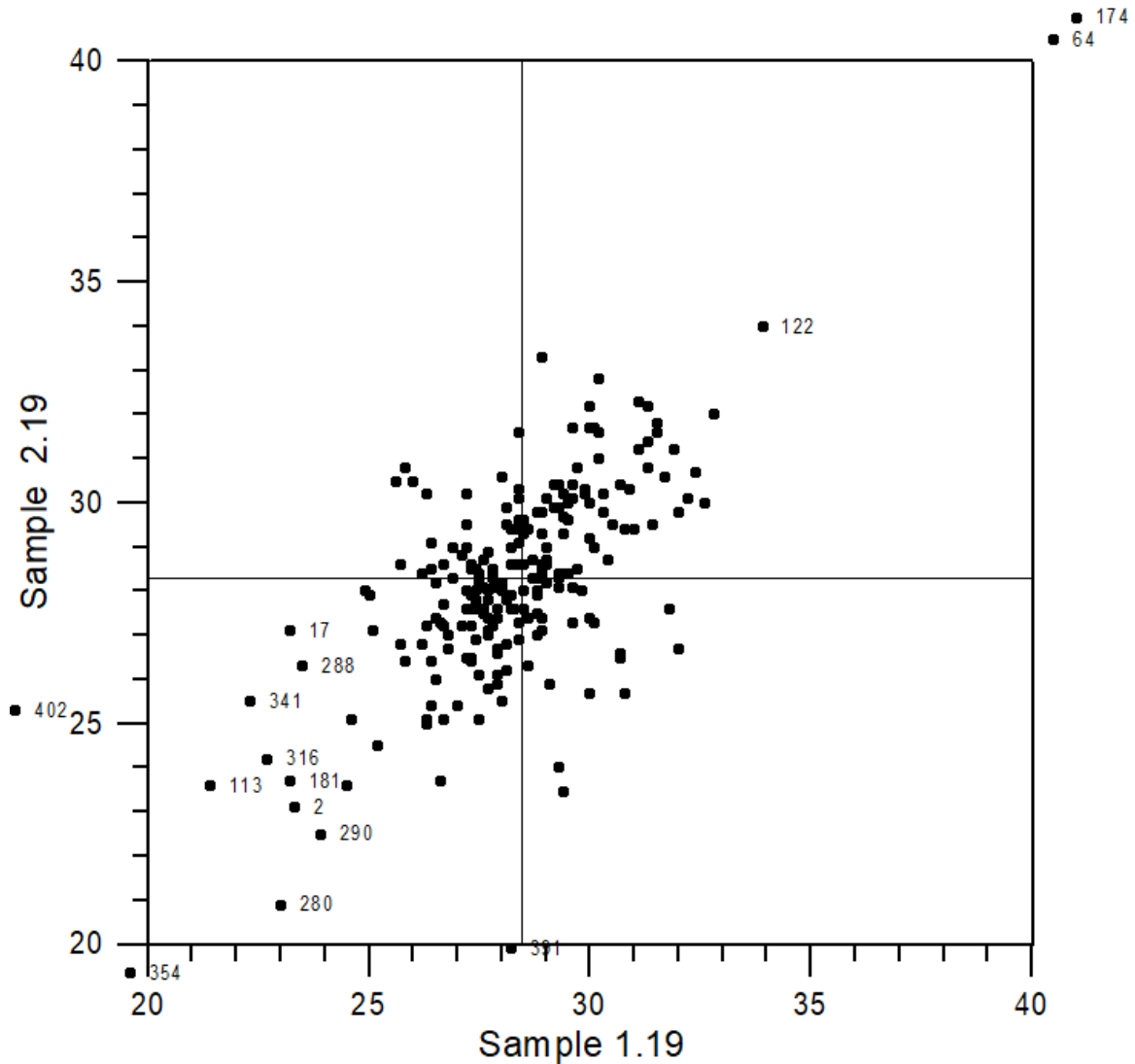
	Mat 1	Mat 2
Mean	34.796	34.764
Median	34.9	35.05
Std Dev	2.136	2.101

n = 215

Labs Eliminated: 2; 64; 113; 122; 174; 181; 280; 290;
316; 354; 375; 391; 402;

Figure 26. Scatter Diagram: Test 21 P1.18 mm.

2019 MTO AGGREGATE AND SOIL
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Test 22: Percent Passing the 600 um Sieve

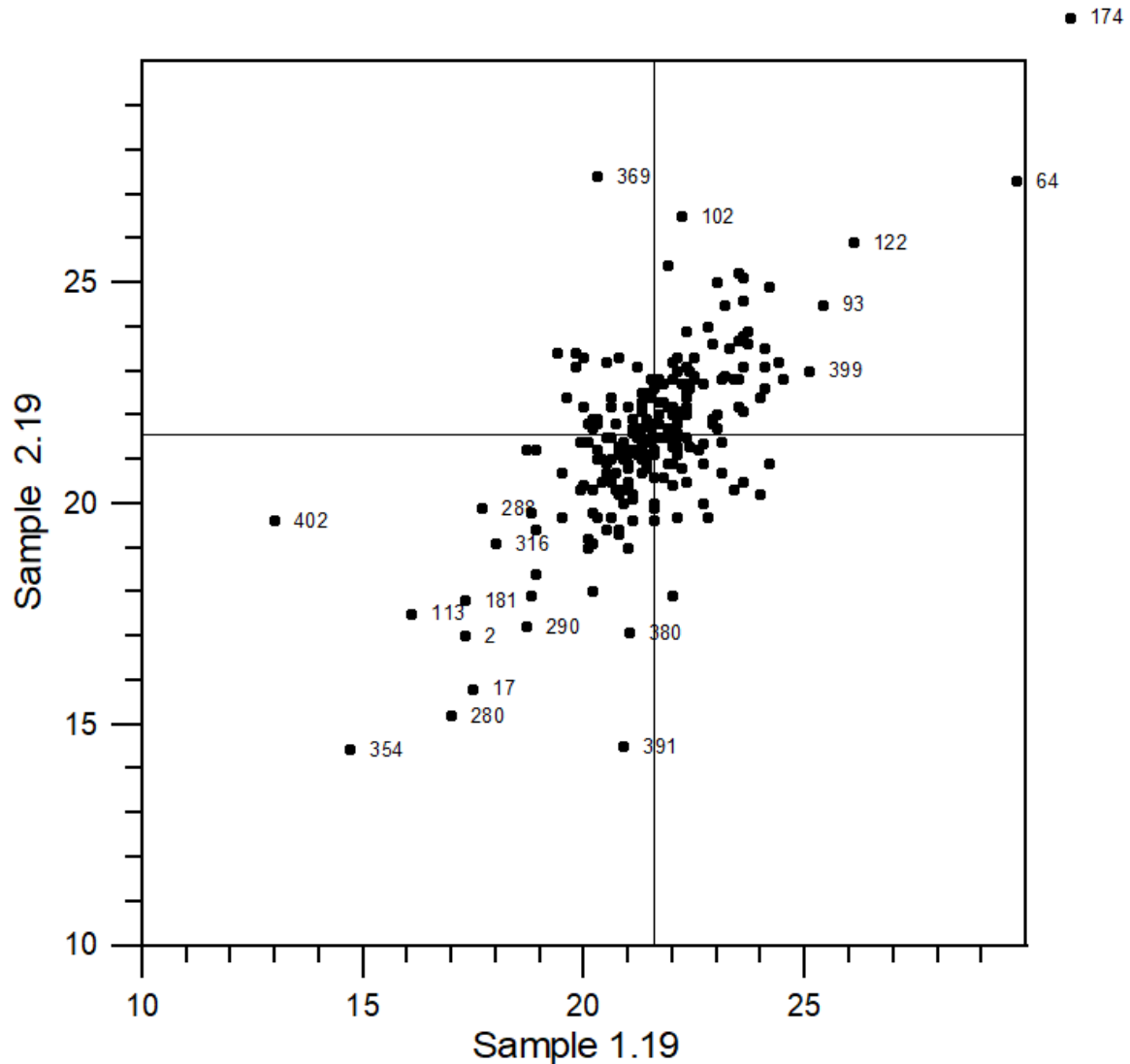
	Mat 1	Mat 2
Mean	28.464	28.284
Median	28.65	28.385
Std Dev	1.673	1.905

n = 213

Labs Eliminated: 2; 17; 64; 113; 122; 174; 181; 280; 288;
290; 316; 341; 354; 391; 402;

Figure 27. Scatter Diagram: Test 22 P600 μm .

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 23: Percent Passing the 300 um Sieve

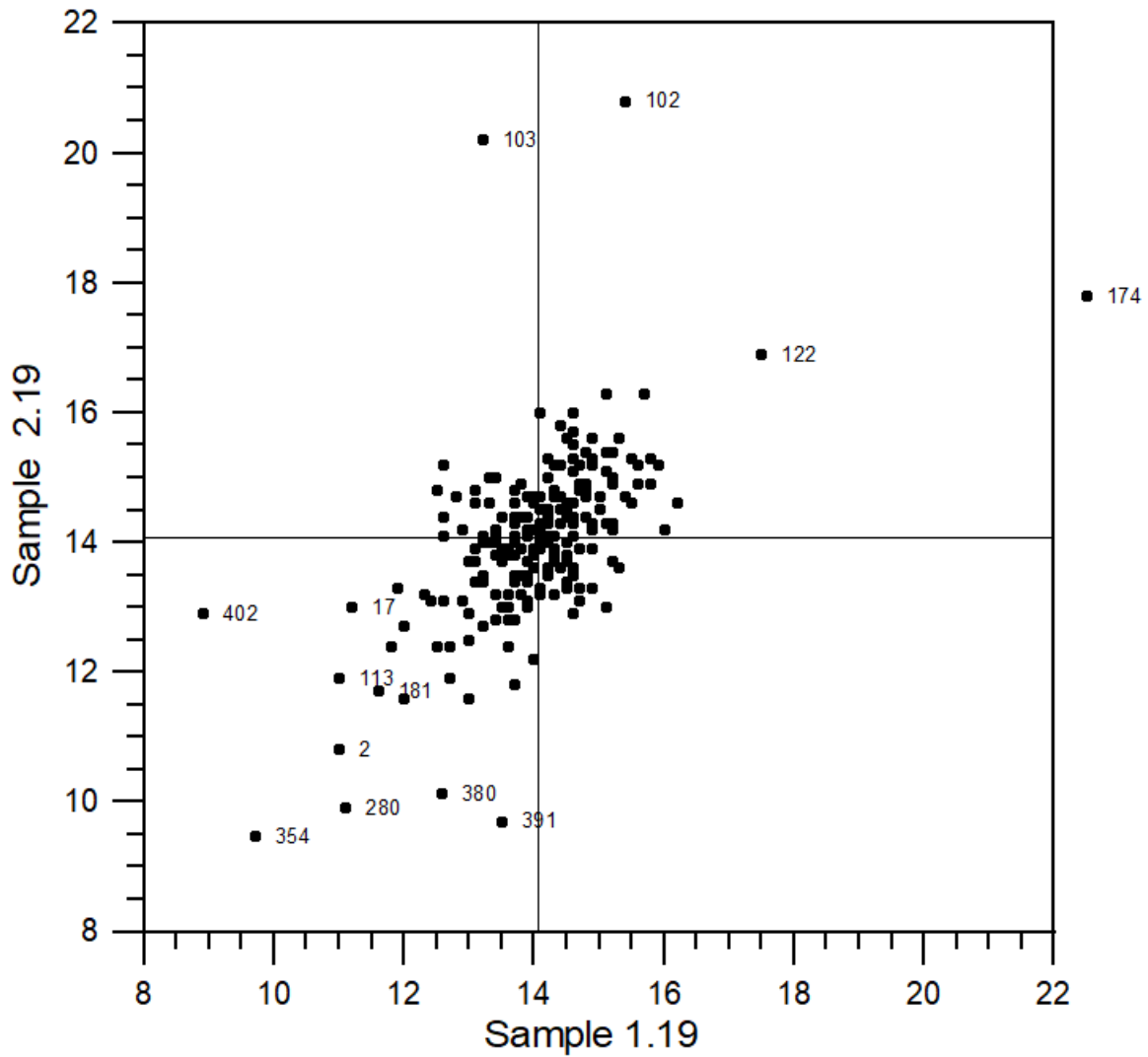
	Mat 1	Mat 2
Mean	21.577	21.578
Median	21.6	21.65
Std Dev	1.228	1.400

n = 209

Labs Eliminated: 2; 17; 64; 93; 102; 113; 122; 174; 181; 280;
288; 290; 316; 354; 369; 380; 391; 399; 402;

Figure 28. Scatter Diagram: Test 23 P300 μm.

2019 MTO AGGREGATE AND SOIL
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Test 24: Percent Passing the 150 um Sieve

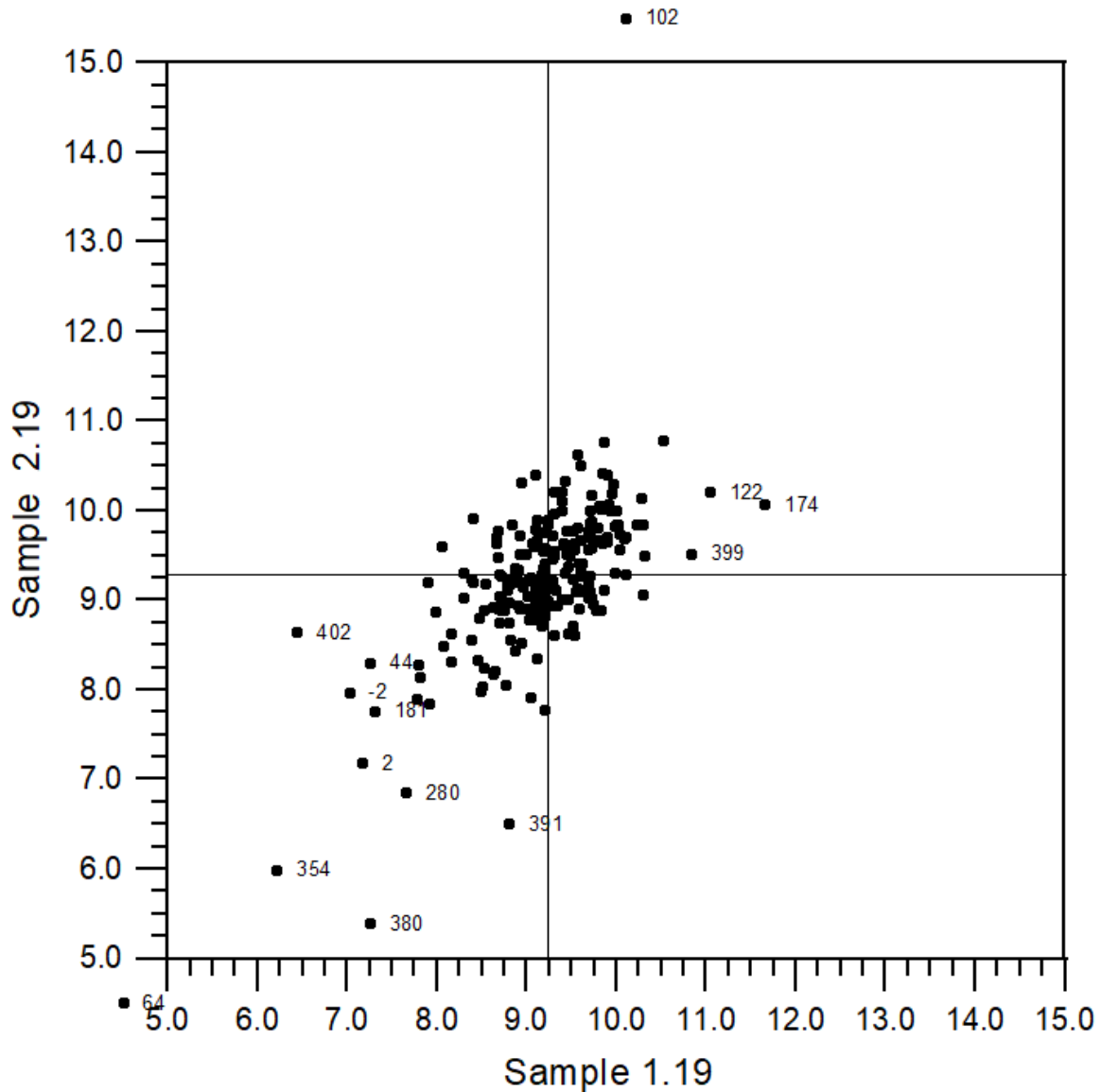
	Mat 1	Mat 2
Mean	14.062	14.074
Median	14	13.95
Std Dev	0.829	0.895

n = 215

Labs Eliminated: 2; 17; 102; 103; 113; 122; 174; 181; 280;
354; 380; 391; 402;

Figure 29. Scatter Diagram: Test 24 P150 μm .

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 25: Percent Passing the 75 um Sieve

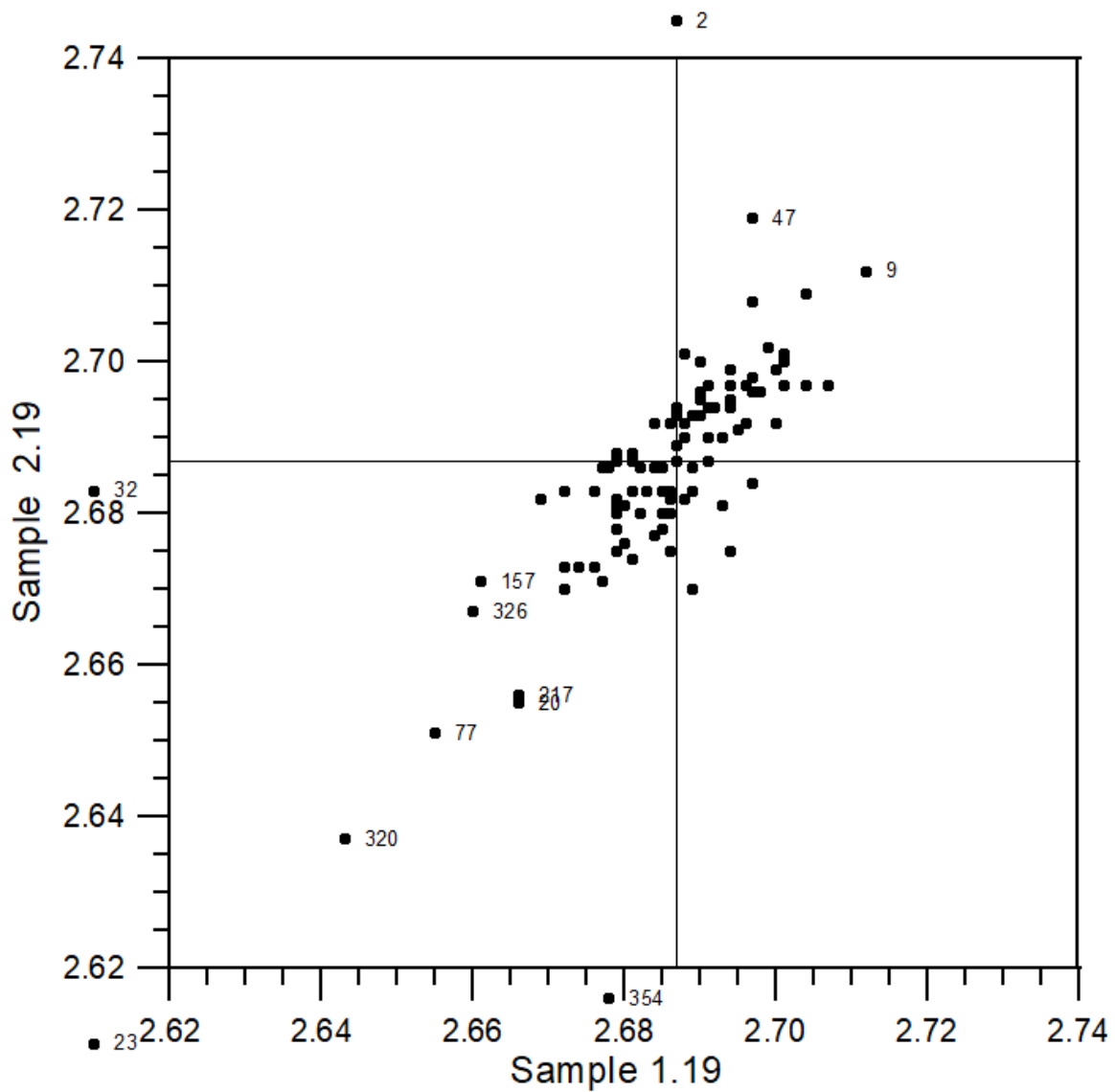
	Mat 1	Mat 2
Mean	9.231	9.290
Median	9.155	9.28
Std Dev	0.537	0.585

n = 214

Labs Eliminated: 2; 17; 44; 64; 102; 122; 174; 181;
280; 354; 380; 391; 399; 402;

Figure 30. Scatter Diagram: Test 25 P75 μm .

2019 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 27: Relative Density of Fine Aggregate (O. D)

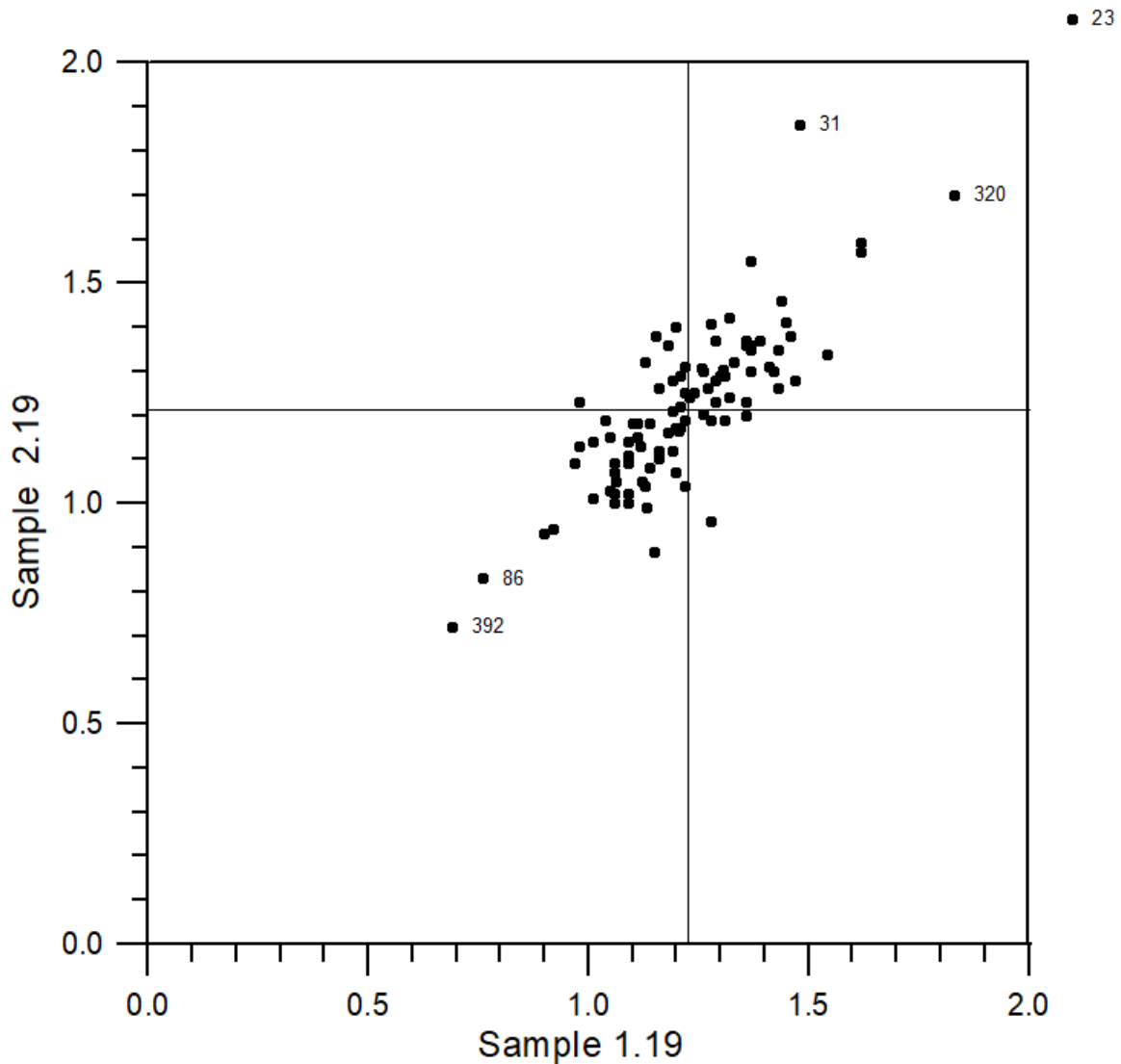
	Mat 1	Mat 2
Mean	2.687	2.687
Median	2.688	2.69
Std Dev	0.009	0.010

n = 87

Labs Eliminated: 2; 9; 20; 23; 32; 47; 77; 157; 217; 320;
326; 354;

Figure 31. Scatter Diagram: Test 27 RD of FA (O.D.).

