



Ministry of Transportation

Engineering Materials Office Report 205

Aggregate and Soil Proficiency Sample Testing Program 2020

EMO-205

YEAR 2023

ISBN 978-1-4868-6223-8 (PDF, 2020 ed.)

Technical Report Documentation	
Publication Title	Aggregate and Soil Proficiency Sample Testing Program for 2020
Author(s)	Ram Chandra Kandel, P.Eng., Zhiyong Jiang, P.Eng.
Originating Office	Soils and Aggregates Section, Engineering Materials Office
Report Number	EMO-205
ISBN	ISBN 978-1-4868-6223-8 (PDF, 2020 ed.)
Publication Date	July 2023
Ministry Contact	Soils and Aggregates Section, Engineering Materials Office Standards and Contracts Branch, Ministry of Transportation 95 Arrow Road, Toronto, Ontario, Canada M9M 2L4 (416) 235-3437; soils-aggregates@ontario.ca
Abstract	MTO Soils and Aggregates Section, conducts an annual proficiency sample testing program for aggregates and soils as a means 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. In 2020, MTO delivered the samples to the laboratories from May to August, and required submission of results in October. The preliminary report issued in early November provided a means for the laboratories to improve their testing system. In 2020, two hundred and thirteen participants from the private and public sectors submitted results for the program. Sixty-five laboratories reported results for all consensus property tests. As observed in the last three years, the 2020 multi-laboratory variations in a majority of the tests show improvements over the ASTM, AASHTO, MTO or CSA precision estimates. However, strong biases remain in some aggregate tests, one of the Superpave tests and some of the soil tests. The sieve analysis results demonstrate that the new 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.
Key Words	MTO, aggregate, soil, correlation, interlaboratory, proficiency
Distribution	Unrestricted technical audience.
Citation	Kandel, R., Jiang, Z. (2023). Aggregate and Soil Proficiency Sample Testing Program for 2020, Engineering Materials Office Report 205, EMO-205, Ministry of Transportation, Engineering Materials Office.

Ministry of Transportation

Engineering Materials Office Report: EMO-205

Aggregate and Soil Proficiency Sample Testing Program for 2020

by

Ram Chandra Kandel, Zhiyong Jiang

2023

Parts of this publication may be quoted if credit is given. It is recommended that reference to this publication be made in the following form:

Kandel, R., Jiang, Z. (2023). Aggregate and Soil Proficiency Sample Testing Program for 2020, Engineering Materials Office Report 205, EMO-205, Ministry of Transportation, Engineering Materials Office.

Published without prejudice as to the application of the findings. The Ontario Ministry of Transportation (MTO) does not assume any liability for discrepancies or inaccuracies. Users should verify critical information.

We are committed to providing accessible customer service. Please get in touch with the Ministry Contact listed on page ii should you require accessible formats or communication supports.

© King's Printer for Ontario, 2023

Table of Contents

List of Tables	vii
List of Figures	viii
Foreword.....	xi
Acknowledgements.....	xii
Executive Summary	xiii
1. Introduction.....	1
2. Test Results	4
2.1 Table of Test Results	4
2.2 Scatter Diagrams	5
2.3 Outliers	11
3. Discussion.....	13
3.1 Material Sources	13
3.2 Sample Preparation	14
3.3 Notes on Individual Tests.....	16
3.4 Proficiency Sample Tests	16
3.4.1 LS-601 - Wash Pass 75 µm (Coarse Aggregate) – Test No. 1	16
3.4.2 LS-602 - Sieve Analysis (Coarse Aggregate) – Test Nos. 2 to 6 ..	17
3.4.3 LS-603 - Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8	18
3.4.4 LS-604 - Relative Density of Coarse Aggregate – Test No. 9 and Absorption of Coarse Aggregate – Test No. 10.....	18
3.4.5 LS-606 - Magnesium Sulphate Soundness (CA) – Test No. 11	18
3.4.6 LS-607 - Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7	19
3.4.7 LS-608 - Percent Flat and Elongated Particles – Test No. 13.....	19
3.4.8 LS-613 - Total Percentage of Insoluble Residue – Test No. 15 and Percentage of Insoluble Residue Retained 75 µm – Test No. 98..	20
3.4.9 LS-618 - Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16	21
3.4.10 LS-614 - Freeze-Thaw Loss – Test No. 17	21
3.4.11 LS-602 - Sieve Analysis (Fine Aggregate) – Test Nos. 20-25.....	22
3.4.12 LS-605 - Relative Density of Fine Aggregate – Test No. 27 and Absorption of Fine Aggregate – Test No. 28	23