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 28: Absorption of Fine Aggregate

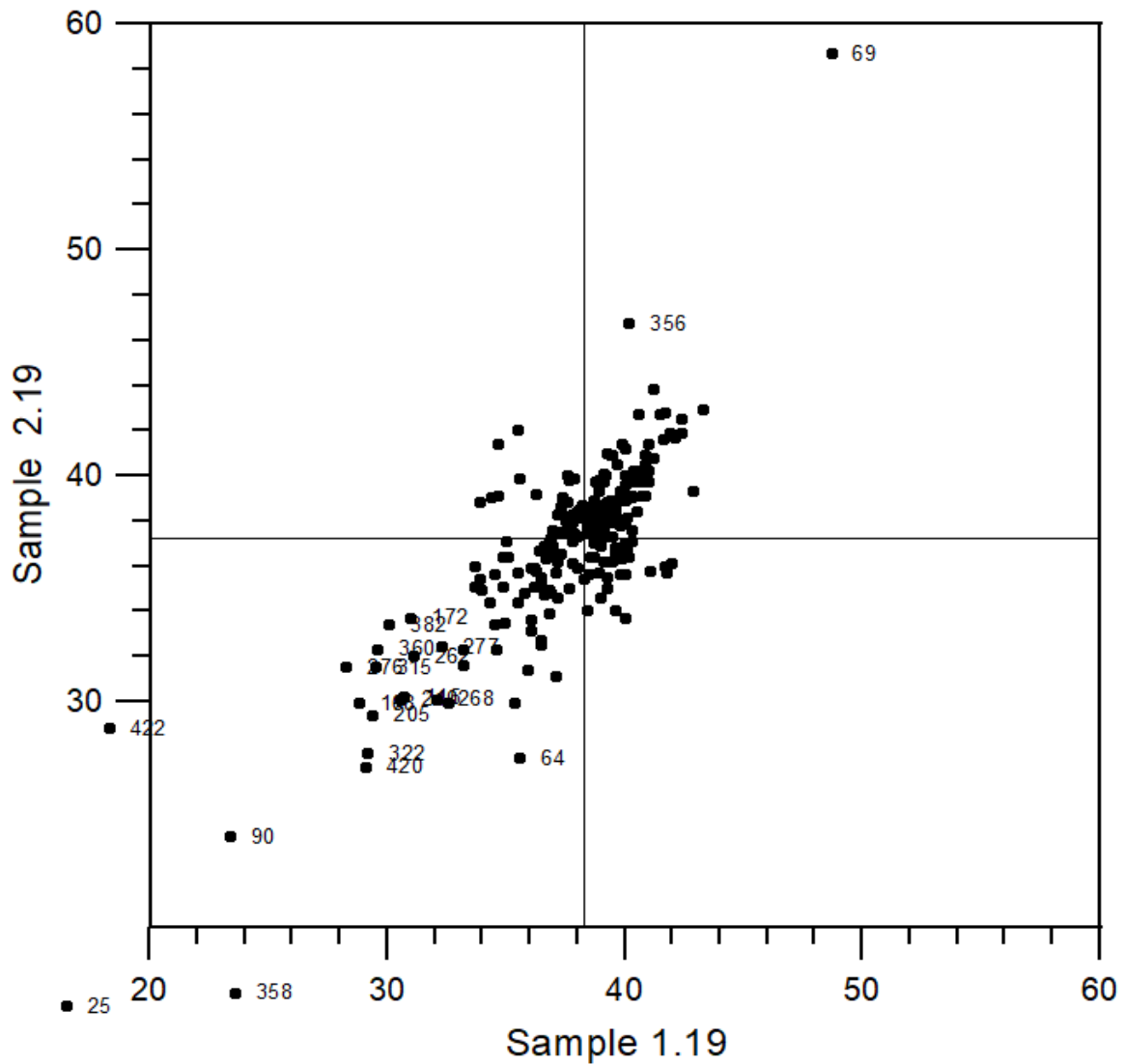
	Mat 1	Mat 2
Mean	1.225	1.213
Median	1.26	1.24
Std Dev	0.148	0.148

n = 94

Labs Eliminated: 23; 31; 86; 320; 392;

Figure 32. Scatter Diagram: Test 28 Absorption of FA.

**2019 MTO AGGREGATE AND SOIL
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Test 30: Percent Asphalt Coated Particles

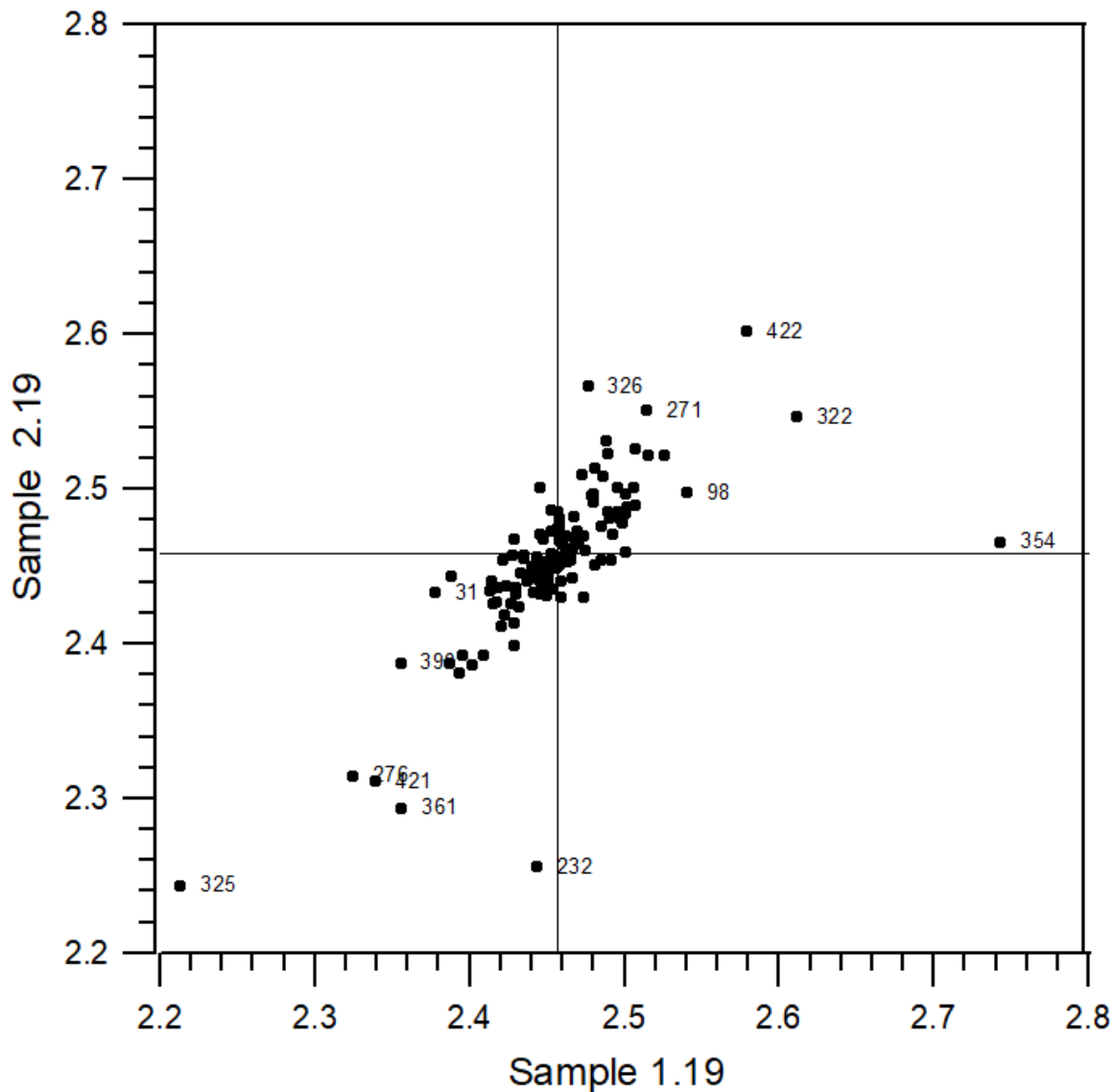
	Mat 1	Mat 2
Mean	38.352	37.226
Median	37.95	36.85
Std Dev	2.123	2.838

n = 204

Labs Eliminated: 25; 64; 69; 90; 145; 168; 172; 205; 210;
262; 268; 276; 277; 315; 322; 356; 358;
360; 382; 420; 422;

Figure 33.Scatter Diagram: Test 30 % Asphalt Coated Particles.

2019 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 31: Maximum Wet Density g/cm³ (Moisture-Density)

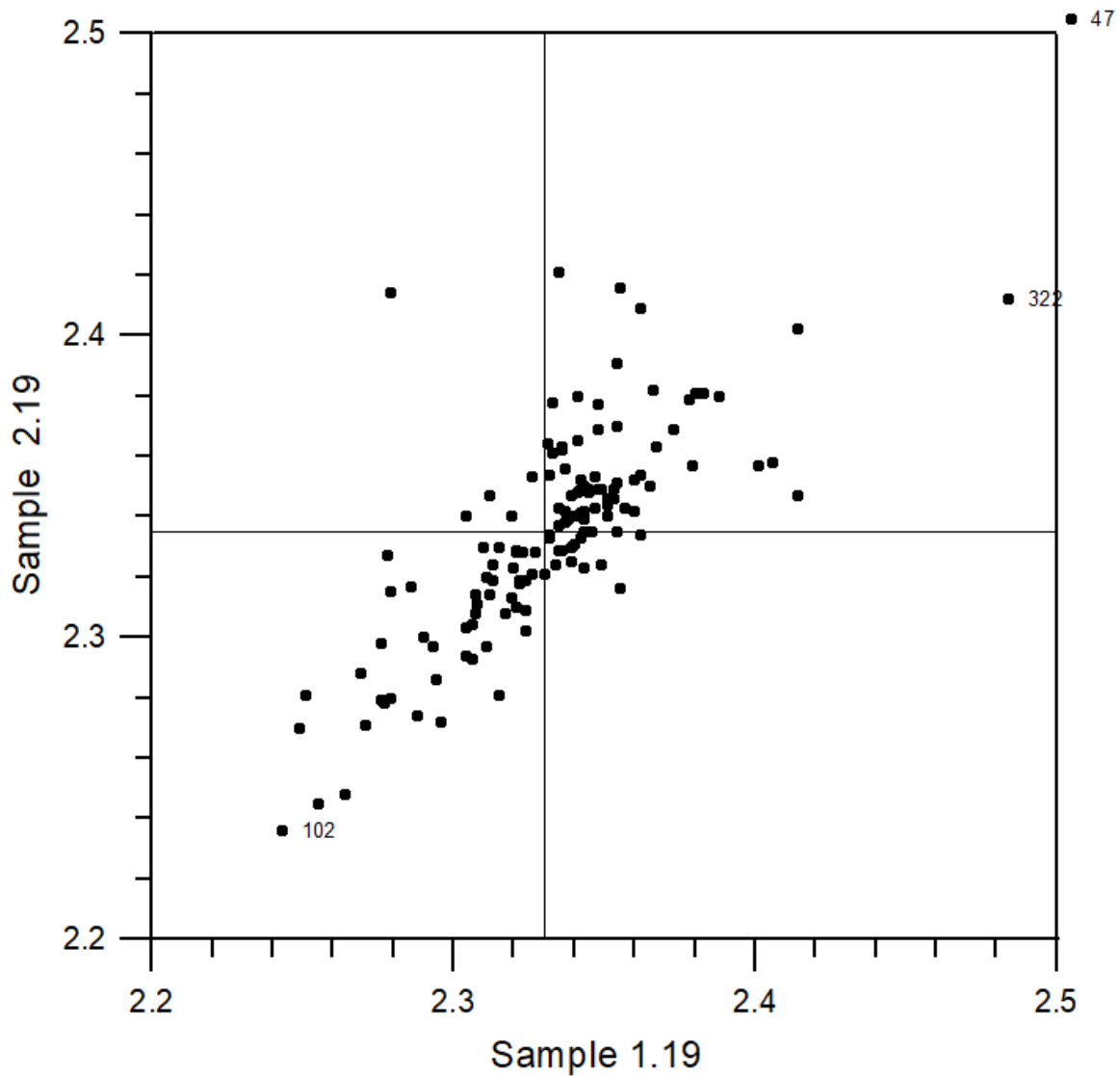
	Mat 1	Mat 2
Mean	2.457	2.458
Median	2.457	2.456
Std Dev	0.028	0.030

n = 125

Labs Eliminated: 31; 37; 98; 232; 271; 276; 322; 325; 326;
354; 361; 390; 413; 421; 422;

Figure 34. Scatter Diagram: Test 31 Max Wet Density.

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Test 32: Maximum Dry Density g/cm³

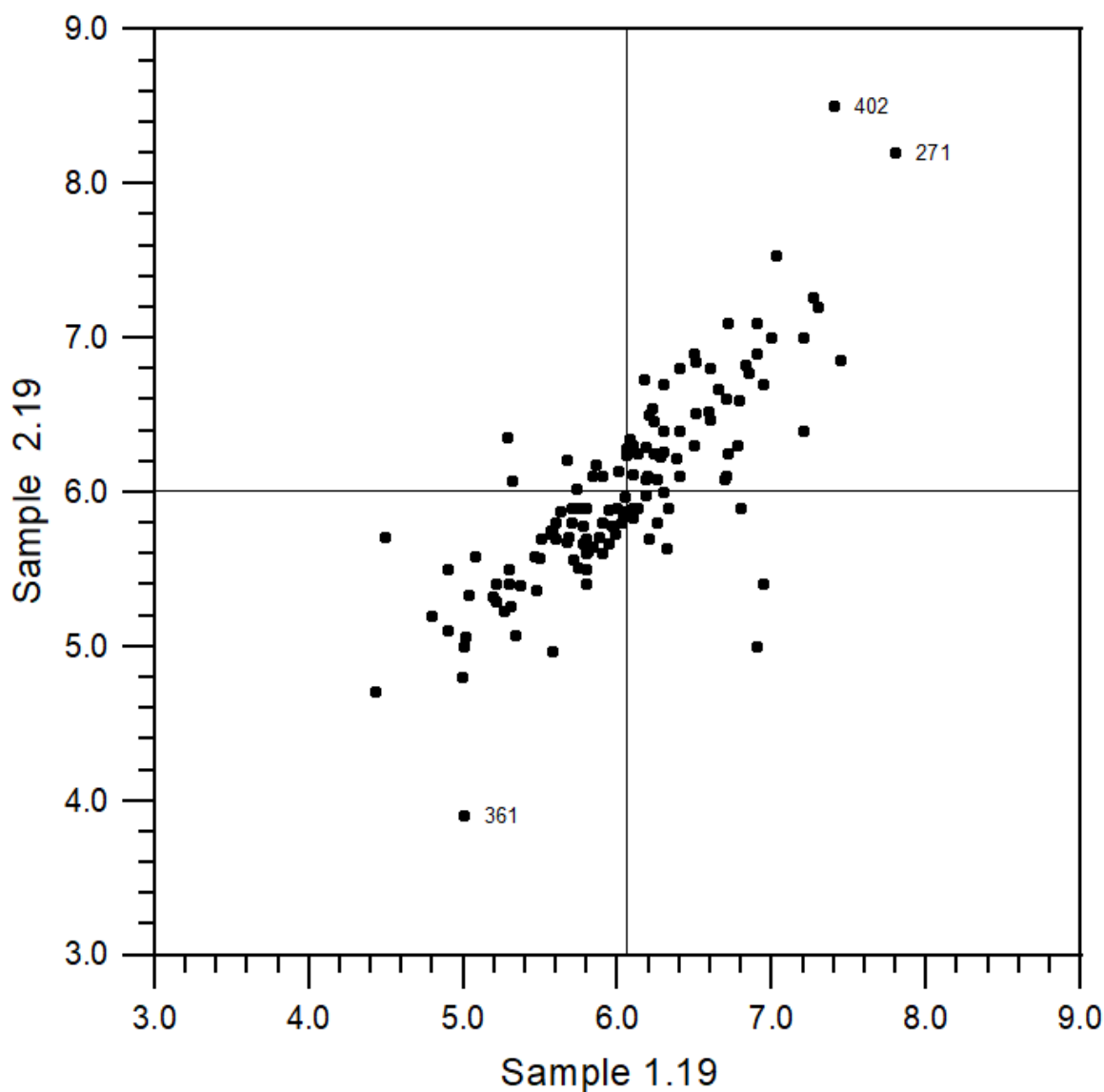
	Mat 1	Mat 2
Mean	2.330	2.335
Median	2.332	2.333
Std Dev	0.032	0.033

n = 135

Labs Eliminated: 47; 102; 172; 322; 413;

Figure 35. Scatter Diagram: Test 32 Max Dry Density.

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Test 33: Optimum Moisture, % (Moisture - Density)

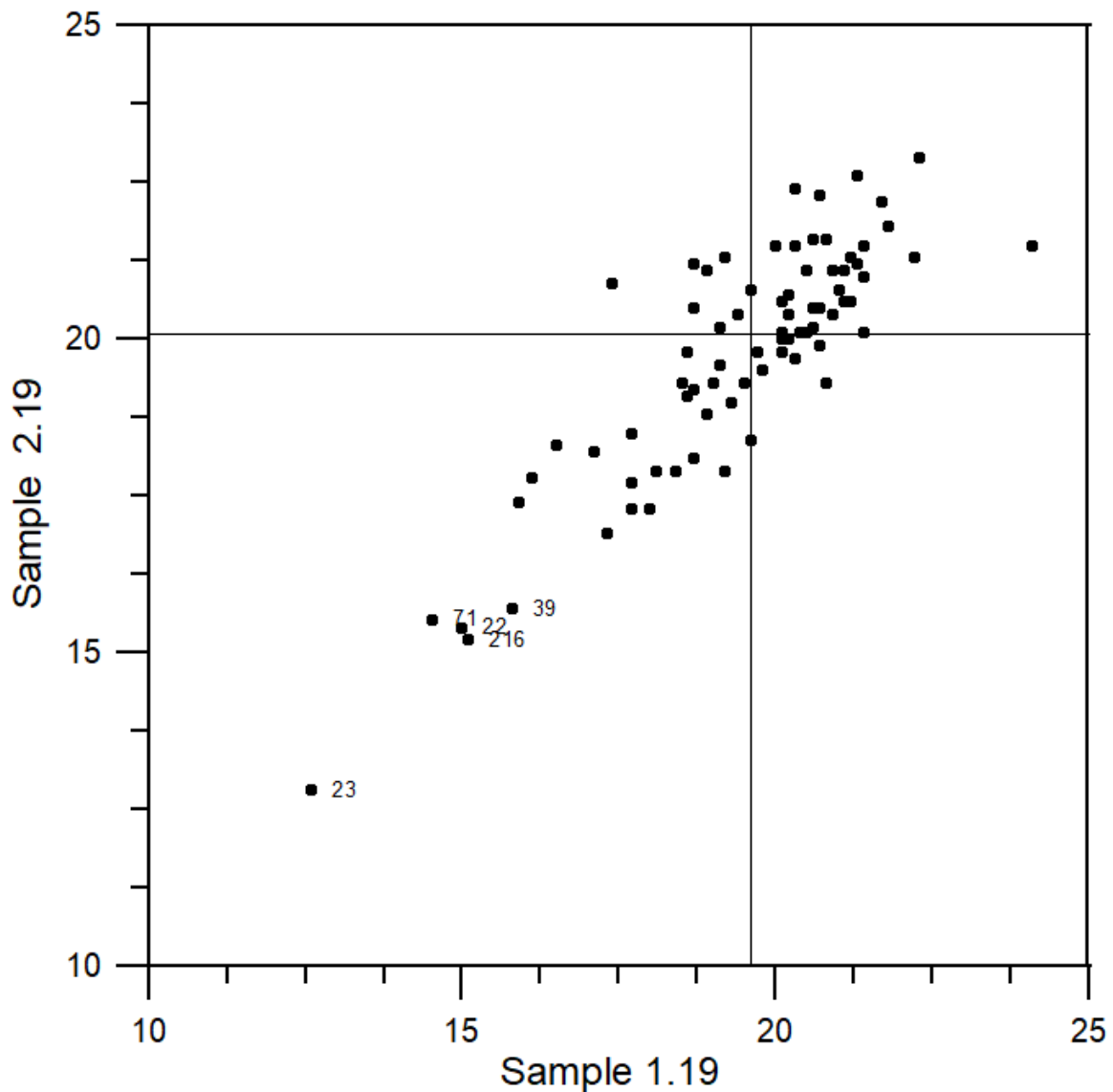
	Mat 1	Mat 2
Mean	6.054	6.015
Median	5.935	6.12
Std Dev	0.638	0.557

n = 137

Labs Eliminated: 271; 361; 402;

Figure 36. Scatter Diagram: Test 33 Optimum Moisture %.

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Test 34: Micro-Deval Abrasion Loss (FA), %

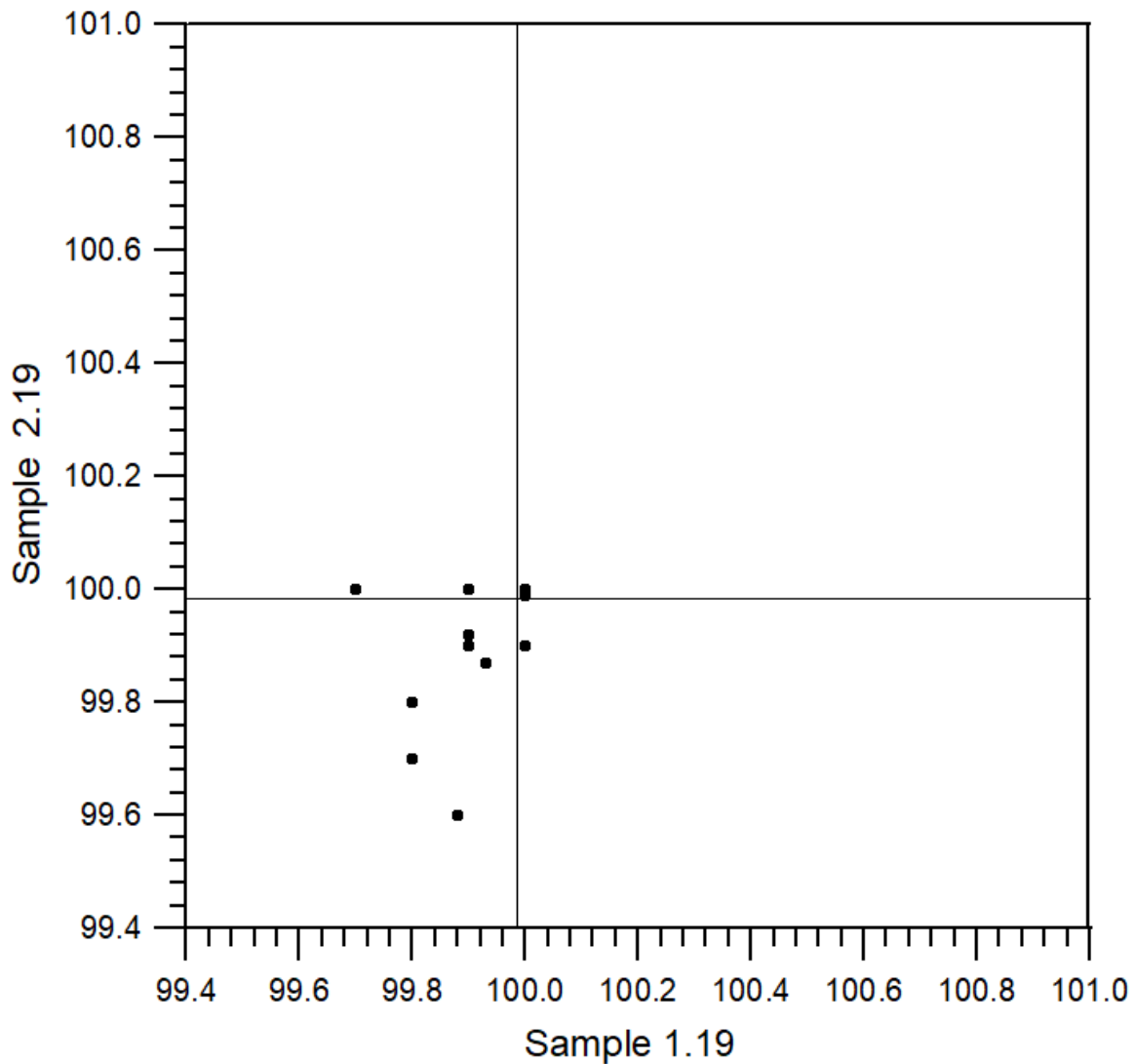
	Mat 1	Mat 2
Mean	19.618	20.077
Median	20	19.9
Std Dev	1.714	1.389

n = 75

Labs Eliminated: 22; 23; 39; 71; 216;

Figure 37. Scatter Diagram: Test 34 MDA, FA3.