3.4.13	LS-621 - Amount of Asphalt Coated Particles – Test No. 30	24
3.4.14	LS-706 - Moisture-Density Relationship (standard) – Test Nos. 31-33	24
3.4.15	LS-619 - Micro-Deval Abrasion (Fine Aggregate) – Test No. 34... ..	25
3.4.16	LS-620 - Accelerated Mortar Bar – Test No. 123 and Test No. 124	25
3.4.17	CSA A23.2-14A- Concrete Prism – Test No. 122 and 125.....	26
3.4.18	LS-702 - Particle Size Analysis of Soil – Test Nos. 40-45.....	27
3.4.19	LS-703 and 704 - Atterberg Limits of Soil – Test Nos. 46-48	28
3.4.20	LS-705 - Specific Gravity of Soils – Test No. 49	29
3.5	Superpave Consensus Property Tests	29
3.5.1	LS-629 - Uncompacted Void Content of Fine Aggregate – Test No. 95	29
3.5.2	ASTM D 2419 - Sand Equivalent Value of Fine Aggregate - Test No. 96	30
3.5.3	ASTM D 5821 - Percent of Fractured Particles – Test No. 97	30
3.5.4	ASTM D 4791 - Percent Flat and Elongated Particles – Test No. 99	31
4.	Laboratory Rating System	32
5.	Conclusions	35
6.	Recommendations.....	37
7.	References	38
Appendix A.	Glossary of Terms.....	A-1
Appendix B.	Test Results for Laboratory 47	B-1
Appendix C.	List of Participants – Aggregates	C-1
Appendix D.	List of Participants – Superpave.....	D-1
Appendix E.	Multi-Laboratory Precision.....	E-1
Appendix F.	Number of Laboratories Excluding Outliers over Outliers	F-1
Appendix G.	Scatter Diagrams – Soils and Aggregates	G-3
Appendix H.	Scatter Diagrams – Superpave	H-58
Appendix I.	Production Laboratory Ratings	I-1
Appendix J.	Full Services Aggregate Laboratory Ratings.....	J-1
Appendix K.	Soil Laboratory Ratings.....	K-1

Appendix L. Superpave Laboratory Ratings	L-1
---	------------

List of Tables

Table 1. Summary of Results for Laboratory 47	B-1
Table 2. List of Participants – Aggregates and Soil.....	C-1
Table 3. List of Participants - Superpave.....	D-1
Table 4. Multi-Laboratory Precision for Proficiency Tests	E-1
Table 5. Number of laboratories excluding outliers(n) over Outliers(Out); (n/Out)	F-1
Table 6. Production Laboratory Ratings.....	I-1
Table 7. Full Service Aggregate Laboratory Ratings.....	J-1
Table 8. Soil Laboratory Ratings	K-1
Table 9. Superpave Laboratory Ratings.....	L-1

List of Figures

Figure 1. Scatter Diagram for a Test Showing Random Variation with Little Laboratory Bias	7
Figure 2. Scatter Diagram for a Test Showing a Combination of Random Variation and Laboratory Bias for Some Laboratories	8
Figure 3. Scatter Diagram for a Test Showing Pronounced Between-Laboratory Bias and Equal Variation for Each Material	9
Figure 4. Scatter Diagram for a Test with Pronounced Between-Laboratory Bias but Unequal Variation for Each Material	10
Figure 5. Production Laboratory Ratings	33
Figure 6. Full Service Laboratory Ratings	33
Figure 7. Soil Laboratory Ratings	34
Figure 8. Superpave Laboratory Ratings	34
Figure 9. Scatter Diagram: Test 1 WP 75 mm	G-3
Figure 10. Scatter Diagram: Test 2 P 19.0 mm	G-4
Figure 11. Scatter Diagram: Test 3 P 16.0 mm	G-5
Figure 12. Scatter Diagram: Test 4 P 13.2 mm	G-6
Figure 13. Scatter Diagram: Test 5 P 9.5 mm	G-7
Figure 14. Scatter Diagram: Test 6 P 4.75 mm	G-8
Figure 15. Scatter Diagram: Test 8 L. A	G-9
Figure 16. Scatter Diagram: Test 9 RD of CA (O.D.)	G-10
Figure 17. Scatter Diagram: Test 10 Absorption of CA	G-11
Figure 18. Scatter Diagram: Test 11 MgSO ₄	G-12
Figure 19. Scatter Diagram: Test 12 % Crush	G-13
Figure 20. Scatter Diagram: Test 13 % Flat & Elongated	G-14
Figure 21. Scatter Diagram: Test 15 Total % Insoluble Residue	G-15
Figure 22. Scatter Diagram: Test 98 % Insoluble Residue	G-16
Figure 23. Scatter Diagram: Test 16 MDA, CA	G-17
Figure 24. Scatter Diagram: Test 17 Freeze-Thaw	G-18
Figure 25. Scatter Diagram: Test 20 P 2.36 mm	G-19
Figure 26. Scatter Diagram: Test 20 P 1.18 mm	G-20
Figure 27. Scatter Diagram: Test 22 P 600 µm	G-21
Figure 28. Scatter Diagram: Test 23 P 300 µm	G-22