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Test 40: Percent Passing the 2.00 mm Sieve (Soil)

	Mat 1	Mat 2
Mean	99.984	99.984
Median	99.85	99.8
Std Dev	0.051	0.061

n = 95

Labs Eliminated: None

Figure 38. Scatter Diagram: Test 40 P2.0 mm.

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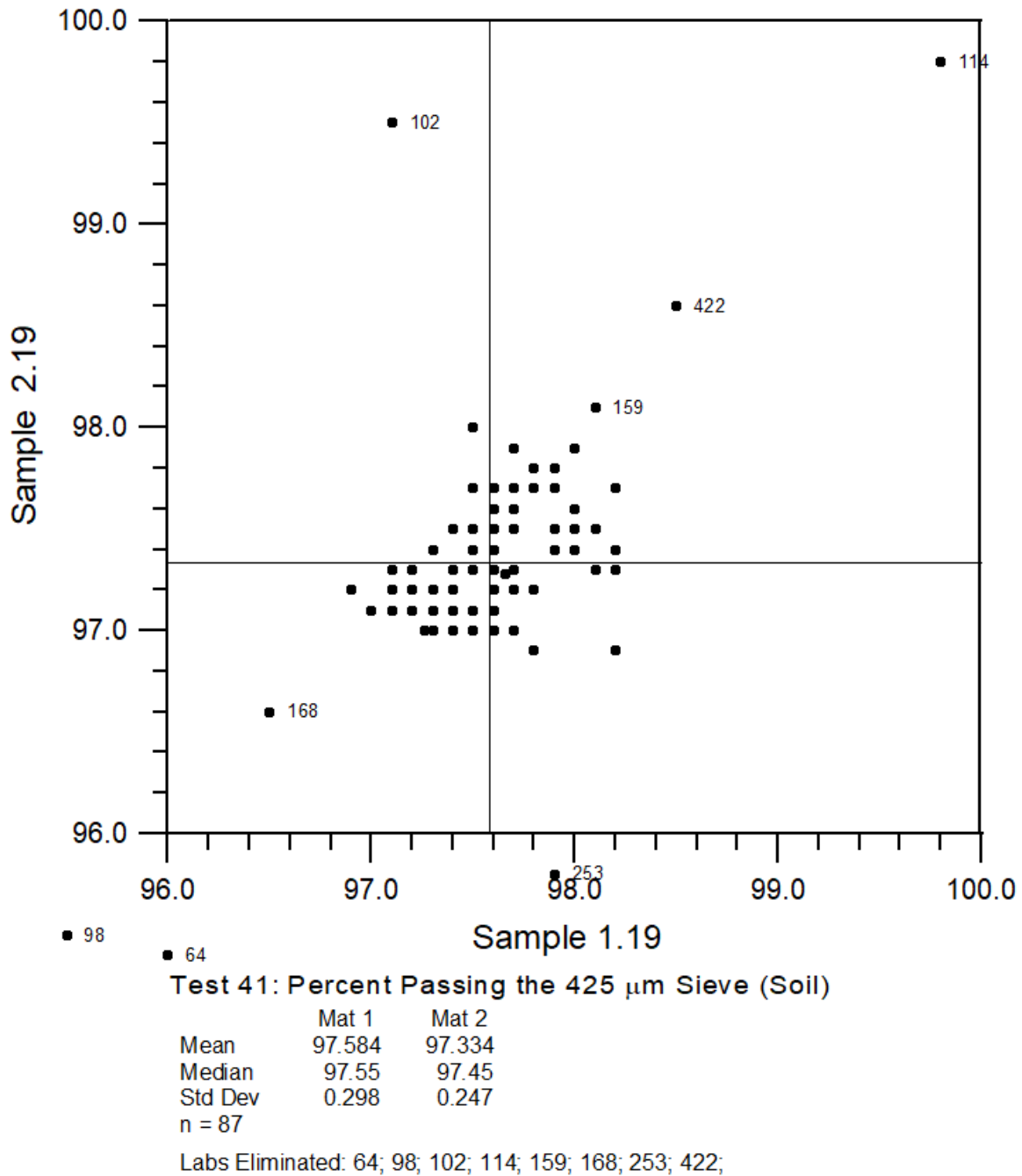
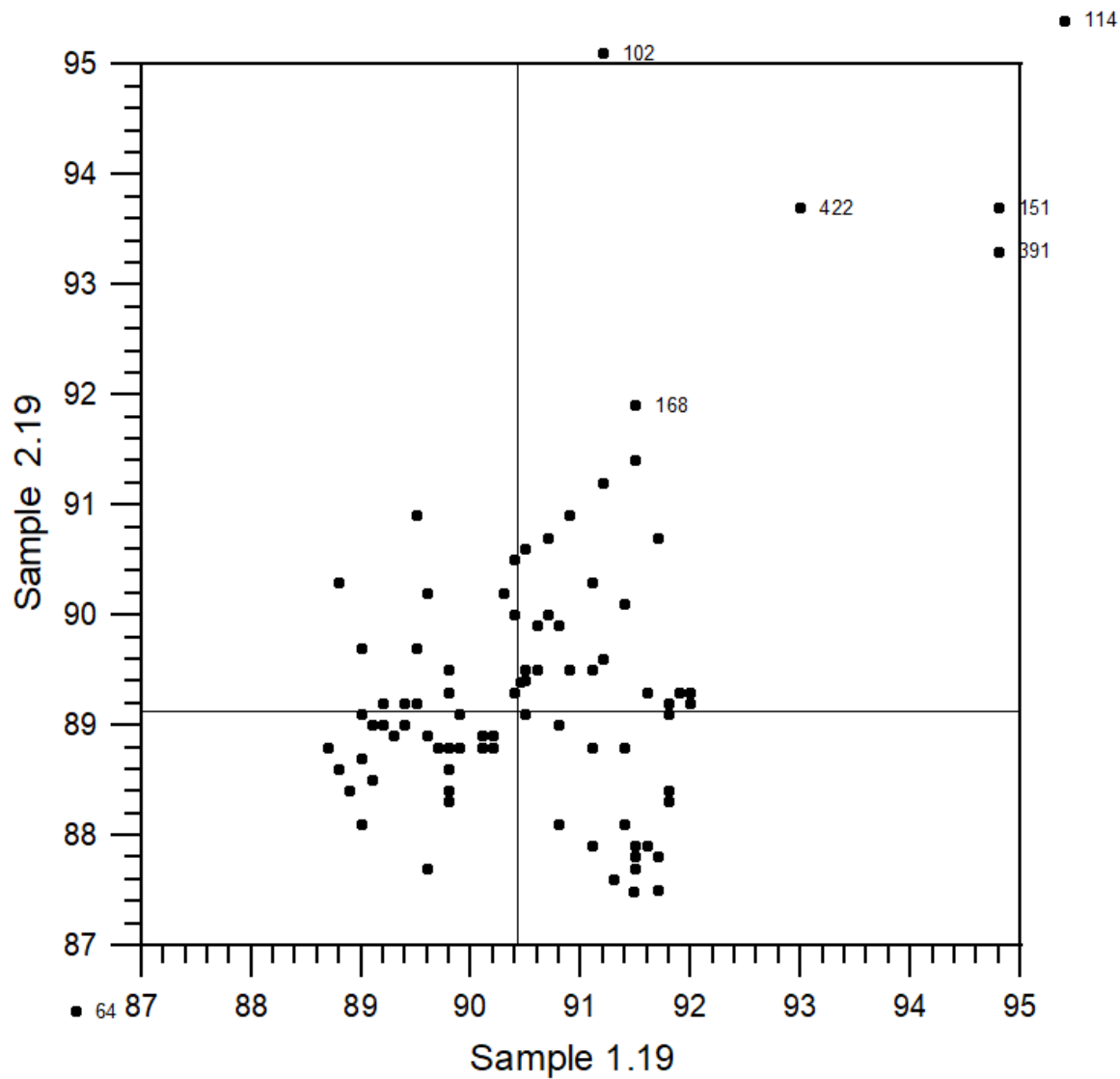


Figure 39. Scatter Diagram: Test 41 P425 μm .

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Test 42: Percent Passing the 75 µm Sieve (Soil)

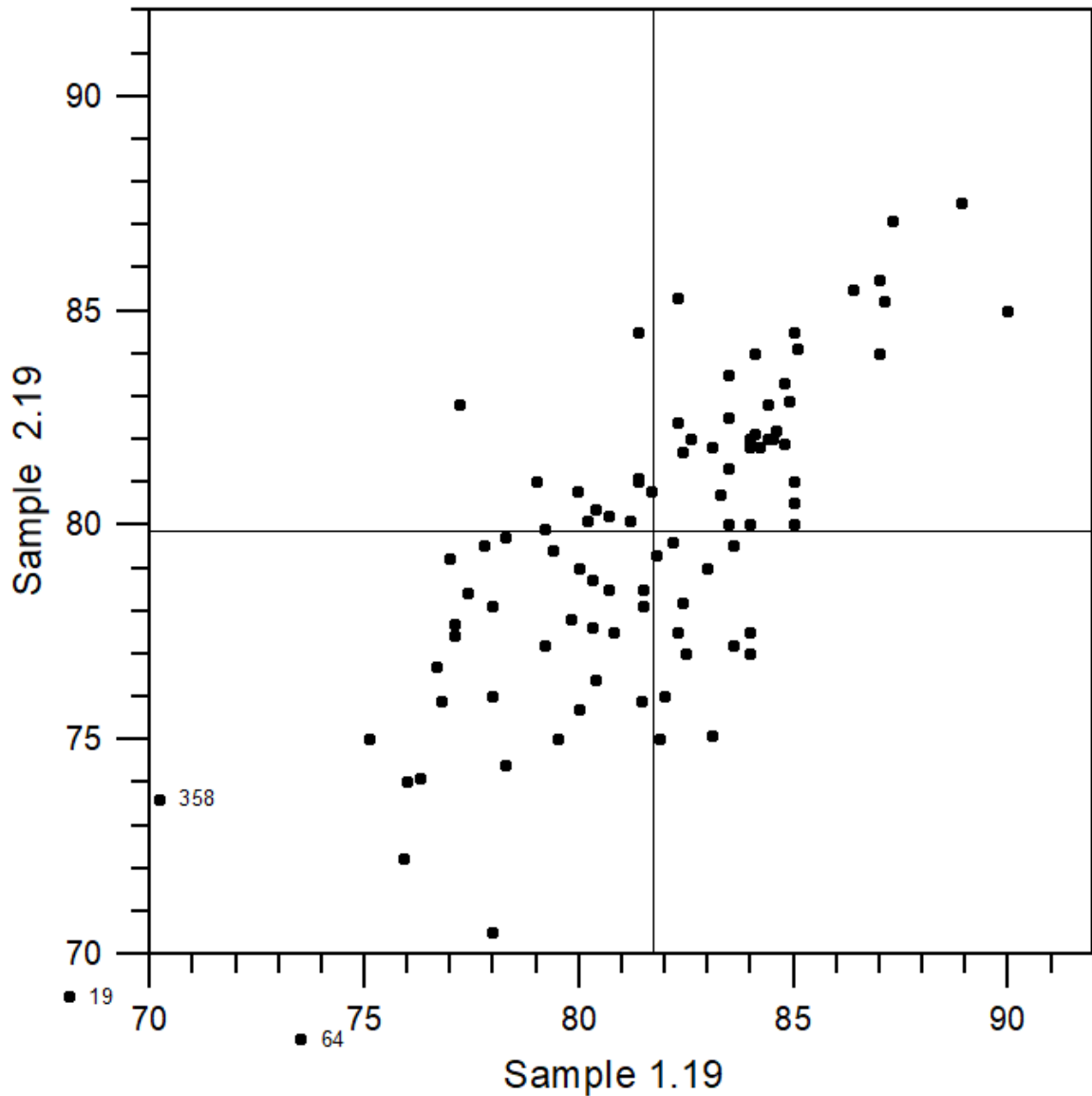
	Mat 1	Mat 2
Mean	90.442	89.128
Median	90.35	89.445
Std Dev	0.965	0.863

n = 88

Labs Eliminated: 64; 102; 114; 151; 168; 391; 422;

Figure 40. Scatter Diagram: Test 42 P75 µm.

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Test 43: Percent Passing the 20 µm Sieve (Soil)

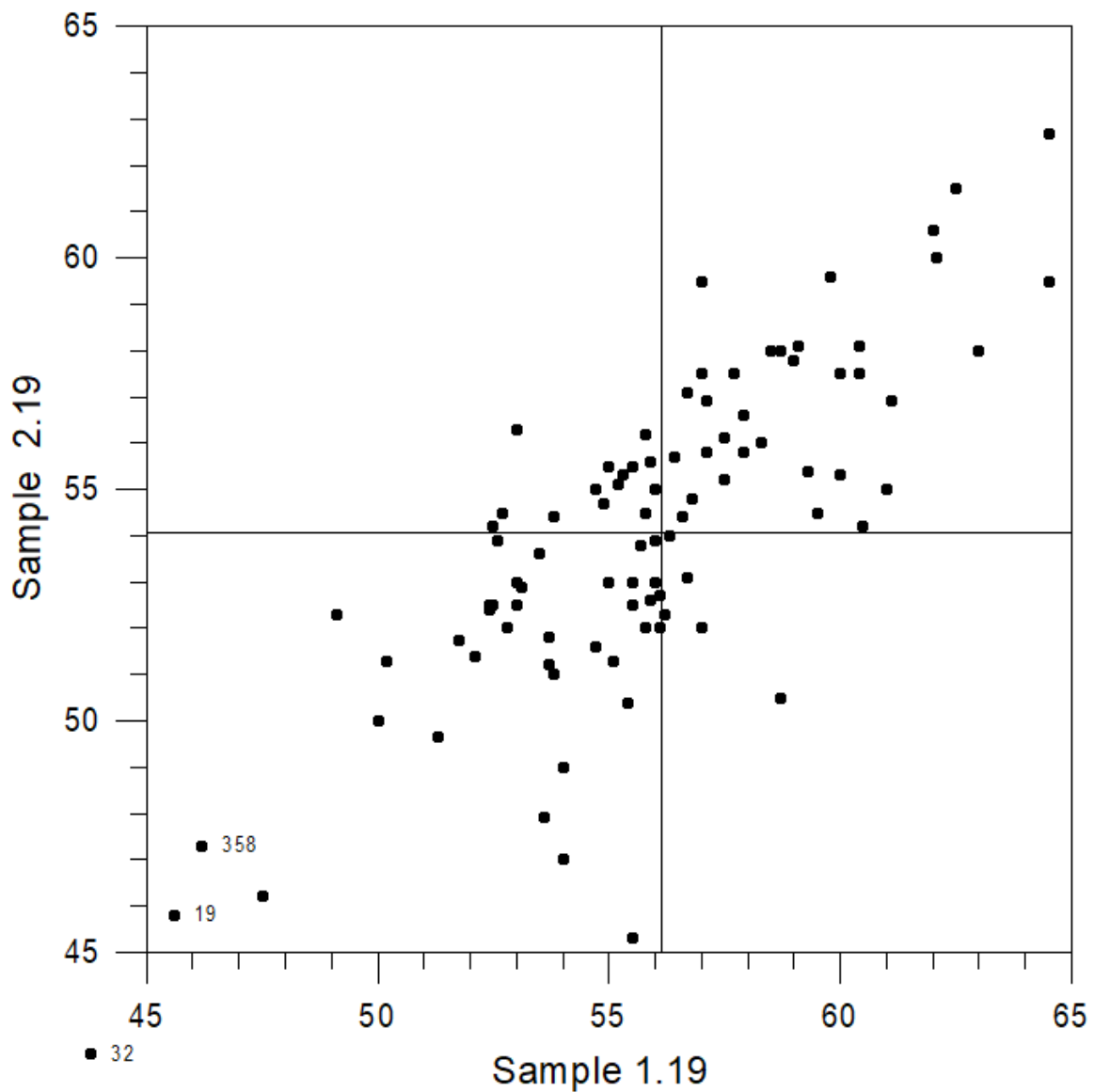
	Mat 1	Mat 2
Mean	81.717	79.853
Median	82.55	79.85
Std Dev	3.208	3.244

n = 91

Labs Eliminated: 19; 64; 69; 358;

Figure 41. Scatter Diagram: Test 43 P20 µm.

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Test 44: Percent Passing the 5 µm Sieve (Soil)

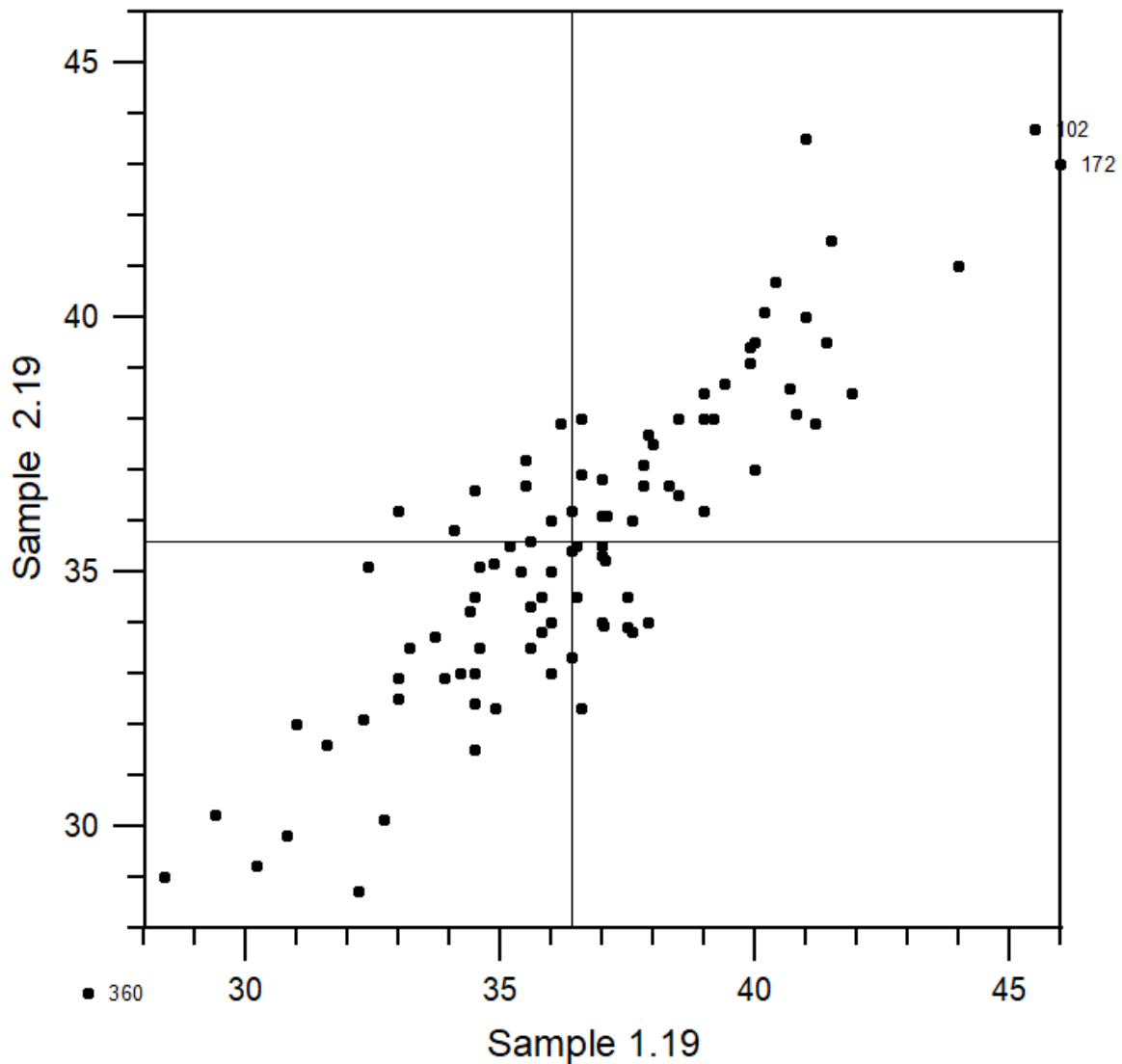
	Mat 1	Mat 2
Mean	56.123	54.079
Median	56	54
Std Dev	3.264	3.372

n = 92

Labs Eliminated: 19; 32; 358;

Figure 42.Scatter Diagram: Test 44 P5 µm.

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Test 45: Percent Passing the 2 µm Sieve (Soil)

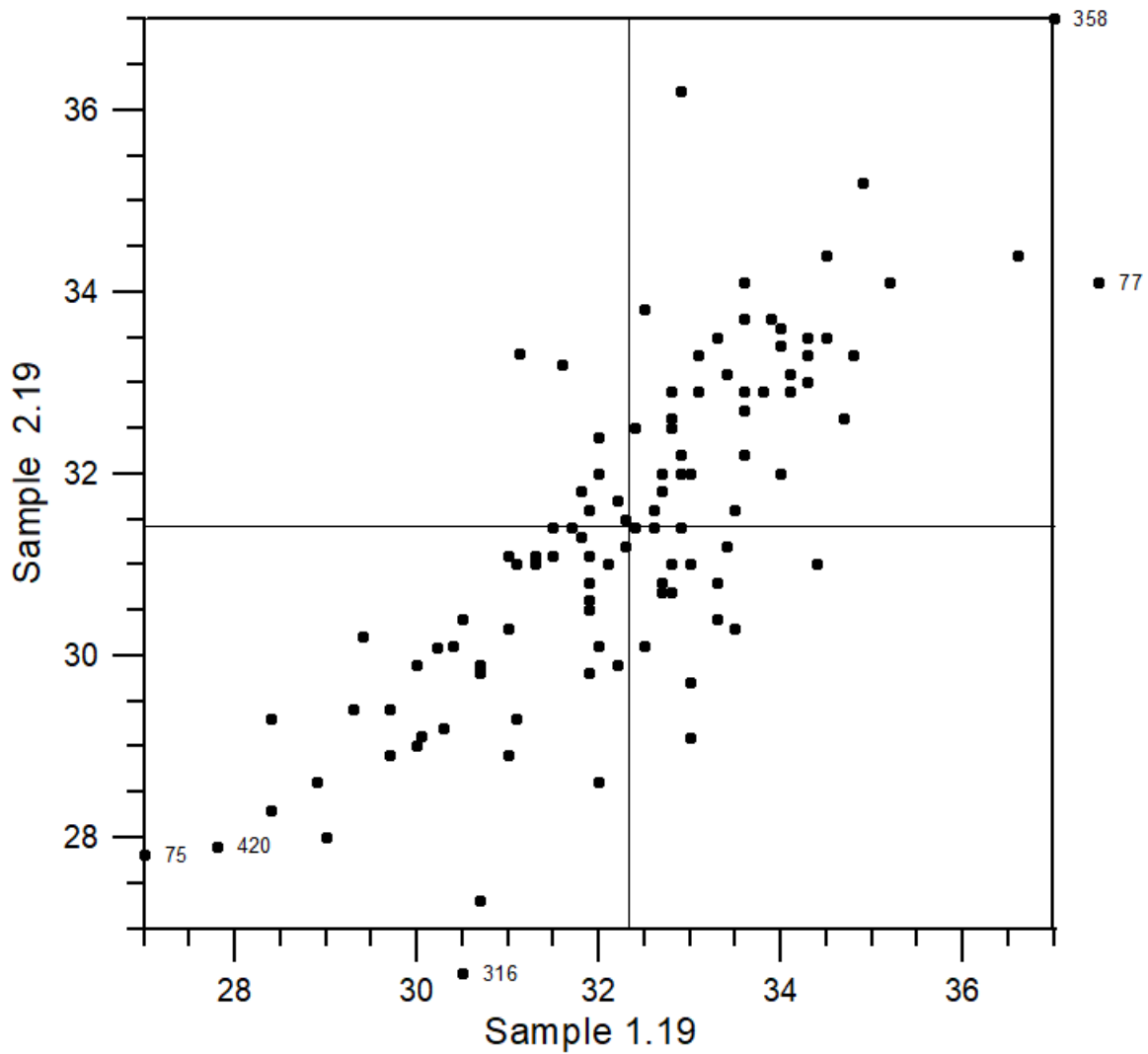
	Mat 1	Mat 2
Mean	34.406	35.595
Median	36.2	36.1
Std Dev	2.967	3.088

n = 92

Labs Eliminated: 102; 172; 360;

Figure 43. Scatter Diagram: Test 45 P2 µm.

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Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	32.222	31.420
Median	32.5	31.75
Std Dev	1.579	1.769

n = 104

Labs Eliminated: 75; 77; 316; 358; 420;

Figure 44. Scatter Diagram: Test 46 Liquid Limit %.

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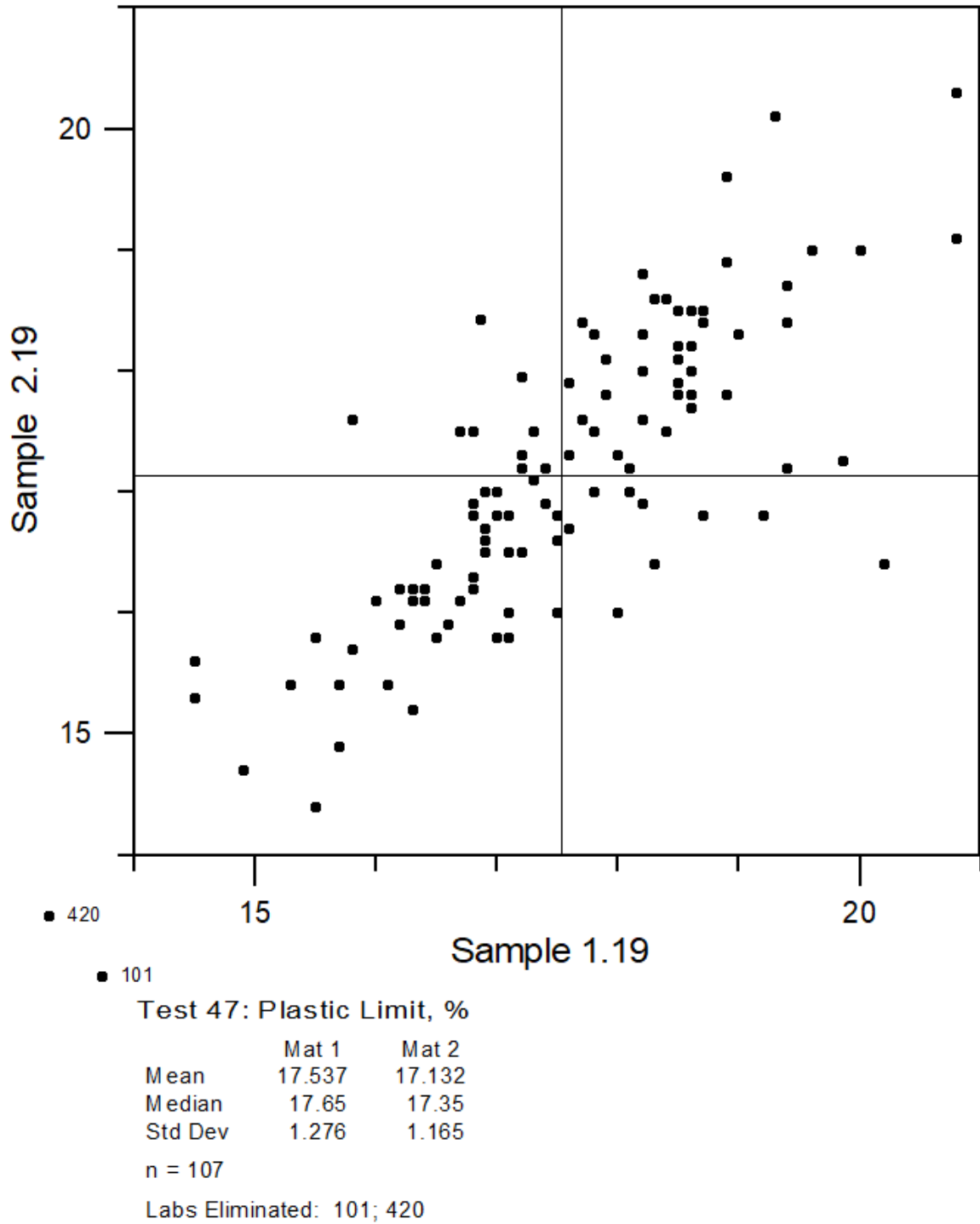
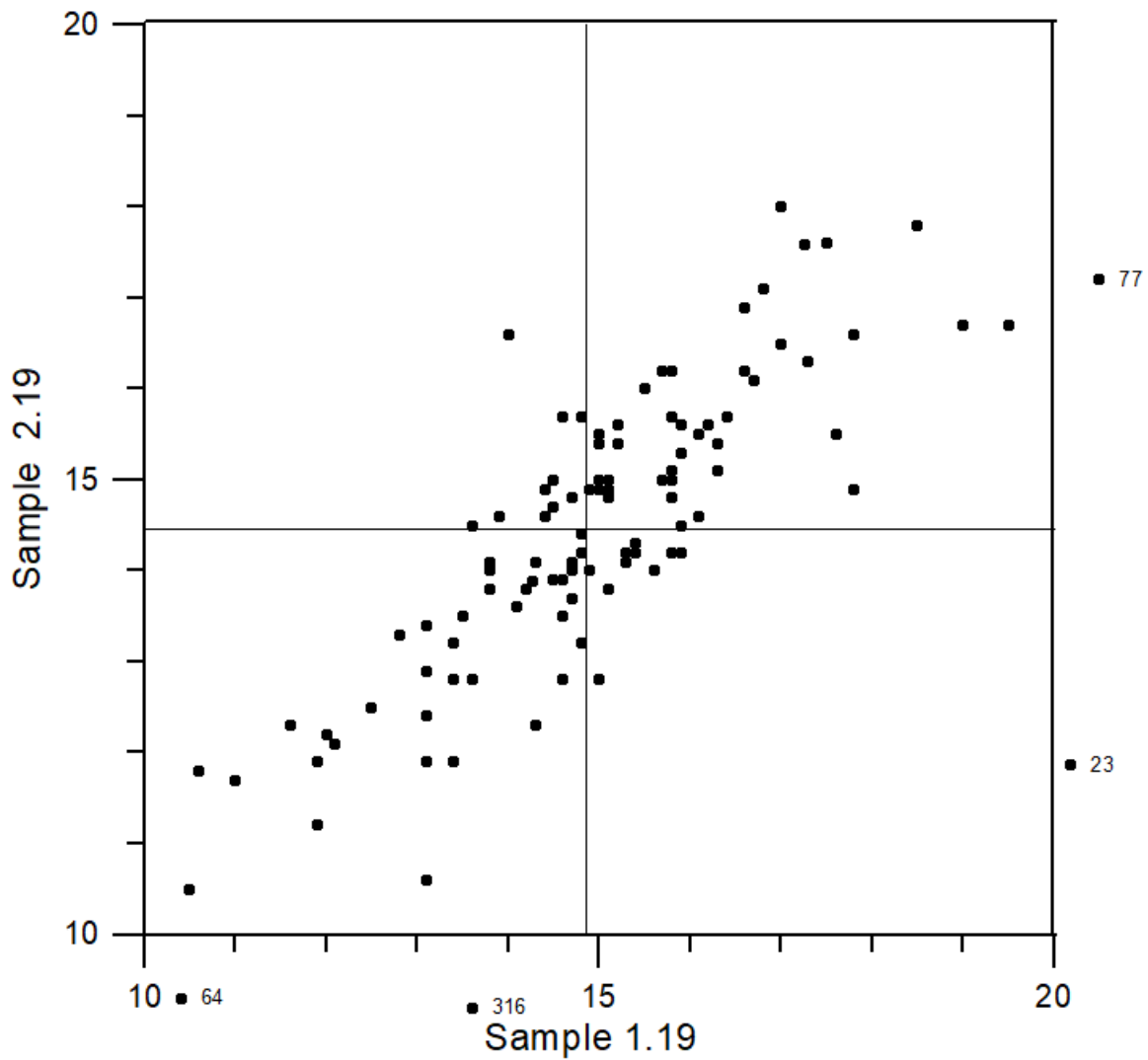


Figure 45. Scatter Diagram: Test 47 Plastic Limit %.

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Test 48: Plasticity Index, %

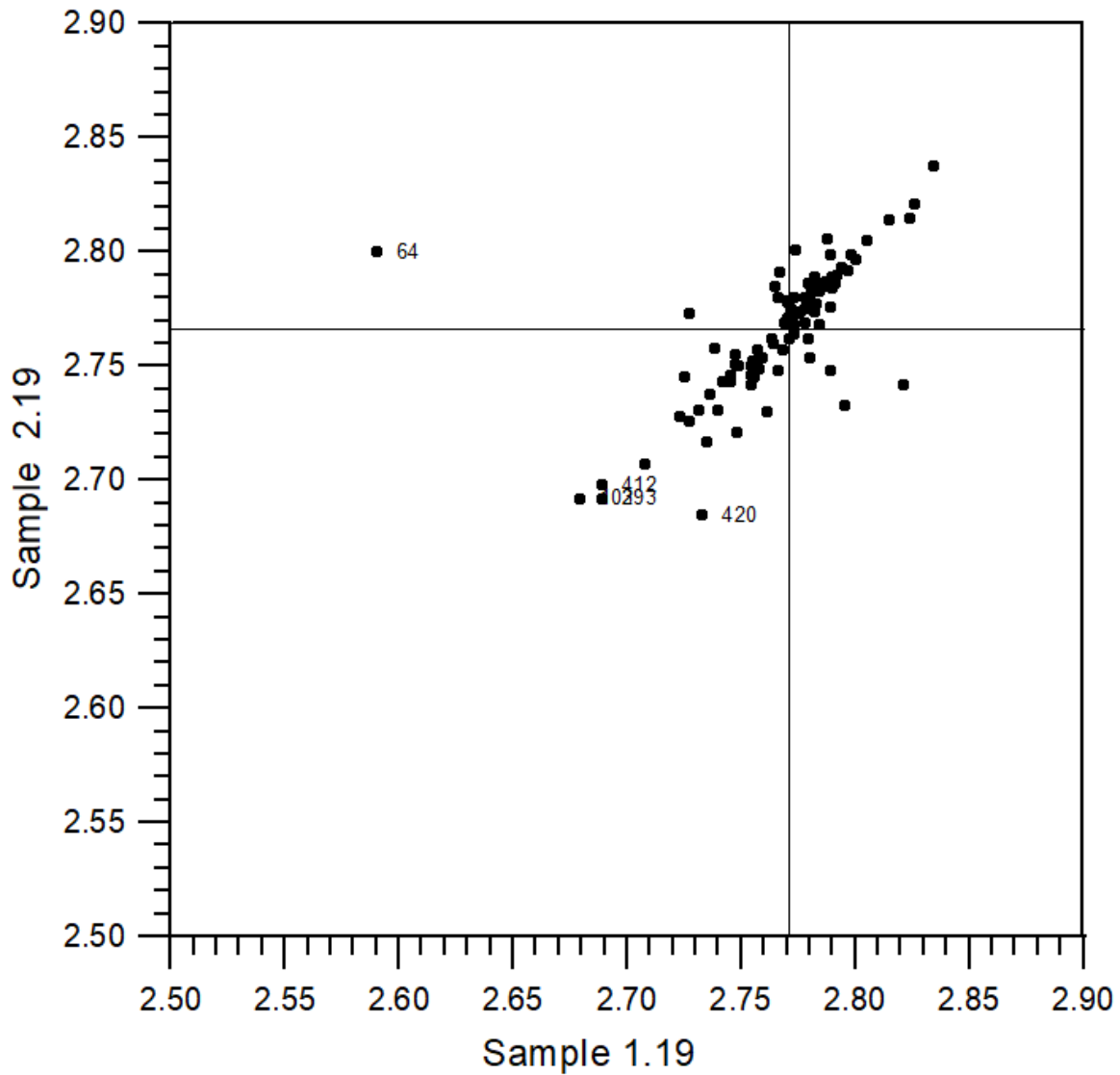
	Mat 1	Mat 2
Mean	14.853	14.464
Median	15	14.25
Std Dev	1.757	1.625

n = 105

Labs Eliminated: 23; 64; 77; 316;

Figure 46. Scatter Diagram: Test 48 Plasticity Index %.

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Test 49: Specific Gravity of Soil

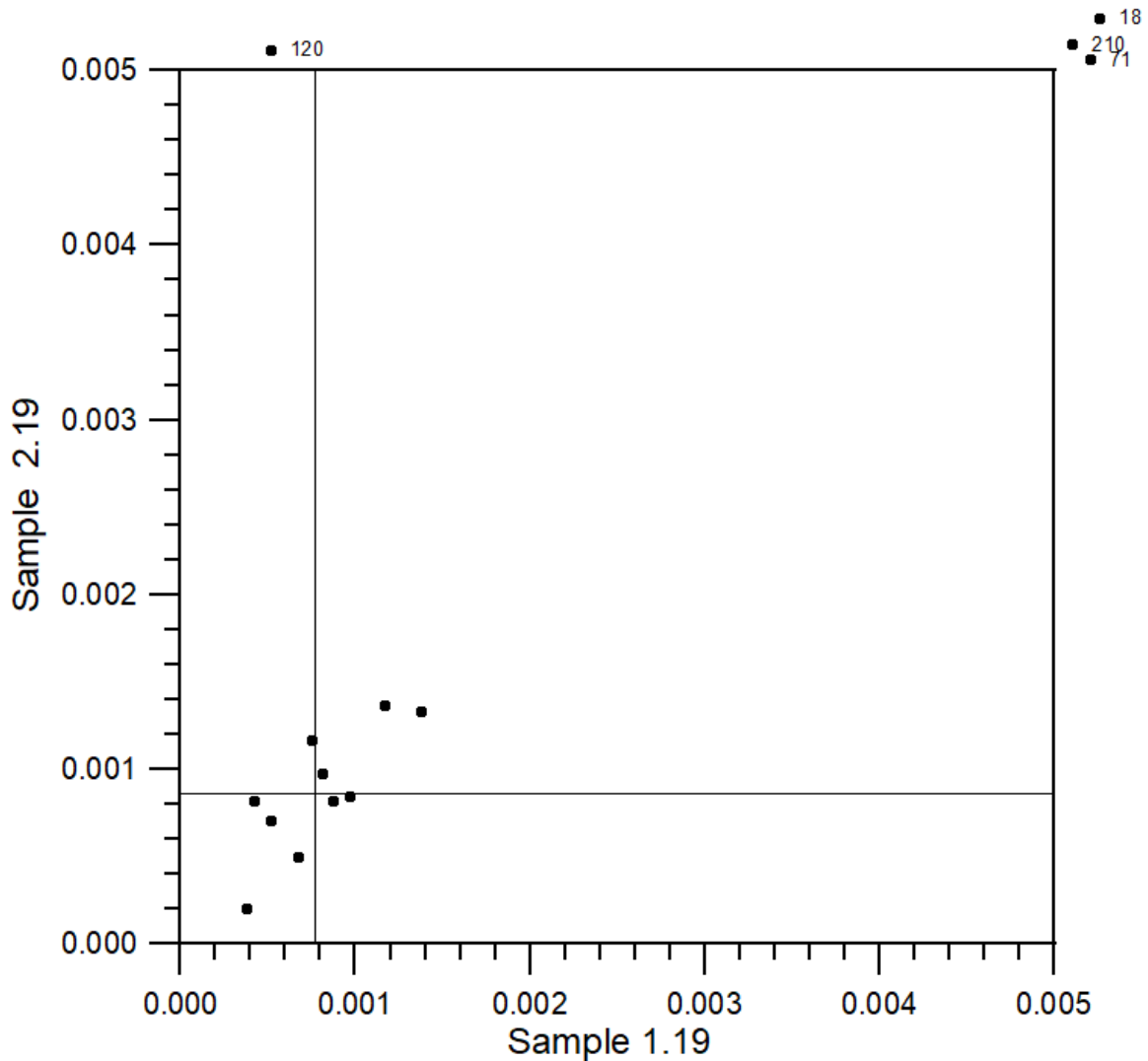
	Mat 1	Mat 2
Mean	2.771	2.766
Median	2.771	2.773
Std Dev	0.024	0.028

n = 90

Labs Eliminated: 64; 102; 393; 412; 420;

Figure 47. Scatter Diagram: Test 49 SG of Soils.

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Test 50: Coefficient of Consolidation (C_v), cm^2/s

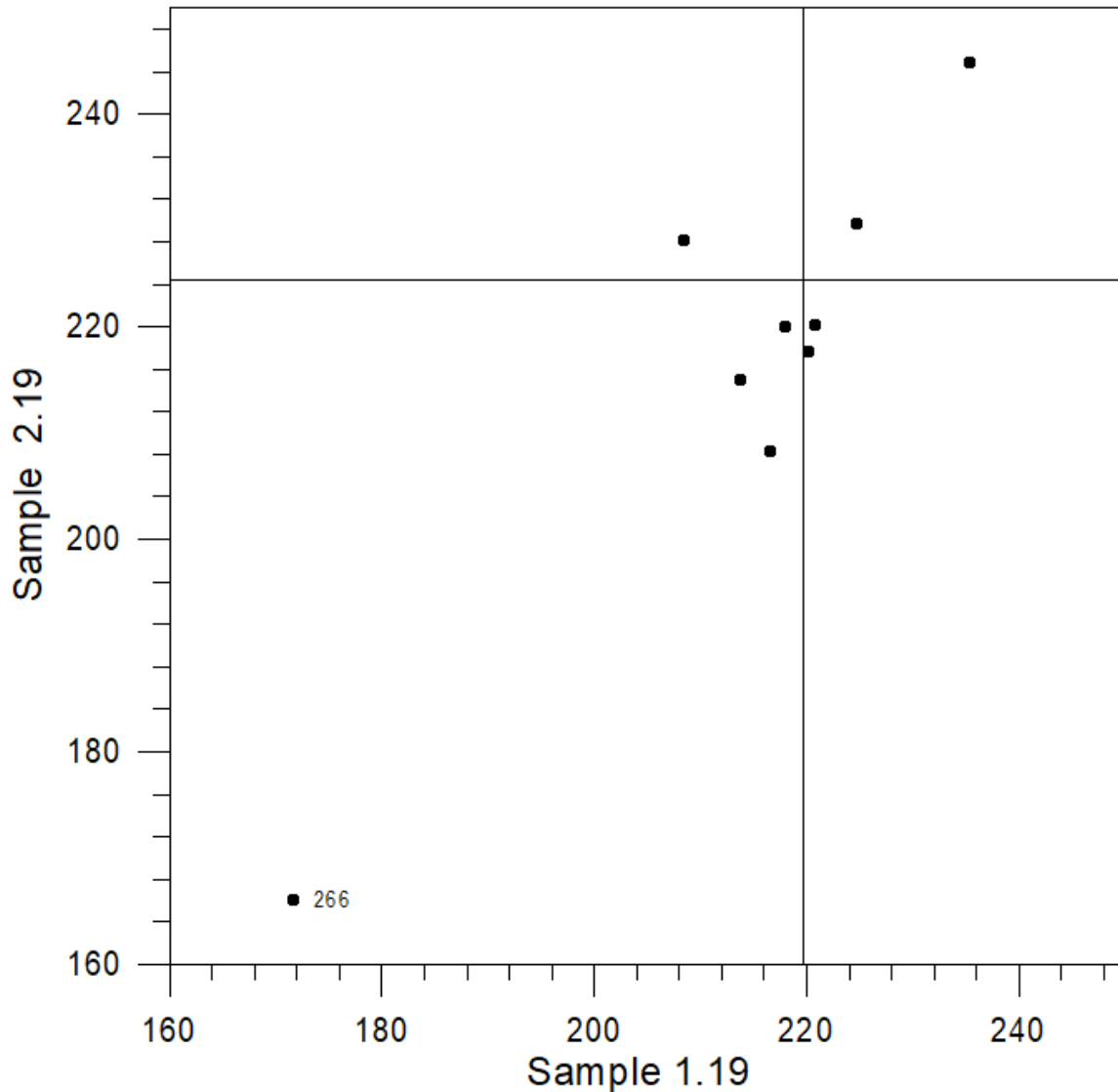
	Mat 1	Mat 2
Mean	0.000770	0.000861
Median	0.000756	0.000818
Std Dev	0.000315	0.000344

n = 11

Labs Eliminated: 18, 71, 120, 210

Figure 48. Scatter Diagram: Test 50 Coefficient of Consolidation.

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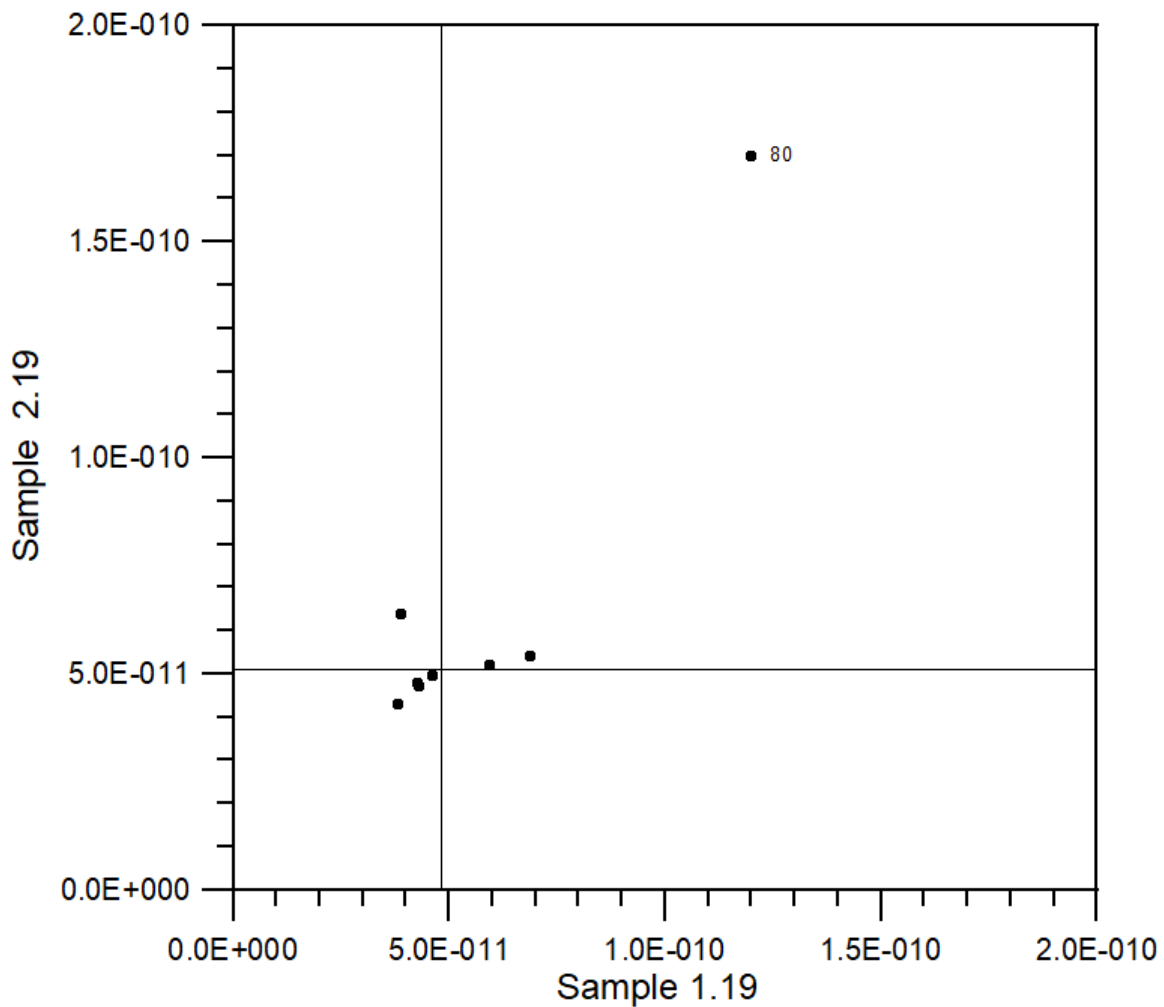
Test 51: Peak Shear Stress by Direct Shear of Soil, kPa

	Mat 1	Mat 2
Mean	219.703	224.407
Median	219.100	220.200
Std Dev	7.985	11.294
n = 9		

Labs Eliminated: 266

Figure 49. Scatter Diagram: Test 51 Direct Shear.