Figure 29. Scatter Diagram: Test 24 P 150 μm	G-23
Figure 30. Scatter Diagram: Test 25 P 75 μm	G-24
Figure 31. Scatter Diagram: Test 27 RD of FA (O.D.)	G-25
Figure 32. Scatter Diagram: Test 28 Absorption of FA	G-26
Figure 33. Scatter Diagram: Test 30 % Asphalt Coated Particles	G-27
Figure 34. Scatter Diagram: Test 31 Max Wet Density	G-28
Figure 35. Scatter Diagram: Test 32 Max Dry Density	G-29
Figure 36. Scatter Diagram: Test 33 Optimum Moisture %	G-30
Figure 37. Scatter Diagram: Test 34 MDA, FA3	G-31
Figure 38. Scatter Diagram: Test 40 P 2.0 mm	G-32
Figure 39. Scatter Diagram: Test 41 P 425 μm	G-33
Figure 40. Scatter Diagram: Test 42 P 75 μm	G-34
Figure 41. Scatter Diagram: Test 43 P 20 μm	G-35
Figure 42. Scatter Diagram: Test 44 P 5 μm	G-36
Figure 43. Scatter Diagram: Test 45 P 2 μm	G-37
Figure 44. Scatter Diagram: Test 46 Liquid Limit %	G-38
Figure 45. Scatter Diagram: Test 47 Plastic Limit %	G-39
Figure 46. Scatter Diagram: Test 48 Plasticity Index %	G-40
Figure 47. Scatter Diagram: Test 49 SG of Soils	G-41
Figure 48. Scatter Diagram: Test 122 Concrete Prism Test CPC1.	G-42
Figure 49. Scatter Diagram: Test 123 AMB (M1)	Error! Bookmark not defined.
Figure 50. Scatter Diagram: Test 123 AMB (M2).	G-44
Figure 51. Scatter Diagram: Test 125 Concrete Prism Test CPC2.	Error! Bookmark not defined.
Figure 52. Scatter Diagram: Test 126 % of SiO_2	G-46
Figure 53. Scatter Diagram: Test 127 % of TiO_2	G-47
Figure 54. Scatter Diagram: Test 128 % of Al_2O_3	G-48
Figure 55. Scatter Diagram: Test 129 % of Fe_2O_3	G-49
Figure 56. Scatter Diagram: Test 130 % of MnO	G-50
Figure 57. Scatter Diagram: Test 131 % of MgO	G-51
Figure 58. Scatter Diagram: Test 132 % of CaO	G-52
Figure 59. Scatter Diagram: Test 133 % of Na_2O	G-53
Figure 60. Scatter Diagram: Test 134 % of K_2O	G-54

Figure 61. Scatter Diagram: Test 135 % of P_2O_5	G-55
Figure 62. Scatter Diagram: Test 136 % of Loss on Ignition.	G-56
Figure 63. Scatter Diagram: Test 137 % of Total.	G-57
Figure 64. Scatter Diagram: Test 95 UC Void	H-58
Figure 65. Scatter Diagram: Test 96 SE Value	H-59
Figure 66. Scatter Diagram: Test 97 % Fractured	H-60
Figure 67. Scatter Diagram: Test 99 % F & E	H-61

Foreword

The annual aggregate and soil proficiency sample testing program delivered by the MTO Soils & Aggregate (S&A) Section is a demonstration of MTO's commitment to developing effective programs that improve OPS operations in building quality infrastructure and benefits industry partners. I am proud to sponsor this program annually as it provides the MTO with a means to select qualified laboratories to provide testing services in direct support of provincial highway construction and maintenance activities. It also offers a unique opportunity for our laboratory testing partners in soil and aggregate testing to evaluate their testing performance relative to other laboratories within the province. With this program, we have sustained a valued partnership with the certification stakeholder (CCIL), who uses the test results for independent certification of laboratories in Ontario.