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Test 52: Constant Head Hydraulic Conductivity of Soil (k_{20}), m/s

	Mat 1	Mat 2
Mean	4.8E-11	5.1E-11
Median	4.3E-11	5.0E-11
Std Dev	1.2E-11	6.7E-12

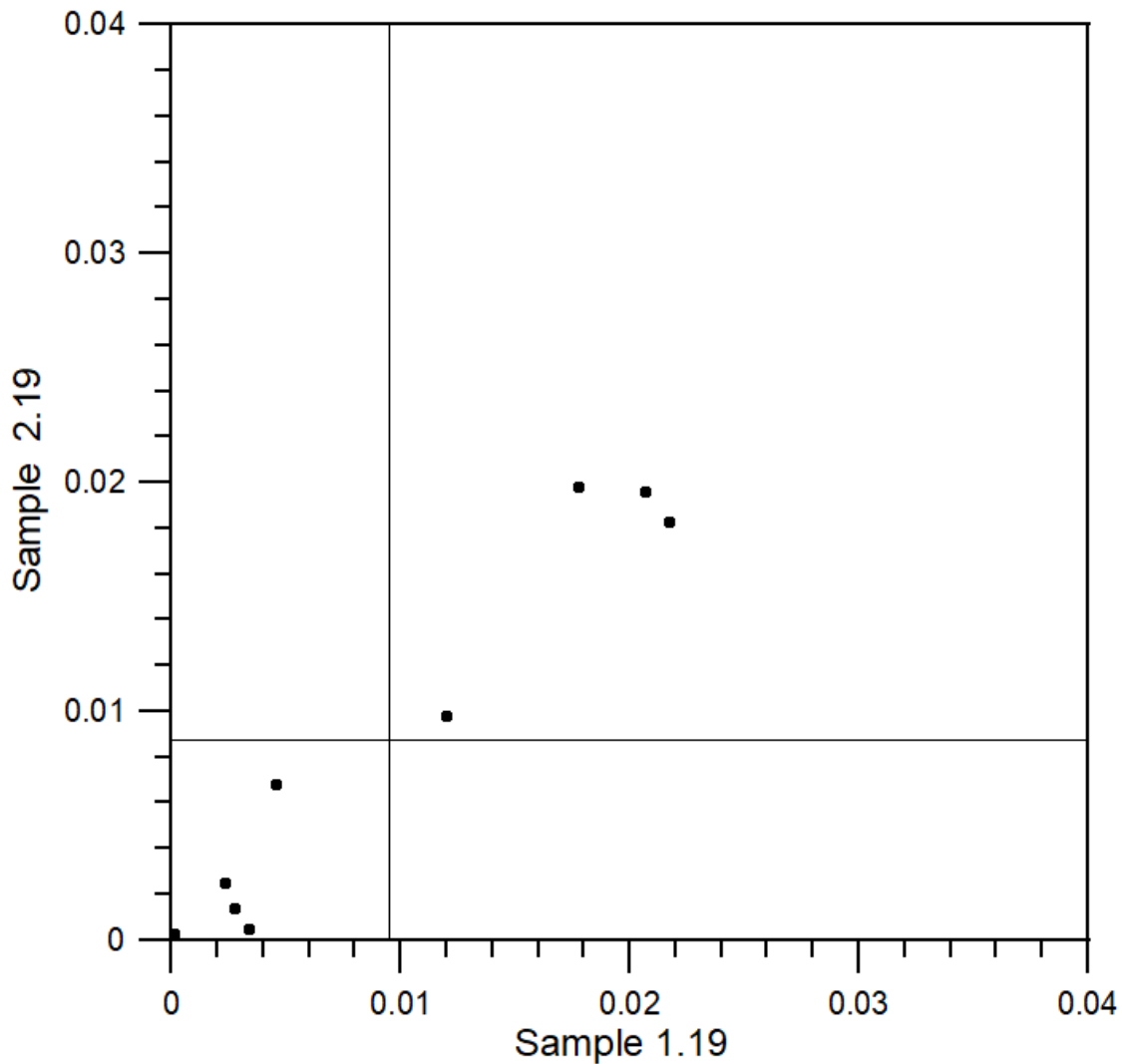
n = 7

Labs Eliminated: 80

Figure 50. Scatter Diagram: Test 52 Conductivity of Soil.

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Test 53: Granular Permeability (k_{20}), cm/s

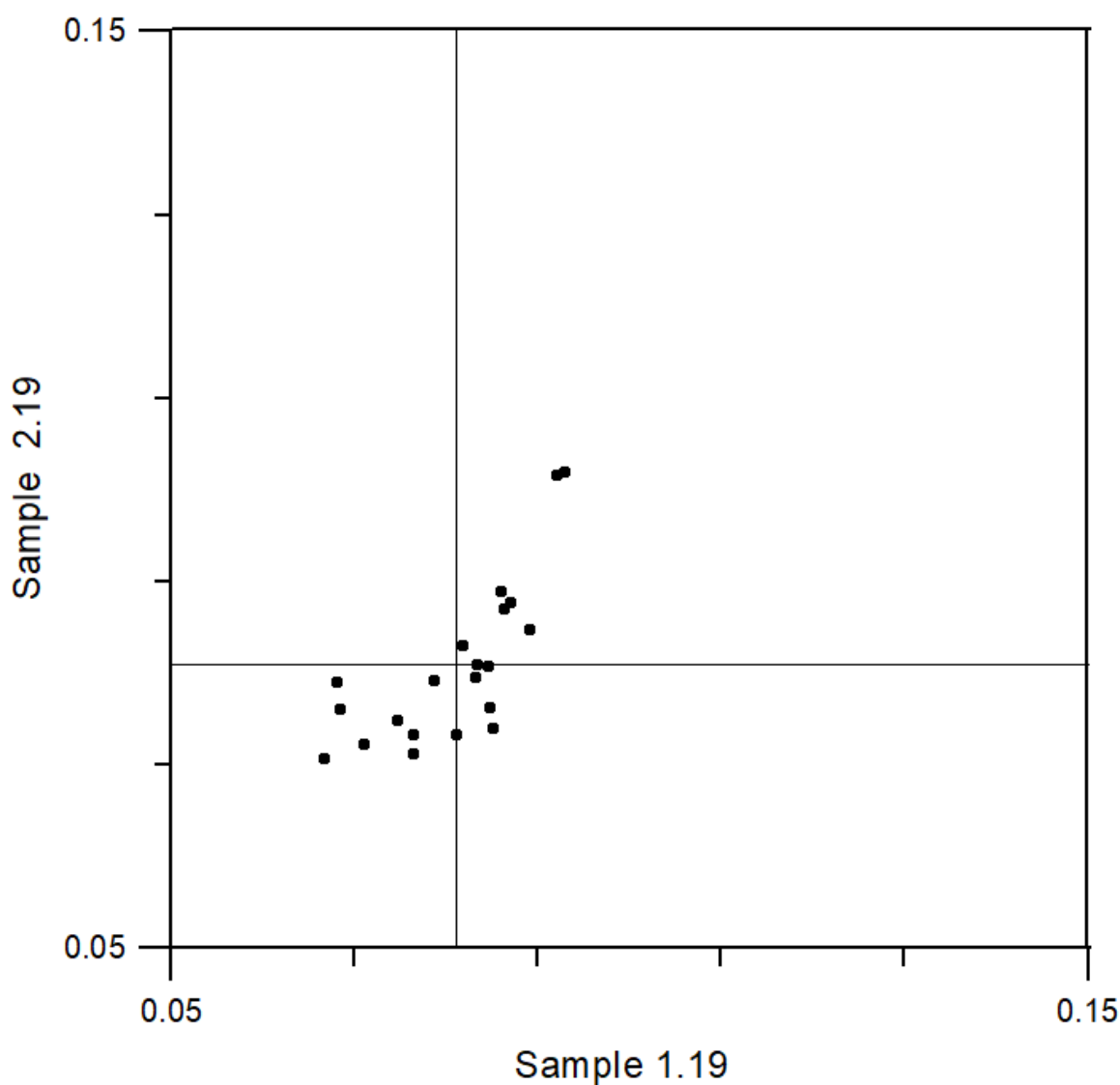
	Mat 1	Mat 2
Mean	0.0095	0.0088
Median	0.0045	0.0068
Std Dev	0.0086	0.0084

n = 9

Labs Eliminated: 58

Figure 51. Scatter Diagram: Test 53 Granular Permeability.

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Test 123: Accelerated Mortar Bar (M1) - 14 Days in NaOH

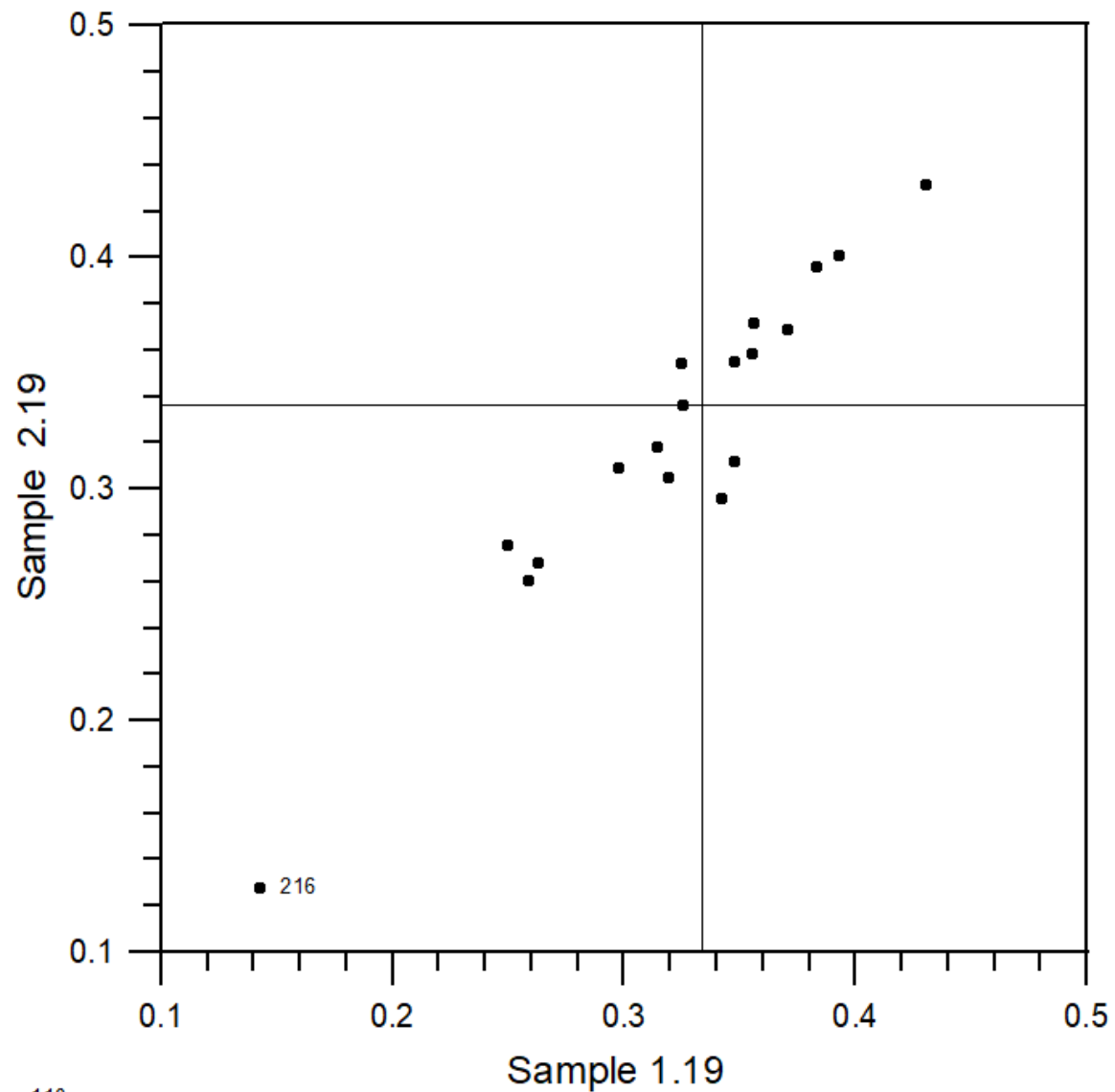
	Mat 1	Mat 2
Mean	0.081	0.081
Median	0.080	0.086
Std Dev	0.008	0.009

n = 21

Labs Eliminated: None

Figure 52. Scatter Diagram: Test 123 AMB (M1).

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Test 124: Accelerated Mortar Bar (M2) - 14 Days in NaOH

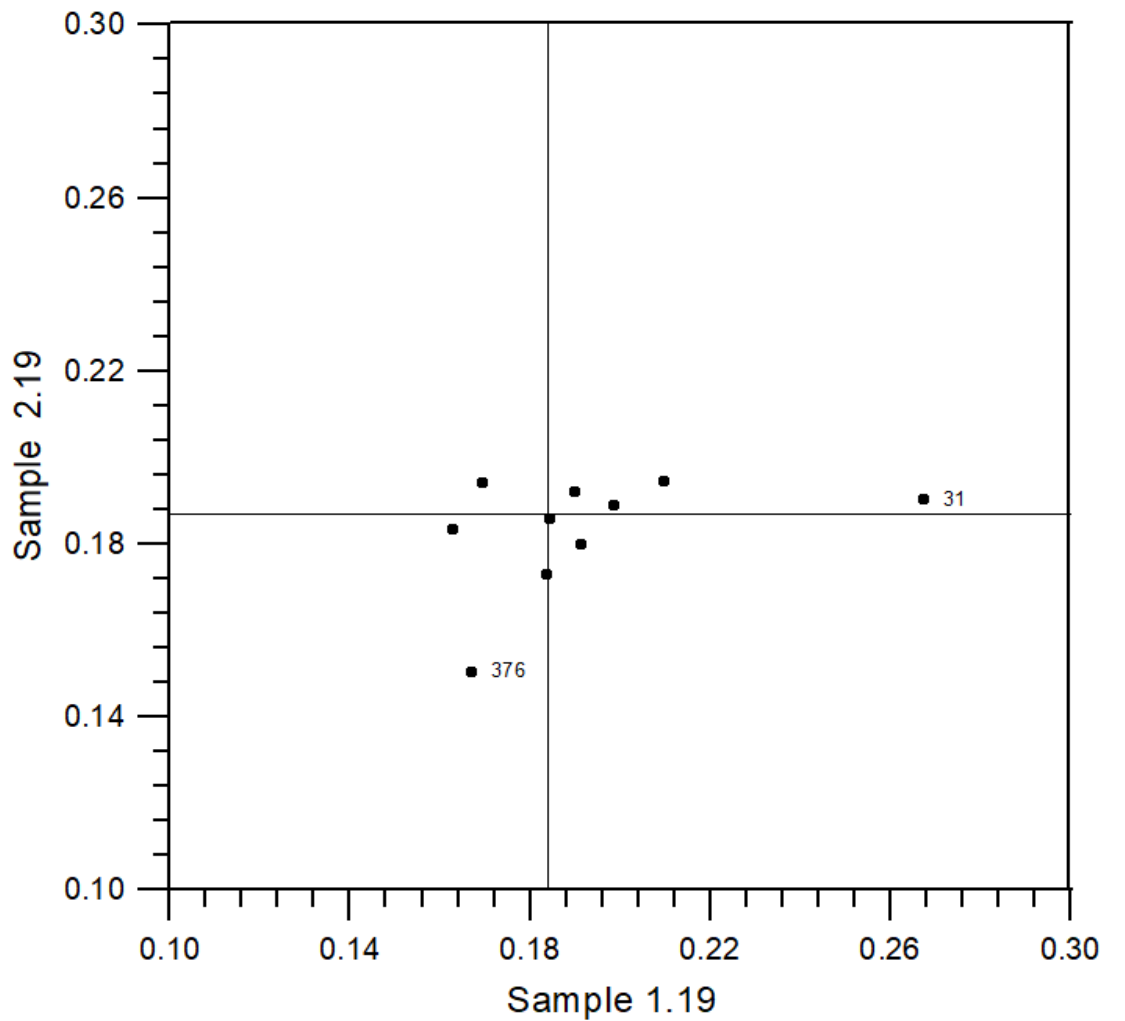
	Mat 1	Mat 2
Mean	0.334	0.336
Median	0.342	0.336
Std Dev	0.049	0.049

n = 17

Labs Eliminated: 110, 216

Figure 53. Scatter Diagram: Test 124 AMB (M2).

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Test 125: Concrete Prism Test at 38°C - Expansion at 52 Weeks

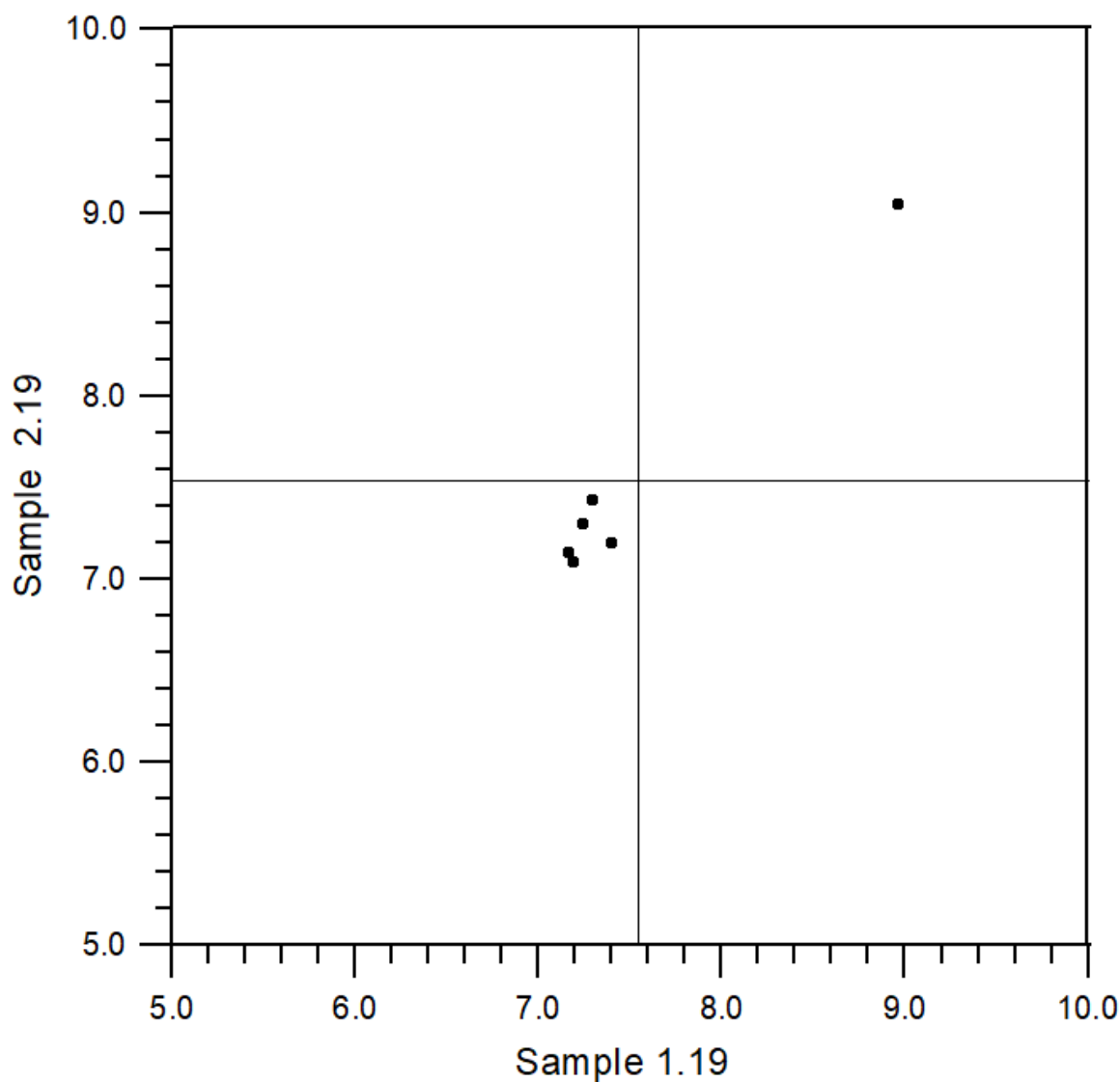
	Mat 1	Mat 2
Mean	0.184	0.187
Median	0.184	0.189
Std Dev	0.015	0.007

n = 10

Labs Eliminated: 31; 376

Figure 54. Scatter Diagram: Test 125 Concrete Prism.

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Test 126: Weight % of SiO_2 - Chemical Composition of Rocks

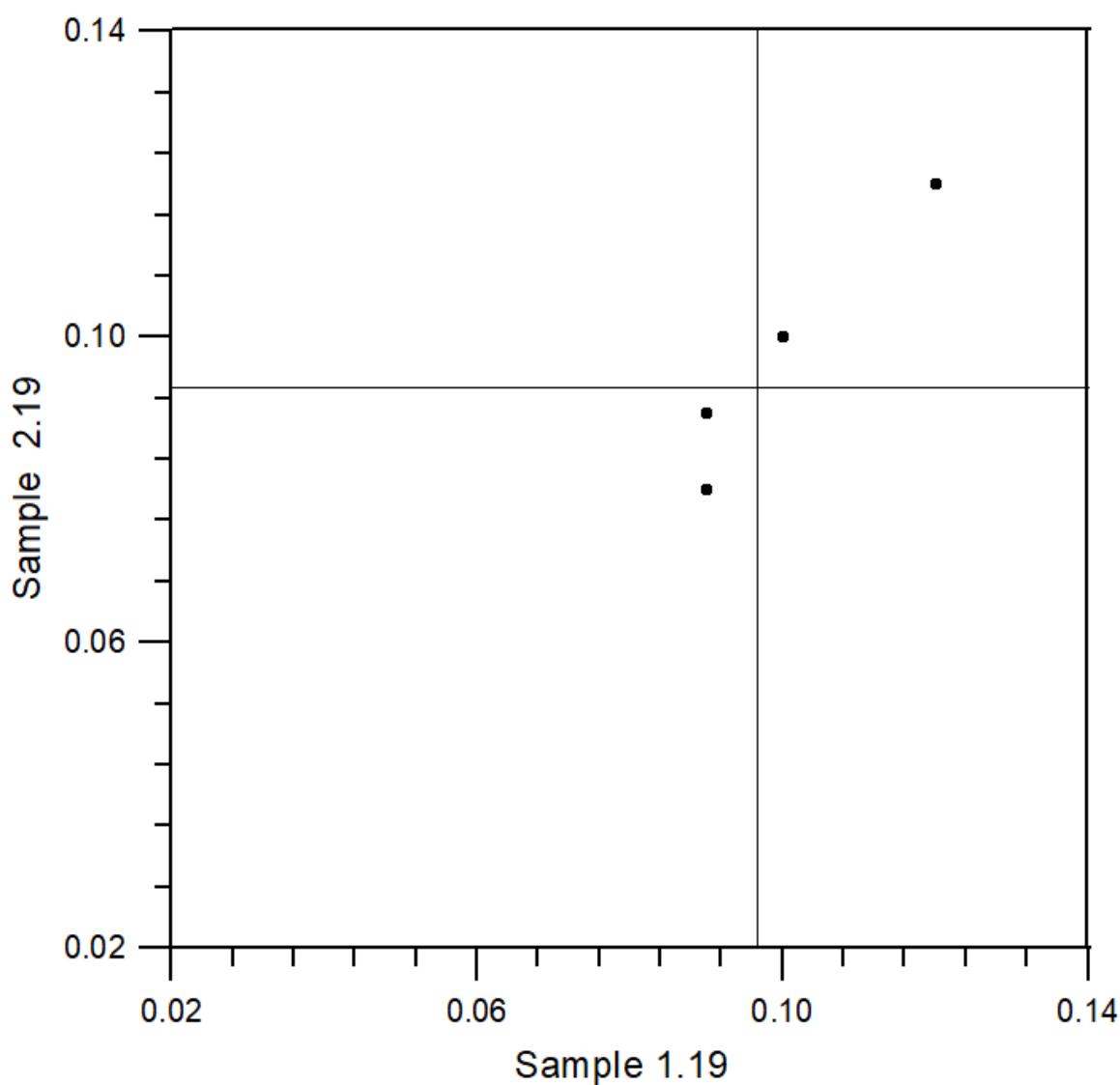
	Mat 1	Mat 2
Mean	7.540	7.537
Median	7.265	7.250
Std Dev	0.701	0.751

n = 6

Labs Eliminated: None

Figure 55. Scatter Diagram: Test 126 CCR SiO_2 .

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Test 127: Weight % of TiO₂ - Chemical Composition of Rocks

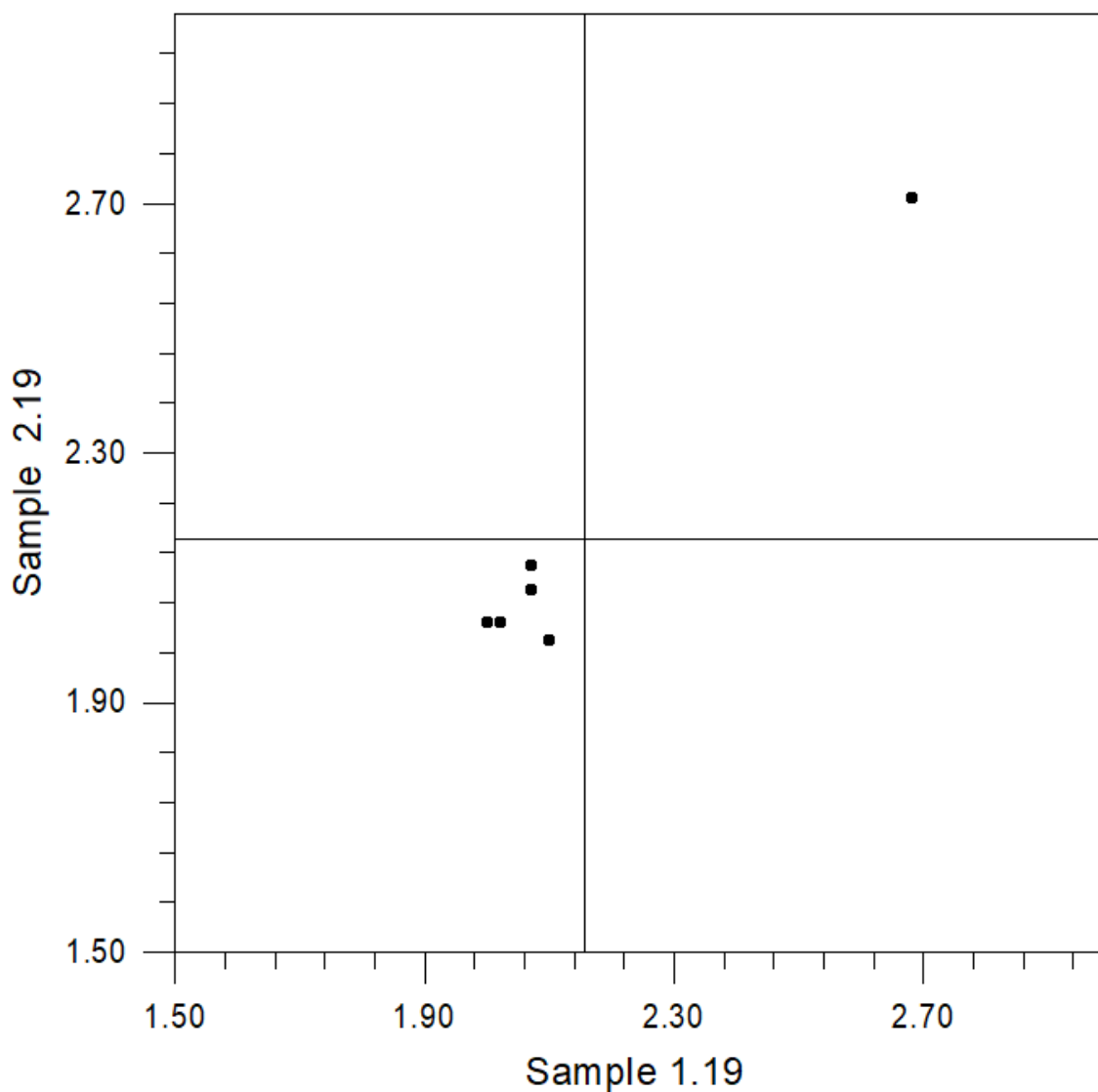
	Mat 1	Mat 2
Mean	0.097	0.093
Median	0.090	0.090
Std Dev	0.012	0.015

n = 6

Labs Eliminated: None

Figure 56. Scatter Diagram: Test 127 CCR TiO₂.

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Test 128: Weight % of Al_2O_3 - Chemical Composition of Rocks

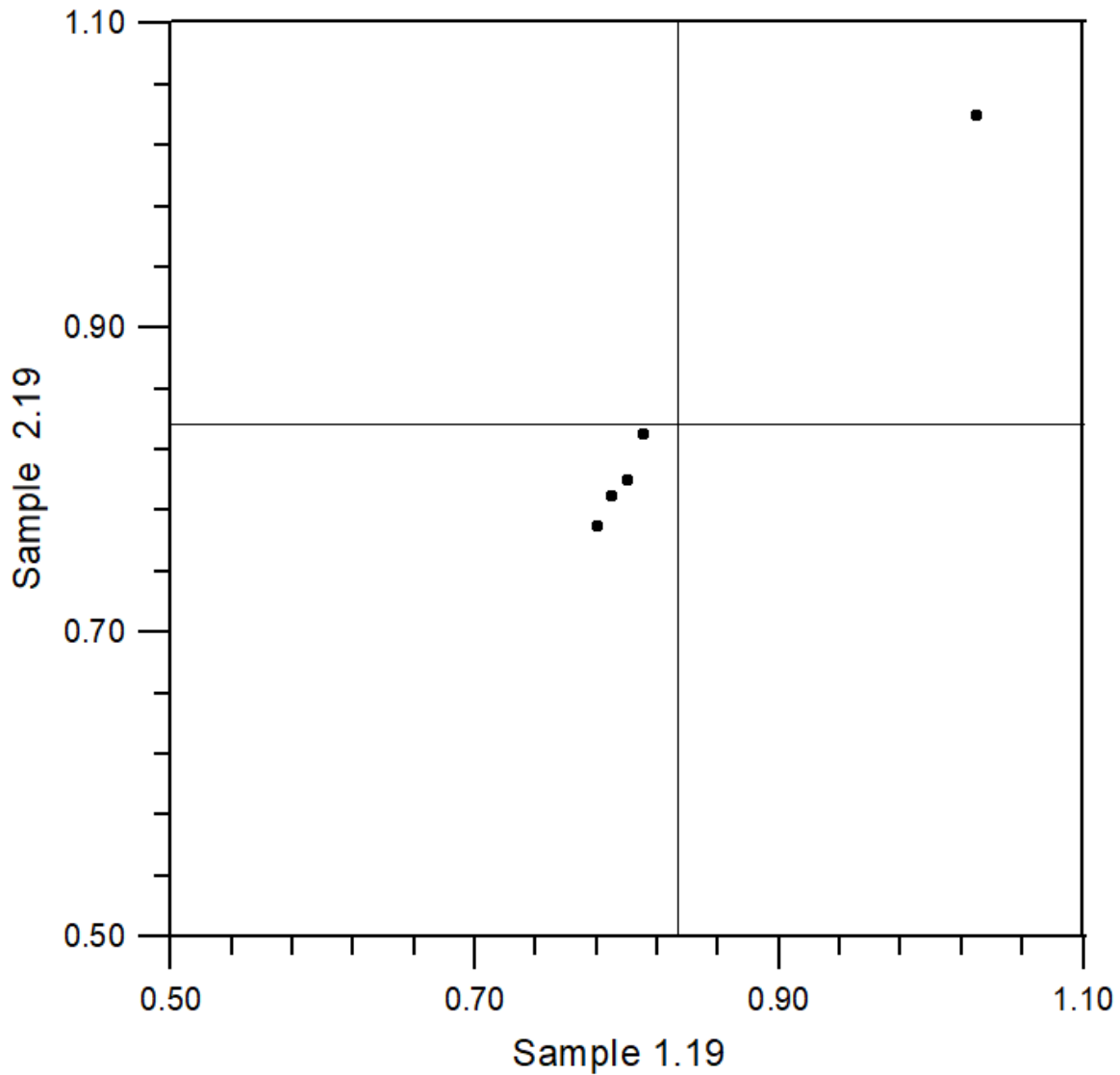
	Mat 1	Mat 2
Mean	2.157	2.162
Median	2.070	2.055
Std Dev	0.259	0.272

n = 6

Labs Eliminated: None

Figure 57. Scatter Diagram: Test 128 Al_2O_3 .

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Test 129: Weight % of Fe_2O_3 - Chemical Composition of Rocks

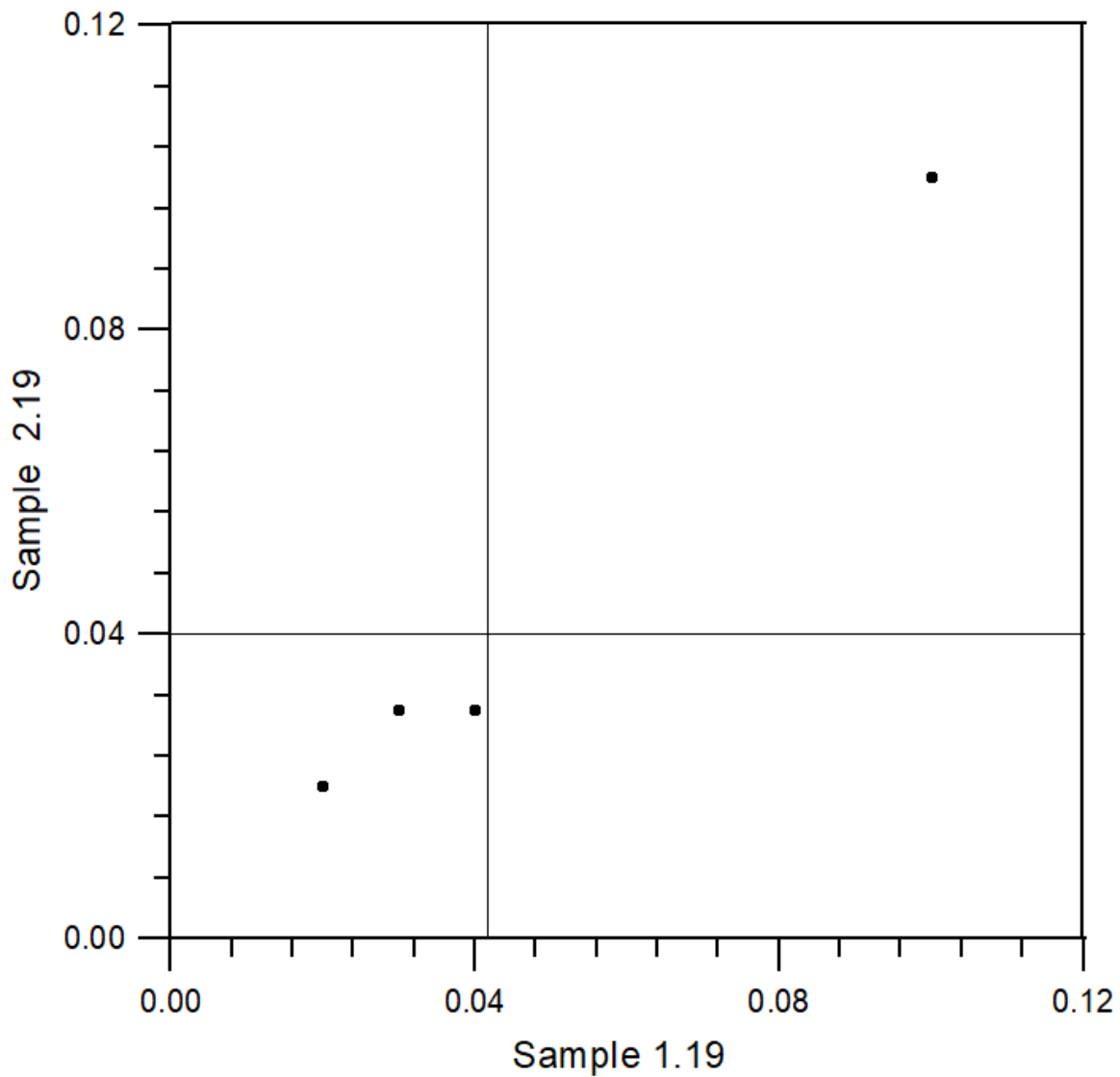
	Mat 1	Mat 2
Mean	0.833	0.837
Median	0.795	0.795
Std Dev	0.097	0.102

n = 6

Labs Eliminated: None

Figure 58. Scatter Diagram: Test 129 CCR Fe_2O_3 .

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Test 130: Weight % of MnO - Chemical Composition of Rocks

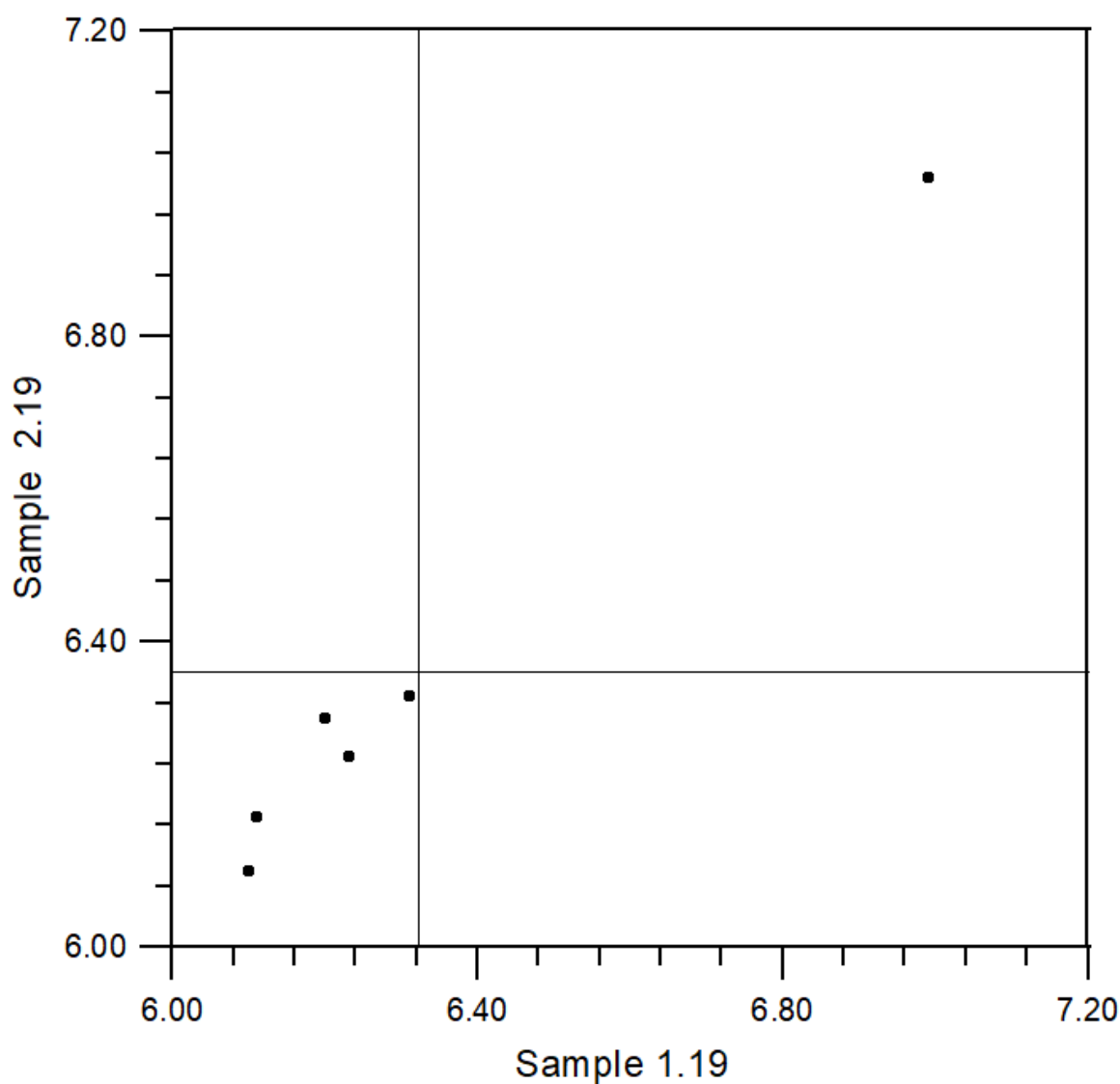
	Mat 1	Mat 2
Mean	0.042	0.040
Median	0.030	0.030
Std Dev	0.029	0.030

n = 6

Labs Eliminated: None

Figure 59. Scatter Diagram: Test 130 CCR MnO.

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Test 131: Weight % of MgO - Chemical Composition of Rocks

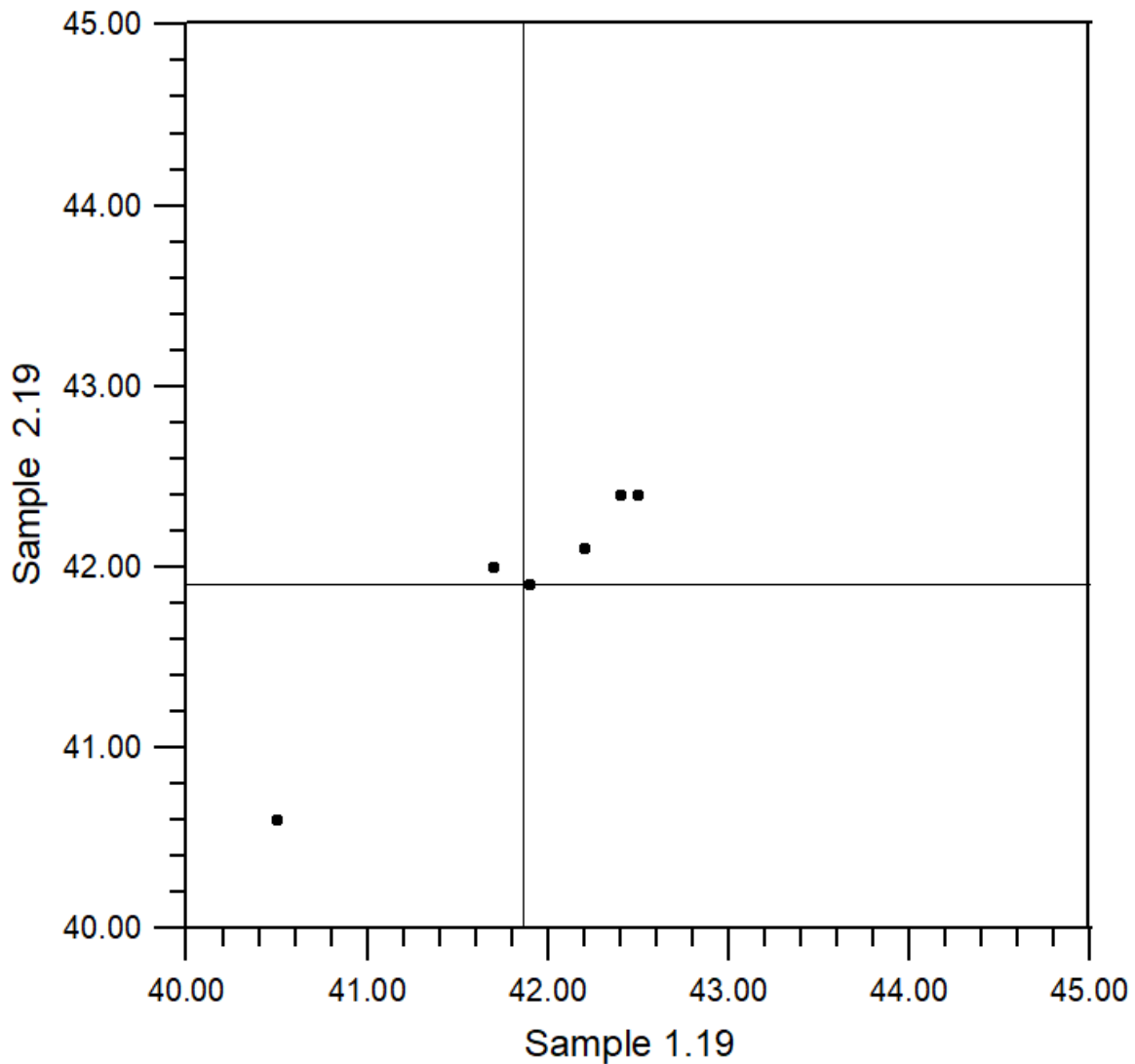
	Mat 1	Mat 2
Mean	6.323	6.360
Median	6.215	6.275
Std Dev	0.336	0.329

n = 6

Labs Eliminated: None

Figure 60. Scatter Diagram: Test 131 CCR MgO.

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Test 132: Weight % of CaO - Chemical Composition of Rocks

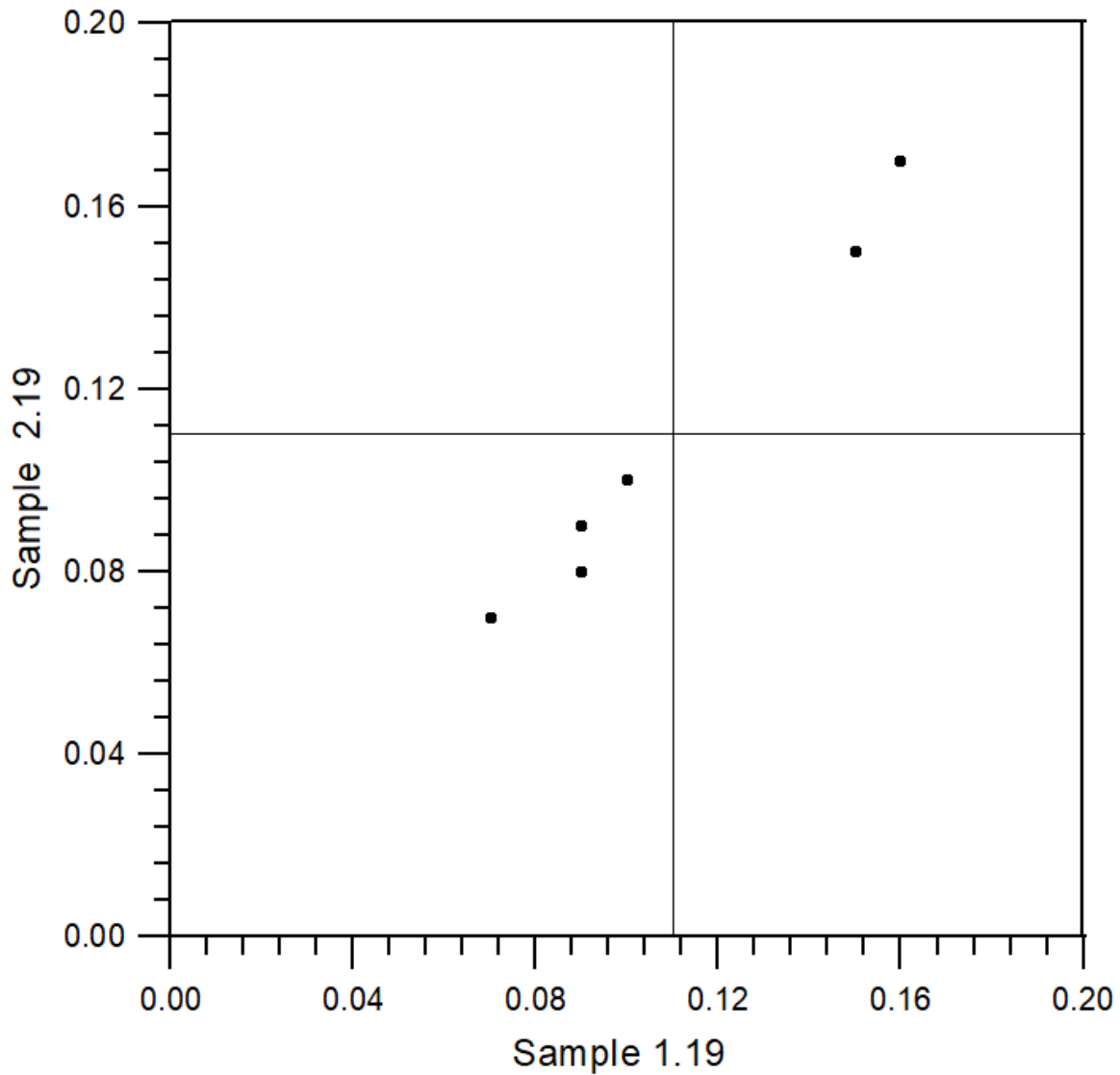
	Mat 1	Mat 2
Mean	41.867	41.900
Median	42.050	42.050
Std Dev	0.734	0.669

n = 6

Labs Eliminated: None

Figure 61. Scatter Diagram: Test 132 CCR CaO.

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Test 133: Weight % of Na_2O - Chemical Composition of Rocks

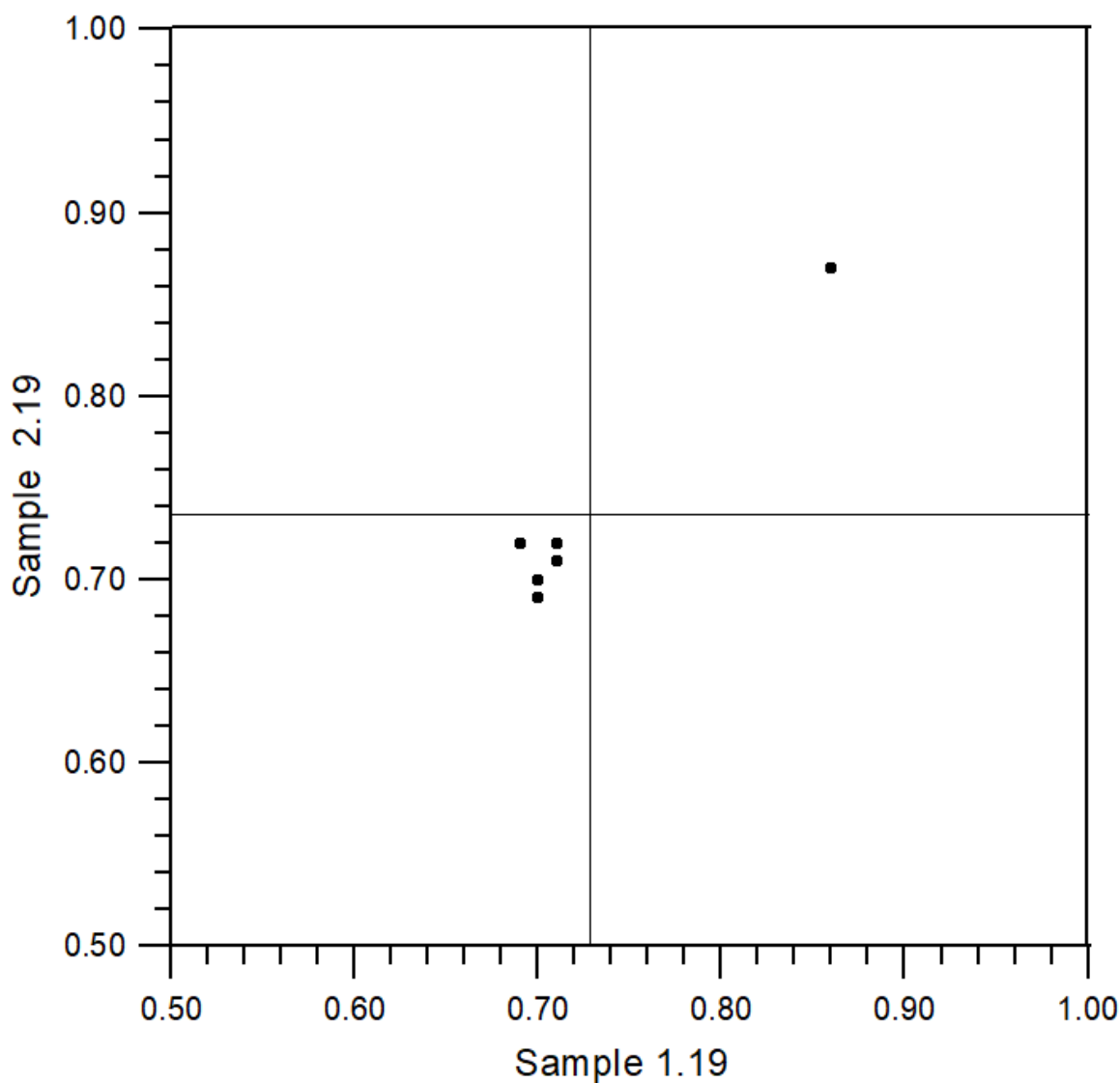
	Mat 1	Mat 2
Mean	0.110	0.110
Median	0.095	0.095
Std Dev	0.036	0.040

n = 6

Labs Eliminated: None

Figure 62. Scatter Diagram: Test 133 CCR Na_2O .