Recognizing the enormous all-year round efforts put into delivering this comprehensive program, through material sourcing, preparing, packaging and delivering samples to laboratories within and outside Ontario, I am reminded of the technical excellence and dedication of the S&A Section workforce to contribute to MTO success. Particularly in the 2020 program, the S&A staff transformed the process flow, equipment and system of sample preparation for the annual proficiency sample testing program for aggregate materials to a streamlined and less labour intensive approach, demonstrating MTO as a forward-thinking innovative organization that actively seeks out safer and more efficient ways of delivering programs. The workforce's innovation of the process flow and equipment modifications ensure that we provide effective and efficient public service with the agility to deliver sustainably, while focussing on meeting the demands of our industry partners with potential future expansion of this successful program.

I acknowledge the extraordinary dedicated efforts of all staff involved in delivering this successful program and I am pleased to endorse this 2020 Aggregate and Soil Proficiency Sample Testing Program. Our services and support for our industry partners have depended fully on your continual forward thinking, collaboration and inclusive engagement – let's keep the flag of success flying!

Veronica Ayetan, P.Eng.
Head, Soils & Aggregates Section
Engineering Materials Office, SCB, TIMD, MTO

Acknowledgements

The authors would like to acknowledge Henry Bykerk, Peter Corsaro, and Carole Anne MacDonald of the Soils and Aggregates Section for the selection of aggregate materials for the 2020 proficiency sample testing program. As listed below, we hereby give special thanks to the engineers, laboratory staff, students and engineers-in-training of the Engineering Materials Office for their dedicated assistance in preparing approximately 2500 individual samples, from approximately 80 tonnes of aggregate and soil materials, for distribution to the program participants across Canada.

Staff who offered dedicated assistance to the Program:

Aleksandri Prifti, Ashley Lam, Carole Anne MacDonald, Derrick Harriot, Desmond Hui, Esme Symons, Henry Bykerk, John Dybczak, Julia Gabriele, Joel Magnan, Kaelan Rorabeck, Monique Seibert, Peter Corsaro, Steven Seto, Tom Gillanders, Tyrone Gilbank.

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, to allow the Ministry of Transportation (MTO) evaluate the competency of laboratories providing testing services to support 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 for the ministry. 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 11 different materials prepared by the Soils and Aggregates Section laboratories. Samples are delivered to the participating laboratories from May to August, who are required to prepare, test and report their results to MTO by October. An initial statistical analysis of the data is conducted by Soils and Aggregates staff and a preliminary report is issued in early November. This portion of the program is intended to give feedback to the participants and allows them to correct any problems that may exist with their testing system. A final report, including ratings for each laboratory, is issued after a full statistical analysis of all the laboratories data has been completed.

Proficiency test samples were shipped to two hundred and twenty-five private and public sector laboratories who requested participation in 2020. Two hundred and thirteen participants submitted test results. Of these, one hundred and thirteen 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 and ASTM laboratory test standards (MTO, 2020).

Results of the aggregate and soil tests from the 2020 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 or ASTM.

1. Introduction

This is the final report of the 2020 Aggregate and Soil Proficiency Sample Testing Program (proficiency program) organized by the Ontario Ministry of Transportation (ministry) 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. This program provides 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 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)

From May to August of 2020, proficiency test samples were distributed to two hundred and twenty-five Ontario participants from the private and public sector laboratories. A total of two hundred and thirteen participants reported results, including sixty-five laboratories that reported results for all 4 tests related to Superpave aggregate consensus properties. Participants in the testing program included both public (MTO and municipality laboratories) and private sector laboratories (contractors, aggregate producers, and engineering consultants). A preliminary report was issued to the participants in early November.

Laboratories conducted tests in accordance with MTO Laboratory Standards (MTO Laboratory Manual) and AASHTO/ASTM standards (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), 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) and standard proctor (LS-706).

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

Aggregate reactivity tests include alkali carbonate reactivity (LS-615), accelerated mortar bar expansion (LS-620) and concrete prism test (LS-635).

Soil tests include particle size analysis (LS-702), Atterberg limits (LS-703/4, ASTM D4318) and relative density (LS-705).

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 or ASTM: wash pass 75 μm , Los Angeles abrasion loss, relative density and absorption of fine aggregate, asphalt coated particles and insoluble residue of carbonate aggregates. 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 still remain in the following test methods: Los Angeles abrasion loss, sulphate soundness loss and accelerated mortar bar. The variations in the test of specific gravity of soils show improvement and are lower than the values reported in the previous three years of study. Since the clay supplied in 2020 has a low to intermediate plasticity with a liquid limit at about 35%, the variations obtained for all three index tests in 2020 may not be comparable to the values reported in 2018 where a clay of high plasticity (CH) was used. A strong laboratory bias still remains in the test of specific gravity of soils.