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Test 134: Weight % of K_2O - Chemical Composition of Rocks

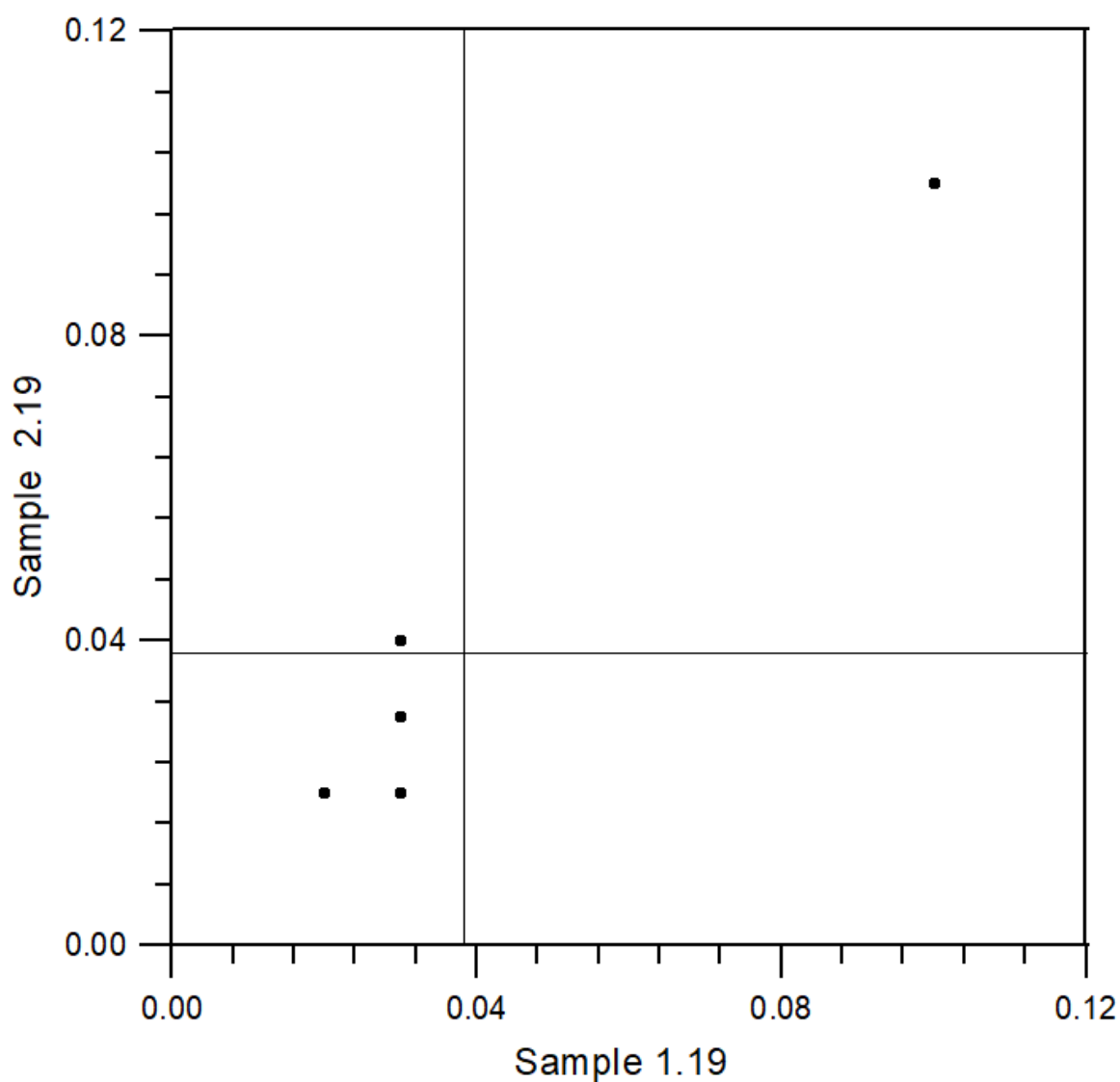
	Mat 1	Mat 2
Mean	0.728	0.735
Median	0.705	0.715
Std Dev	0.065	0.067

n = 6

Labs Eliminated: None

Figure 63. Scatter Diagram: Test 134 CCR K_2O .

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Test 135: Weight % of P_2O_5 - Chemical Composition of Rocks

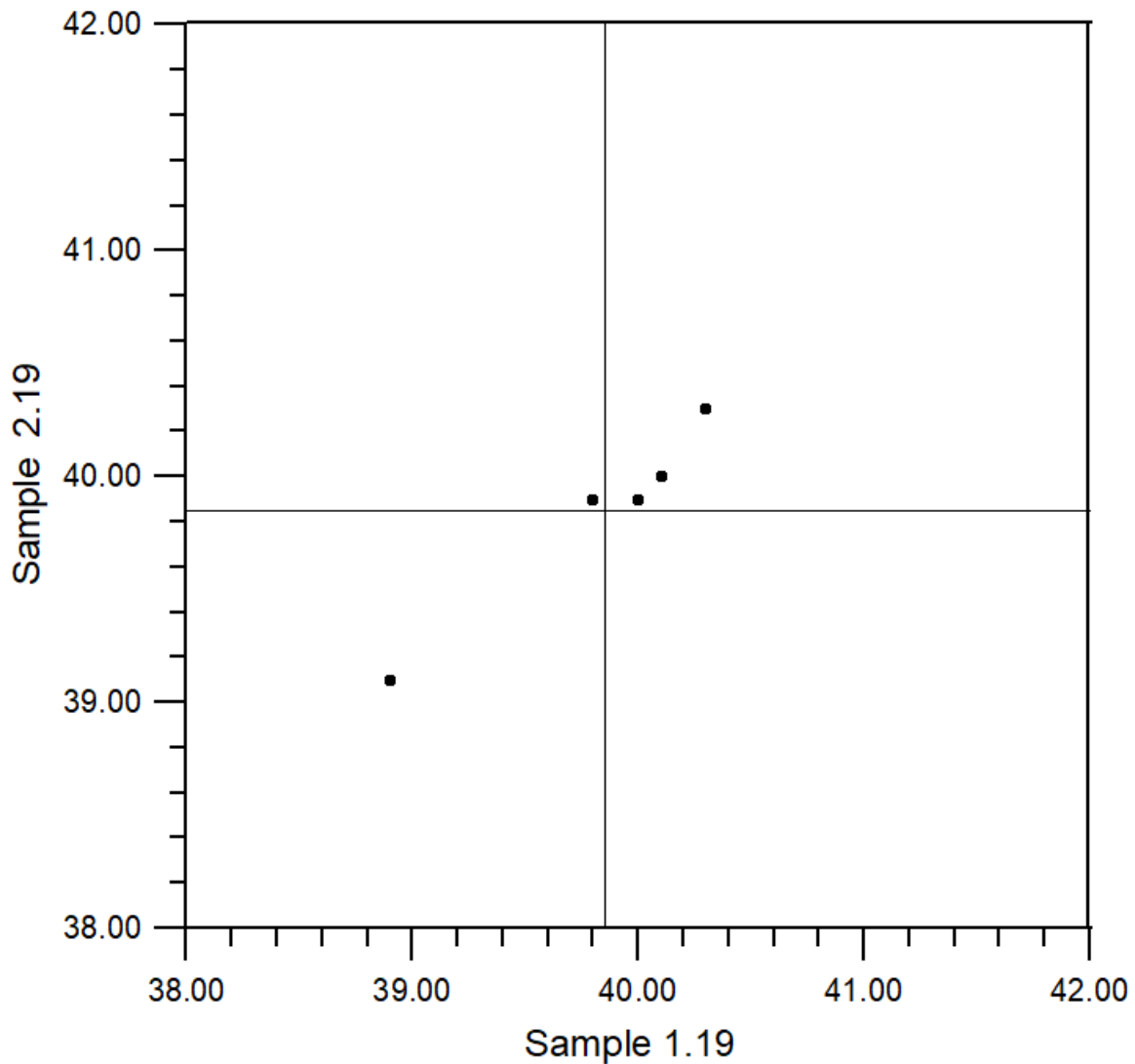
	Mat 1	Mat 2
Mean	0.038	0.038
Median	0.030	0.025
Std Dev	0.031	0.031

n = 6

Labs Eliminated: None

Figure 64. Scatter Diagram: Test 135 CCR P_2O_5 .

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Test 136: % Loss of Ignition - Chemical Composition of Rocks

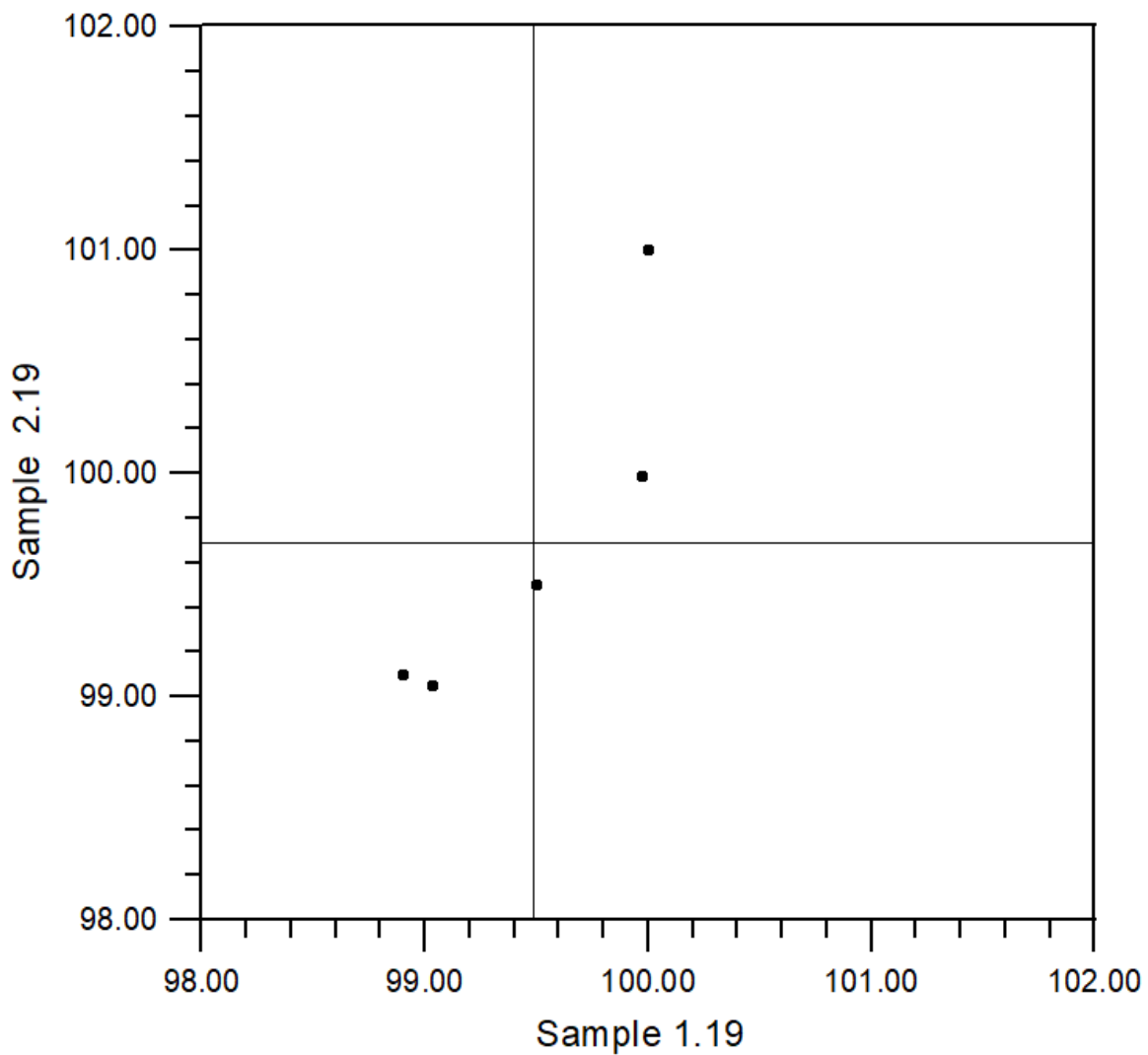
	Mat 1	Mat 2
Mean	39.850	39.850
Median	40.000	39.900
Std Dev	0.493	0.399

n = 6

Labs Eliminated: None

Figure 65. Scatter Diagram: Test 136 CCR Loss on Ignition.

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Test 137: % Total - Chemical Composition of Rocks

	Mat 1	Mat 2
Mean	99.483	99.690
Median	99.500	99.500
Std Dev	0.458	0.726

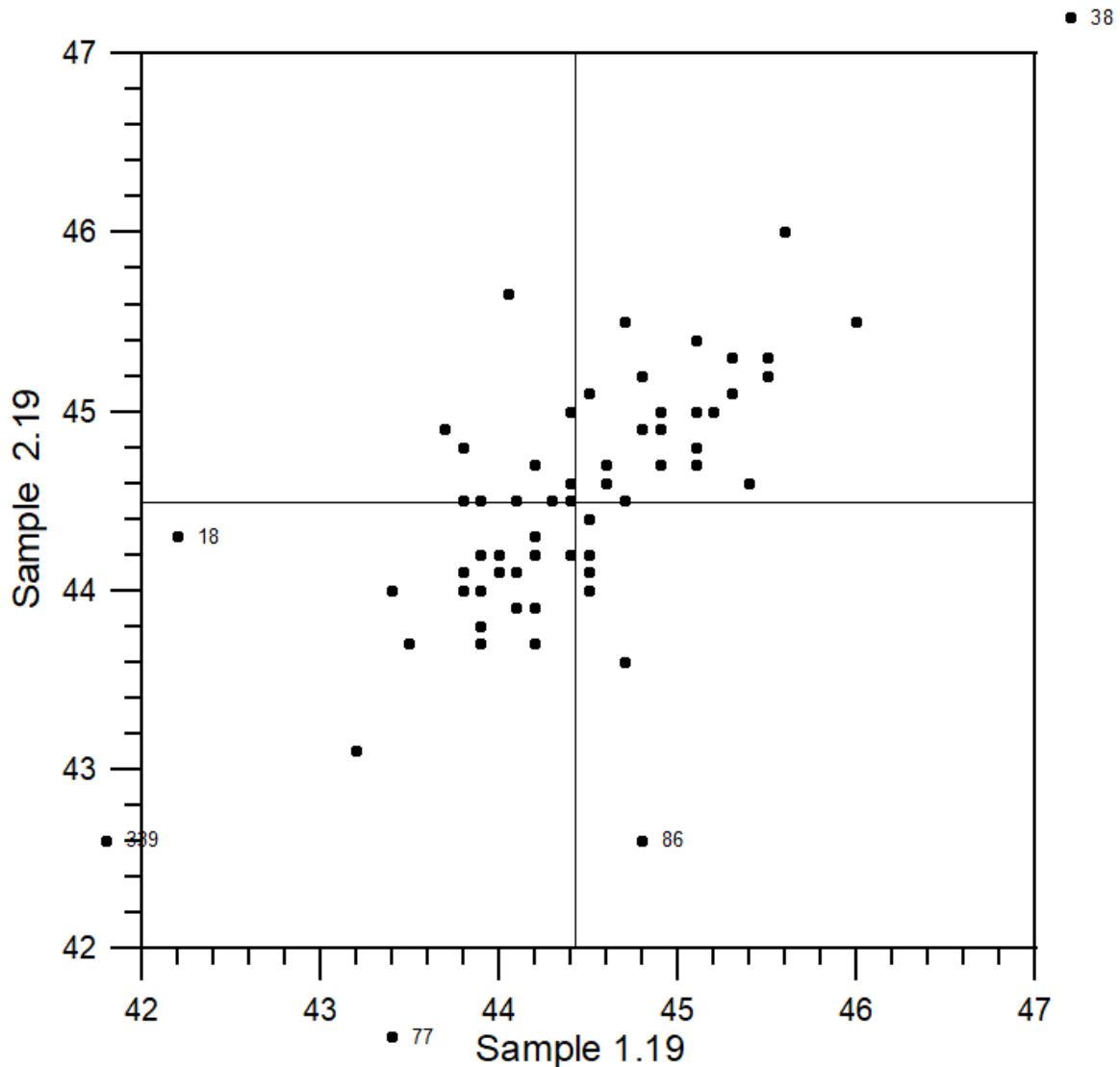
n = 6

Labs Eliminated: None

Figure 66. Scatter Diagram: Test 137 CCR Total.

Appendix I. Scatter Diagrams – Superpave

2019 MTO SUPERPAVE CONSENSUS PROPERTY TESTING PROGRAM



Test 95: Uncompacted Void Content of Fine Aggregate

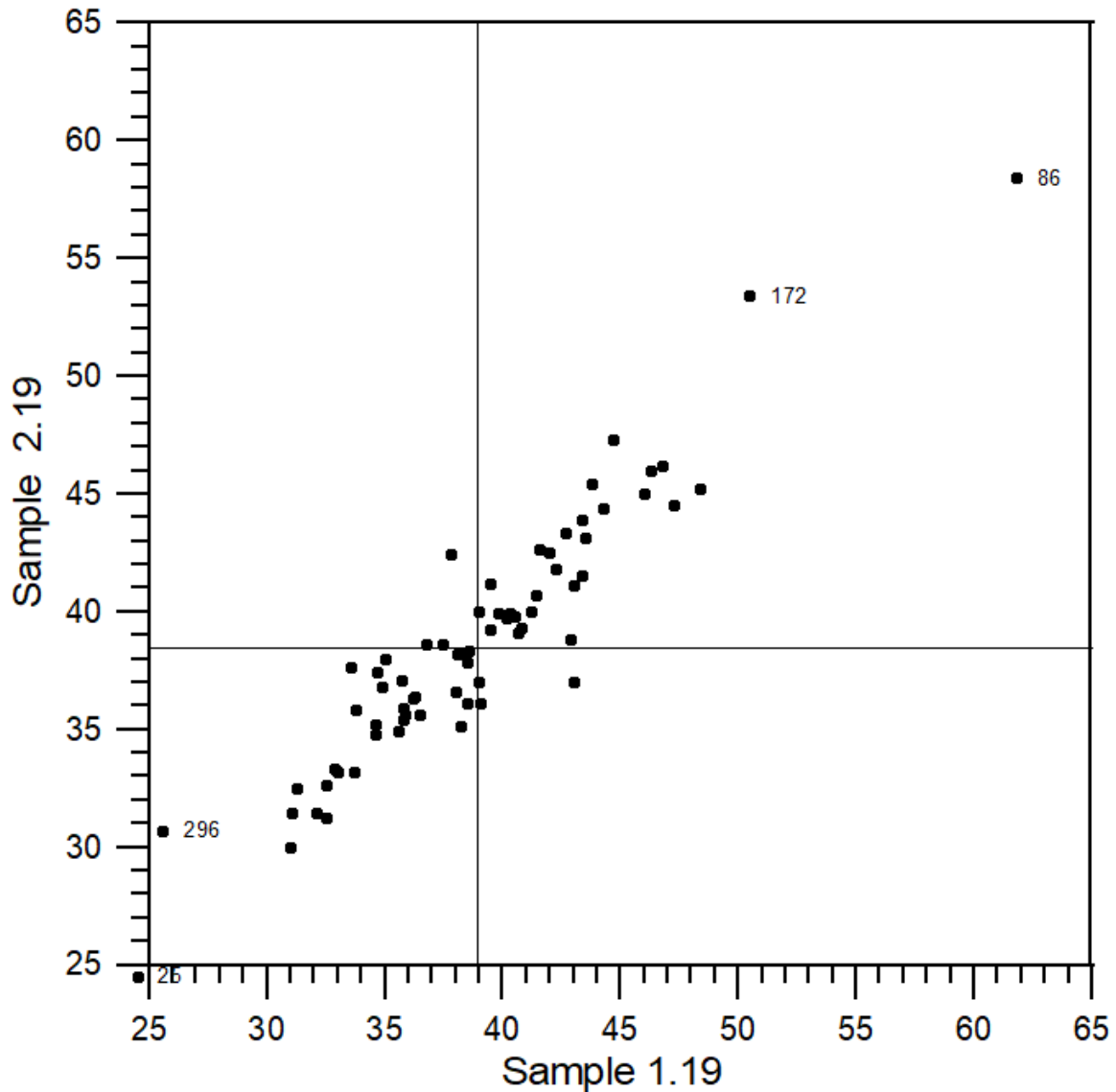
	Mat 1	Mat 2
Mean	44.425	44.495
Median	44.6	44.55
Std Dev	0.586	0.569

n = 65

Labs Eliminated: 18; 38; 77; 86; 339;

Figure 67. Scatter Diagram: Test 95 UC Void.

2019 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 96: Sand Equivalent Value of Fine Aggregate

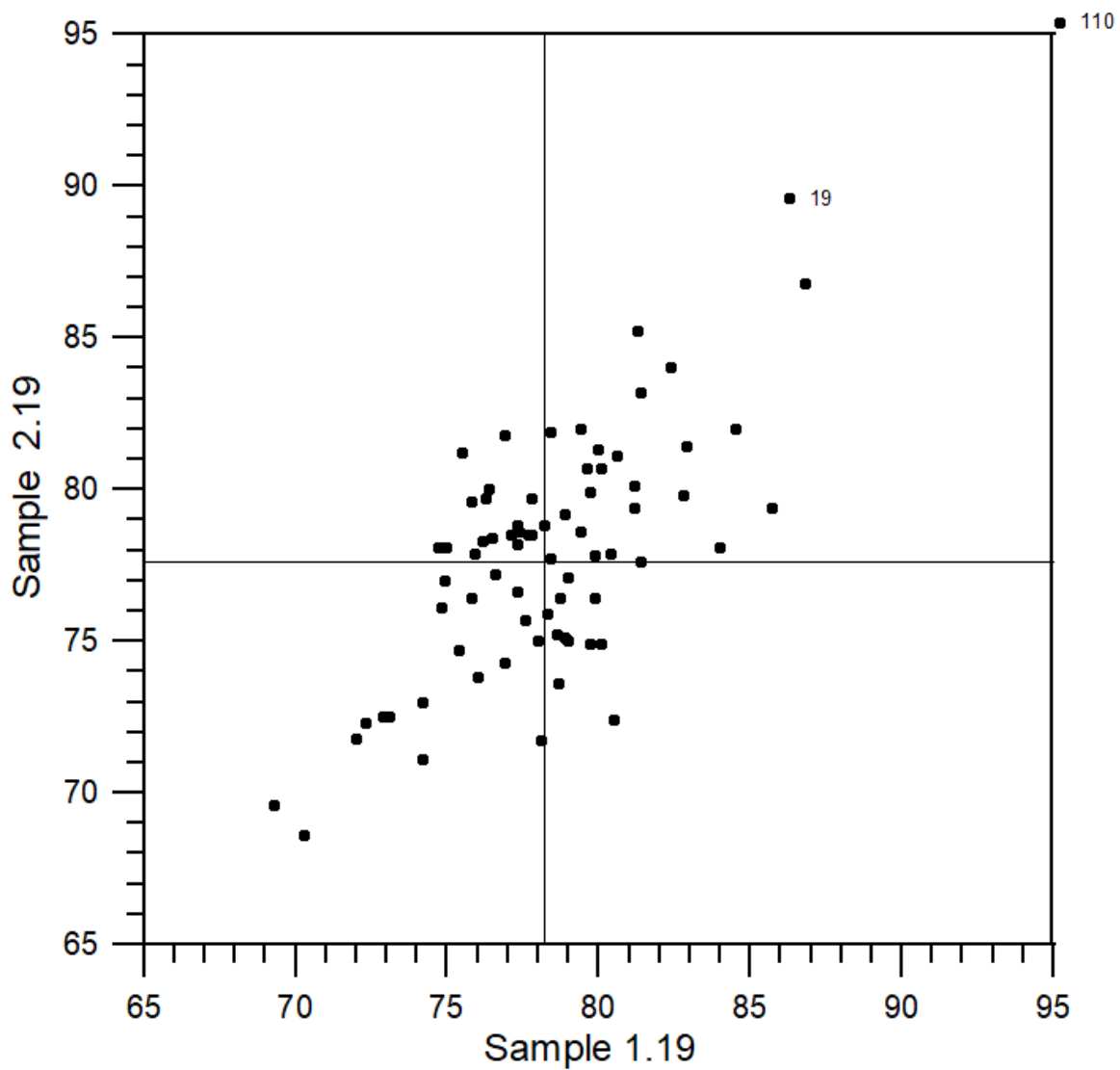
	Mat 1	Mat 2
Mean	38.963	38.479
Median	39.7	38.65
Std Dev	4.582	4.218

n = 66

Labs Eliminated: 25; 86; 296;

Figure 68. Scatter Diagram: Test 96 SE Value.

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Test 97: Percent Fractured Particles

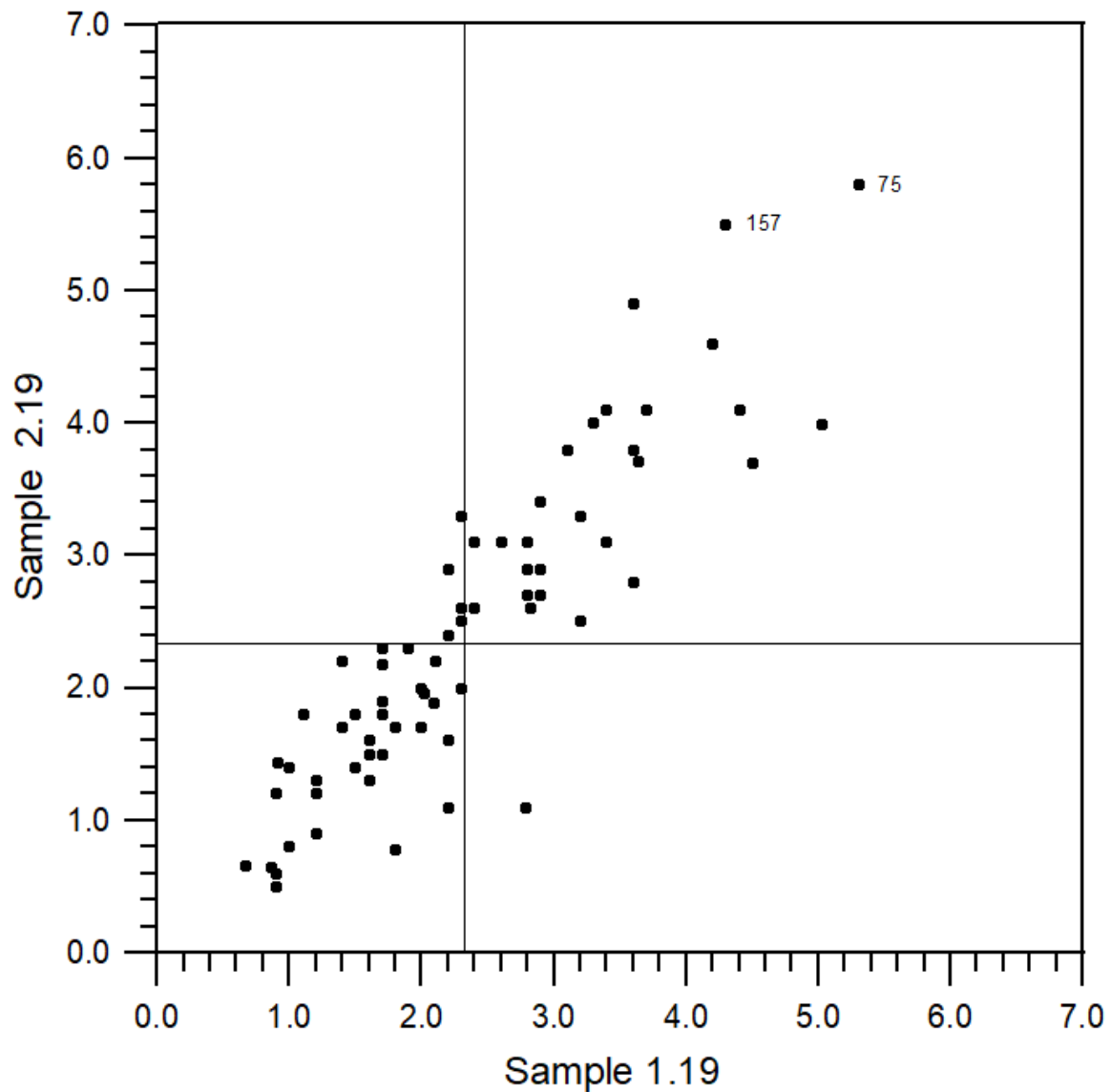
	Mat 1	Mat 2
Mean	78.190	77.634
Median	78.06	77.705
Std Dev	3.373	3.581

n = 73

Labs Eliminated: 19; 110;

Figure 69. Scatter Diagram: Test 97 % Fractured.

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Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	2.317	2.331
Median	2.85	2.7
Std Dev	1.019	1.085

n = 71

Labs Eliminated: 75; 157;

Figure 70. Scatter Diagram: Test 99 % F & E.

Appendix J. Production Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
2	8	10.1	3	10	10	59
4	7	29.7	9	10	7	90
9	10	29.2	10	10	10	99
12	8	25.4	10	10	9	89
13	10	30.0	10	10	10	100
15	10	30.0	10	6	10	94
17	6	16.6	0	5	0	39
18	10	30.0	7	9	10	94
19	10	26.5	9	7	10	89
20	10	30.0	10	9	7	94
21	8	16.9	10	9	2	66
22	9	30.0	10	10	10	99
23	10	30.0	10	6	10	94
25	10	25.6	10	0	10	79
26	9	29.7	8	6	10	90
27	10	20.7	10	9	10	85
28	10	29.5	4	6	10	85
29	9	29.7	10	7	5	87
30	10	25.4	9	7	10	88
31	10	28.1	10	10	1	84
32	5	28.1	10	10	8	87
33	10	29.7	9	10	9	97
35	10	30.0	10	10	10	100
37	8	28.9	5	10	10	88
38	9	27.8	9	10	8	91
39	10	30.0	10	10	10	100
42	10	25.9	10	7	2	78
43	10	24.0	10	7	9	86
44	10	24.8	10	10	9	91
46	6	29.5	10	10	10	94
47	10	29.2	10	7	5	87
52	9	29.5	5	8	7	84
54	1	25.6	10	8	10	78
56	10	26.7	10	10	9	94
58	9	28.1	10	10	10	96
59	10	29.2	10	9	10	97
60	9	30.0	5	7	2	76
61	10	29.2	7	10	10	95
64	6	5.7	1	4	6	32

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
65	8	29.5	10	10	9	95
68	10	30.0	10	10	10	100
69	7	23.7	10	0	8	70
70	6	16.9	10	10	10	76
71	10	30.0	10	10	9	99
72	6	26.2	10	10	10	89
73	10	27.5	10	5	10	89
74	4	28.4	7	10	4	76
75	10	23.7	10	10	0	77
76	7	29.7	10	10	10	95
77	10	24.3	10	8	9	88
78	9	29.5	9	10	8	94
79	10	21.0	10	8	10	84
80	10	29.5	8	10	10	96
81	10	29.2	7	10	10	95
83	9	27.8	10	9	8	91
85	10	29.5	10	10	10	99
86	2	28.9	10	8	6	78
90	3	25.4	5	0	10	62
95	10	29.7	10	10	10	100
97	10	22.6	10	10	10	89
98	10	28.1	4	9	7	83
99	10	21.3	9	8	10	83
100	10	24.0	7	10	9	86
101	10	29.7	10	10	10	100
102	10	24.0	9	10	10	90
103	8	22.1	9	8	7	77
107	10	28.9	6	8	10	90
108	10	29.7	10	10	10	100
110	9	27.5	10	9	10	94
112	7	29.7	10	8	10	92
113	6	15.8	5	10	10	67
114	10	22.4	10	10	10	89
115	10	18.5	8	8	10	78
117	10	30.0	10	8	8	94
118	10	27.5	8	10	10	94
119	8	27.0	5	10	10	86
120	8	29.7	3	7	10	82
121	10	28.6	8	10	10	95
122	9	15.8	7	10	8	71
124	8	29.2	9	10	10	95
126	8	16.4	10	10	10	78

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
129	10	28.6	10	10	10	98
137	10	28.6	10	10	10	98
138	10	29.5	6	10	10	94
139	9	28.9	10	10	9	96
140	10	25.6	9	10	10	92
141	6	25.1	9	10	10	86
144	0	24.3	10	10	1	65
145	9	25.1	10	2	7	76
146	10	27.8	5	2	9	77
147	9	28.1	10	9	8	92
150	10	29.5	5	10	10	92
151	8	28.6	10	10	10	95
154	10	29.2	9	10	9	96
156	10	28.9	8	8	10	93
157	9	20.5	10	10	9	84
158	3	30.0	10	10	10	90
159	7	24.3	10	8	10	85
161	10	30.0	5	10	10	93
163	8	30.0	10	10	10	97
167	10	22.9	10	6	10	84
168	9	25.4	10	1	10	79
171	9	25.9	9	8	10	88
172	8	24.8	8	4	3	68
174	0	1.1	10	10	9	43
175	8	28.1	0	6	9	73
176	10	29.7	9	10	6	92
178	10	29.7	10	10	9	98
179	8	24.5	9	9	8	84
181	8	13.9	4	10	9	64
183	10	28.4	9	8	9	92
184	10	27.3	8	10	8	90
187	5	19.6	10	10	7	74
188	10	30.0	10	10	10	100
193	3	29.2	9	10	10	87
194	6	29.7	10	10	10	94
195	10	28.4	10	10	10	98
196	6	29.5	8	10	10	91
198	6	20.7	10	8	10	78
199	10	30.0	10	10	10	100
200	7	23.7	10	10	6	81
205	10	28.4	10	1	0	71
210	10	29.7	8	1	7	80

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
214	10	28.6	10	10	10	98
216	10	30.0	8	10	10	97
217	10	27.0	10	9	10	94
219	10	21.5	10	10	10	88
234	5	19.9	10	10	9	77
236	10	27.0	9	10	7	90
245	4	25.4	10	10	10	85
249	10	29.5	10	10	8	96
250	10	27.5	10	10	9	95
251	10	30.0	10	10	8	97
253	10	28.4	10	10	9	96
254	9	21.0	10	9	10	84
255	10	27.3	10	10	9	95
257	10	28.6	10	10	6	92
258	10	29.5	7	7	10	91
261	6	28.9	10	7	10	88
262	9	23.2	10	3	9	77
263	10	29.2	10	10	9	97
264	9	29.5	10	10	9	96
266	9	24.5	7	9	7	81
268	9	29.7	8	1	9	81
269	10	25.4	10	10	7	89
271	10	29.5	10	10	10	99
272	7	29.2	10	9	10	93
274	10	26.5	10	6	9	88
275	5	30.0	10	10	8	90
276	9	28.9	8	2	6	77
277	9	25.4	9	3	10	81
278	10	15.5	10	10	10	79
279	10	28.4	9	10	10	96
280	10	11.2	9	10	10	72
285	9	28.6	10	9	10	95
287	8	28.4	10	9	10	93
288	10	21.3	9	9	10	85
290	5	17.2	9	5	6	60
291	10	29.7	9	5	9	90
293	10	29.5	10	10	10	99
294	9	30.0	10	10	10	99
296	10	27.0	10	10	9	94
297	0	19.1	10	10	10	70
300	10	29.7	3	9	9	87
301	10	22.6	6	6	10	78

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
303	10	15.8	10	10	6	74
305	10	24.8	8	10	0	75
309	10	23.5	10	10	10	91
310	10	28.9	10	7	9	93
312	10	30.0	10	10	8	97
314	0	29.2	7	10	10	80
315	2	29.5	9	2	9	74
316	1	16.9	9	10	10	67
318	10	19.4	9	10	10	83
320	5	29.7	10	10	5	85
321	10	27.5	7	9	10	91
322	9	27.0	6	0	10	74
324	5	29.2	9	9	10	89
325	10	25.6	10	10	8	91
326	10	29.7	10	8	8	94
328	10	29.7	10	10	10	100
329	9	29.7	10	9	10	97
331	10	29.2	9	7	10	93
332	10	25.4	10	10	5	86
335	6	25.6	10	10	2	77
339	10	30.0	9	10	10	99
340	6	26.2	9	7	8	80
341	0	27.5	7	8	7	71
344	10	28.6	7	10	10	94
352	10	25.1	7	10	9	87
353	10	27.0	10	10	10	96
354	10	13.6	0	8	9	58
358	10	27.3	10	0	9	80
360	10	25.9	8	3	9	80
361	10	28.6	10	10	7	94
368	10	26.5	10	10	10	95
369	10	24.5	8	9	9	86
375	10	27.3	9	10	10	95
378	10	27.0	10	10	10	96
379	8	26.5	9	10	10	91
380	0	16.1	9	10	10	64
382	9	29.2	9	4	10	87
386	10	29.2	10	10	10	99
387	10	25.9	8	10	10	91
390	0	25.1	10	8	8	73
391	10	18.3	0	10	7	65
392	9	28.4	10	9	10	95

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
393	10	26.5	4	10	9	85
399	10	12.0	10	10	4	66
400	9	29.5	9	9	10	95
402	0	16.1	5	9	7	53
403	10	24.5	10	10	10	92
404	10	30.0	10	10	8	97
405	10	28.4	10	10	8	95
406	10	22.4	10	10	10	89
412	4	26.5	9	10	10	85
413	8	29.5	2	6	10	79
415	9	27.8	10	6	6	84
421	10	29.2	10	10	8	96

Appendix K. Full Services Aggregate Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crush	LS-608 % Flat & Elongated	LS-621 % Asphalt	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 MgSO ₄ (CA)	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-706 Stand. Proctor	LS-619 MDA (FA)	Rating
13	10	30.0	10	10	10		10.0	10	10	10	7.5	10.0	10	98
15	10	30.0	10	10	10		7.0	10	9	10	6.5	8.3	5	90
18	10	30.0	10	9	9	10	9.5	10	4	9	10.0	10.0	9	93
19	10	25.6	10	10	9	10	10.0		10	10	9.5	10.0	10	96
22	10	30.0	10	10	9		10.0		10	10	10.0	10.0	1	92
23	0	30.0	4	7	10		4.5		10	0		8.0	0	61
28	10	28.6	9	8	10		9.5		10	10	10.0	10.0	10	96
31	0	28.9	10	8	9	8	8.0	10	10	10	6.0	6.7	10	83
35	8	27.5	10	10	10	10	10.0	10	9	10	8.5	10.0	10	95
37	9	29.5	10	10	10	10	8.5	8	10	10	9.5	7.7	8	93
38	10	27.0	10	10	9	6	8.5	9	9	10	9.5	9.3	10	92
47	10	29.7	10	10	9	9	10.0	10	10	10	6.0	6.0	10	93
56	9	26.7	10	10	10	7	10.0	9	8	10	10.0	9.3	10	93
59	10	27.5	10	10	10		10.0	10	7	10	10.0	7.0	10	94
61	10	28.9	10	10	6		9.5		10	9	8.5		10	93
69	9	23.5	10	9	9		9.0		8	2	7.0	8.7	10	81
75	10	25.6	10	10	10		7.0	10	9	10	9.5	10.0	10	94
76	10	29.7	10	10	1		10.0	9	8	5	10.0		10	87
78	7	29.2	9	0	10		8.5	8	10	10	10.0	8.7	9	85
79	10	23.7	10	9	3		10.0		5	10	6.5	8.7	10	81
80	9	29.2	9	8	9	9	10.0	10	7	9	9.5	9.7	10	92
81	10	30.0	10	9	10		8.5		10	9	9.5	10.0	9	96
83	9	28.6	10	10	6		6.0	10	10	10	10.0	9.0	6	89
86	9	28.6	10	9	9		9.0		9	10	4.5	6.7	7	86
90	10	25.1	10	5	10		10.0	9	6		7.5		7	83

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crush	LS-608 % Flat & Elongated	LS-621 % Asphalt	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 MgSO ₄ (CA)	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-706 Stand. Proctor	LS-619 MDA (FA)	Rating
98	8	28.4	0	10	10		5.5		6	9	10.0	7.0	10	80
101	7	30.0	10	10	10		9.5	10	10	10	10.0	9.0	10	97
107	9	27.5	4	10	10		7.0	10	9	10	10.0		10	90
108	10	27.5	3	10	10		7.0	10	9		8.5	9.0	10	88
110	10	27.5	10	7	10		9.5	8	8	7	7.0	7.0	7	84
112	6	29.7	10	7	10		9.5	9	10	10	10.0	9.7	10	93
114	10	19.1	10	10	7		10.0	5	5	10	9.5	9.7	8	81
120	10	29.7	10	10	10		8.0		10	10	10.0	10.0	8	97
121	9	28.6	9	8	9		10.0	10	9	9	9.0	9.7	10	93
124	9	27.3	10	10	10		6.5		10	10	10.0	8.7	9	93
157	6	21.8	8	10	10		8.5	8	10	8	5.5		8	80
172	7	27.5	0	10	8		8.0	5	10	6	9.5	5.7	8	75
183	8	27.0	10	8	10		10.0	10	10	10	9.5	10.0	10	95
188	10	28.6	10	8	8	10	9.5	10	10	10	9.0	8.3	9	94
199	10	30.0	10	10	7		9.5		10	6	10.0	9.7	10	94
216	10	30.0	10	10	5		10.0	10	6	8	9.0	10.0	1	85
217	10	28.9	10	9	9		10.0	10	10		6.0		10	94
245	10	27.3	10	10	10		9.0		9	8	8.5	10.0	9	93
257	4	28.6	10	10	10		10.0	2	8	1	10.0	9.0	10	80
263	8	30.0	10	10	10		10.0	8	10	6	9.5	10.0	7	92
285	8	25.9	10	10	10		9.5	9	8	10	10.0	10.0	10	93
293	10	28.4	10	10	9		7.5	9	9	10	9.0		10	94
296	9	27.5	10	9	10		10.0		8	1	8.5	8.7	8	84
309	10	24.3	10	8	10		5.0	10	10	10	10.0		10	90
316	10	16.6	10	7	10		8.5	7	10	8	8.0	10.0	10	82
326	9	29.2	10	10	7		8.5		9	9	2.5	7.0	10	86
390	6	23.5	8	10	5		9.5		10	6	8.5	5.0	8	77
406	10	25.1	10	10	9		10.0	10	9	10	9.5	10.0	9	94

Appendix L. Soil Laboratory Ratings

Lab Number	LS-702: Hydrometer Analysis	LS-703 & 4: Atterberg Limits	LS-705: Specific Gravity	Rating
2	9.0	9.7	7	86
9	9.0	10.0	7	87
12	8.8	9.0	9	89
13	9.4	10.0	10	98
15	9.6	10.0	10	99
18	10.0	10.0	8	93
19	5.2	9.7	10	83
20	7.8	9.7	10	92
21	9.4	9.7	10	97
22	9.6	10.0	10	99
23	8.2	5.3	8	72
27	9.6	7.0	2	62
28	8.2	7.7	10	86
29	9.8	8.7	10	95
30	9.2	9.3	5	78
31	9.4	9.0	10	95
32	6.6	7.0	10	79
35	9.6	10.0	10	99
37	8.8	9.7	10	95
38	10.0	9.7	9	96
44	9.8	10.0	10	99
46	9.4	7.0	9	85
47	9.4	9.3	10	96
52	9.6	9.7	10	98
54	9.6	9.7	10	98
56	8.4	8.7	10	90
58	8.8	10.0	10	96
59	9.0	9.7	10	96
64	3.4	4.3	4	39
68	9.6	10.0	10	99
69	7.6	6.7	10	81
71	9.4	10.0	10	98
72	10.0	8.7	7	86
74	8.6	9.7	10	94
78	10.0	10.0	10	100
79	9.6	10.0	3	75
80	9.6	9.7	10	98
81	9.2	9.7	10	96
83	10.0	10.0	10	100

Lab Number	LS-702: Hydrometer Analysis	LS-703 & 4: Atterberg Limits	LS-705: Specific Gravity	Rating
85	9.2	10.0	10	97
86	8.8	8.7	10	92
98	6.6	9.7	9	84
101	6.6	5.3	10	73
102	3.0	9.3	1	44
105	10.0	6.3	10	88
108	10.0	6.3	10	88
112	10.0	8.7	10	96
114	5.8	9.0	6	69
118	10.0	9.0	8	90
120	8.2	9.3	10	92
121	9.6	10.0	10	99
126	7.4	9.3	10	89
138	9.6	9.7	10	98
139	9.6	10.0	10	99
144	9.4	7.0	10	88
146	8.6	8.0	10	89
151	7.0	8.7	10	86
156	9.6	6.3	10	86
159	7.0	10.0	10	90
168	5.6	8.3	10	80
172	7.4	9.3	10	89
183	8.2	10.0	10	94
188	9.6	10.0	10	99
195	10.0	8.0	10	93
210	8.4	7.7	9	84
216	9.6	9.0	10	95
253	8.2	8.7	10	90
261	9.4	9.7	8	90
266	8.6	7.0	9	82
276	8.8	9.3	8	87
285	7.8	10.0	5	76
287	9.0	9.3	10	94
296	8.4	8.7	8	84
300	9.4	10.0	9	95
312	9.6	10.0	10	99
315	7.8	8.0	7	76
320	9.8	6.7	9	85
322	9.6	9.7	8	91
354	8.4	8.0	8	81
358	4.6	4.0	10	62

Lab Number	LS-702: Hydrometer Analysis	LS-703 & 4: Atterberg Limits	LS-705: Specific Gravity	Rating
360	7.2	10.0	10	91
361	9.0	9.0	10	93
368	9.6	9.0	10	95
369	10.0	8.7	8	89
375	9.8	9.3	10	97
378	9.0	9.7	10	96
391	6.6	8.3	7	73
393	8.4	7.0	1	55
399	9.4	10.0	9	95
406	7.4	9.3	10	89
412	9.8	8.3	2	67
420	9.0	4.3	3	54
421	8.4	9.7	10	94
422	5.4	9.0	10	81

Appendix M. Superpave Laboratory Ratings

Laboratory No.	T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
2	7	10	10	10	93
13	10	9	10	10	98
15	9	10	10	10	98
18	0	10	9	9	70
20	10	10	9	9	95
22	10	10	7	10	93
25	4	0	10	10	60
26	10	9	10	10	98
27	10	10	10	10	100
28	10	5	3	10	70
31	8	7	7	7	73
33	10	10	10	10	100
35	9	10	10	10	98
37	10	8	2	10	75
38	0	10	10	9	73
39	10	10	6	10	90
43	10	7	10	10	93
47	9	10	9	9	93
56	10	5	10	9	85
58	10	10	8	10	95
59	4	10	10	10	85
61	9	10	9	10	95
69	9	9	10	10	95
71	10	10	10	10	100
74	10	10	9	7	90
75	10	7	7	0	60
77	3	10	10	10	83
79	10	10	10	10	100
80	8	8	10	7	83
83	10	10	10	10	100
86	5	0	10	8	58
101	10	6	10	10	90
105	10	8	9	5	80
108	10	8	9	5	80
112	10	10	10	9	98
114	10	10	10	10	100
115	7	7	9	10	83

Laboratory No.	T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
118	9	10	8	10	93
120	9	10	10	4	83
121	7	8	10	8	83
124	8	10	7	10	88
141	9	6	9	10	85
157	9	9	10	3	78
172	8	1	10	8	68
183	10	10	9	5	85
188	10	10	10	10	100
193	10	6	7	10	83
199	9	10	10	10	98
216	10	10	3	10	83
217	7	10	10	9	90
245	8	10	7	10	88
253	9	9	10	10	95
255	7	10	10	9	90
257	9	8	10	6	83
263	10	10	10	10	100
271	10	7	10	7	85
285	9	10	8	10	93
293	10	10	10	10	100
296	10	3	7	10	75
300	9	6	10	10	88
316	9	10	8	9	90
325	8	10	10	8	90
326	9	10	10	6	88
339	0	10	10	10	75
340	10	10	9	8	93
352	10	10	10	8	95
368	10	10	10	10	100
390	10	6	10	9	88

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