The results of Superpave consensus property tests from the 2020 program also compare favourably with the past performance of the laboratories. The multi-laboratory variations of sand equivalent value of fine aggregate show noticeable improvements over the precision estimates published by ASTM. Although there is noticeable improvement in the performance of the laboratories, the scatter diagram for ASTM D2419 still shows a strong laboratory bias.

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 over 213 laboratories participated in the 2020 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.

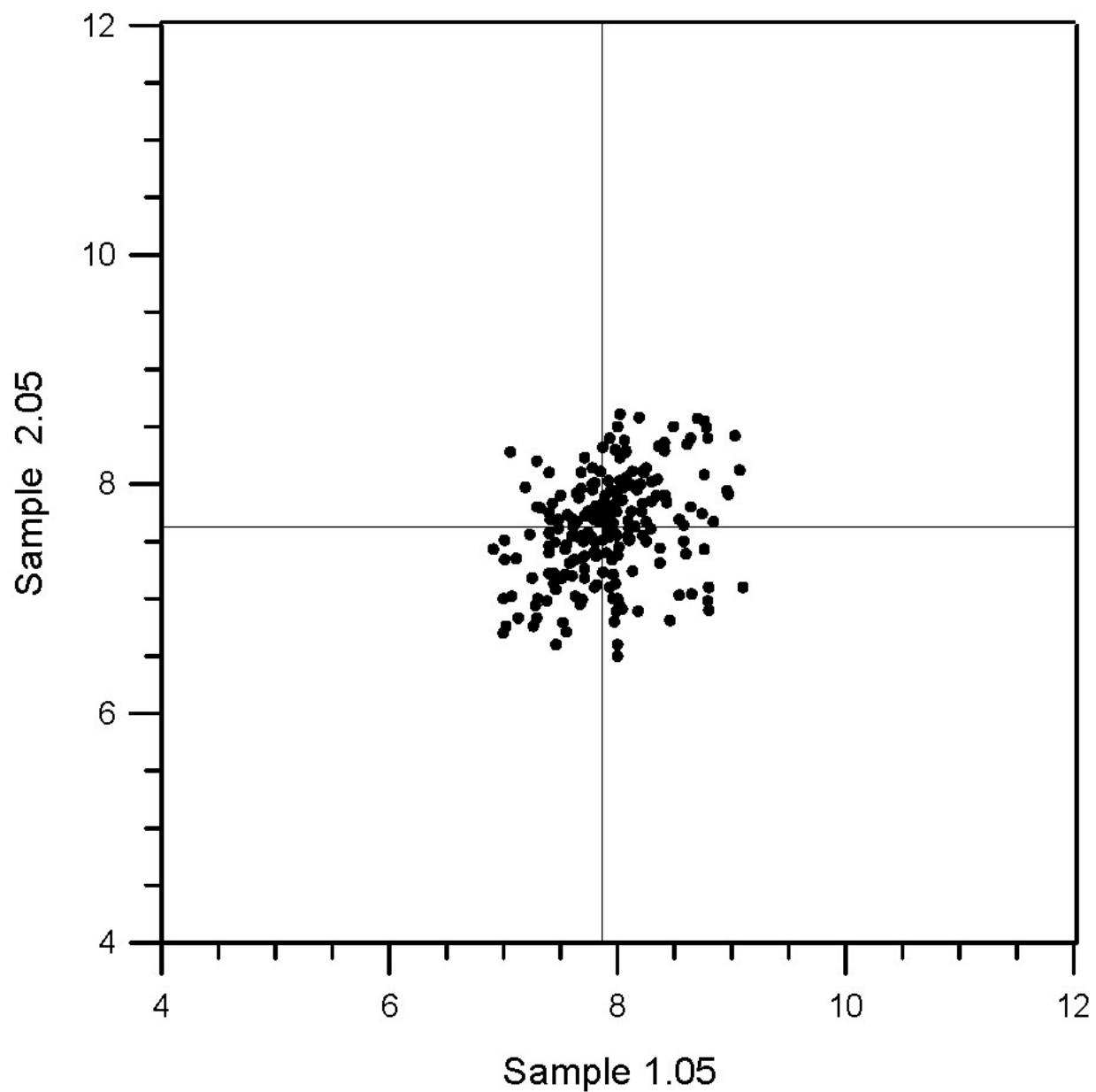
2.2 Scatter Diagrams

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

sample (1.20) on the horizontal axis, against its test value for the second sample (2.20) 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 (1.20) and the second sample (2.20), 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, Figure 2, Figure 3 and Figure 4 below gives examples of scatter diagrams.

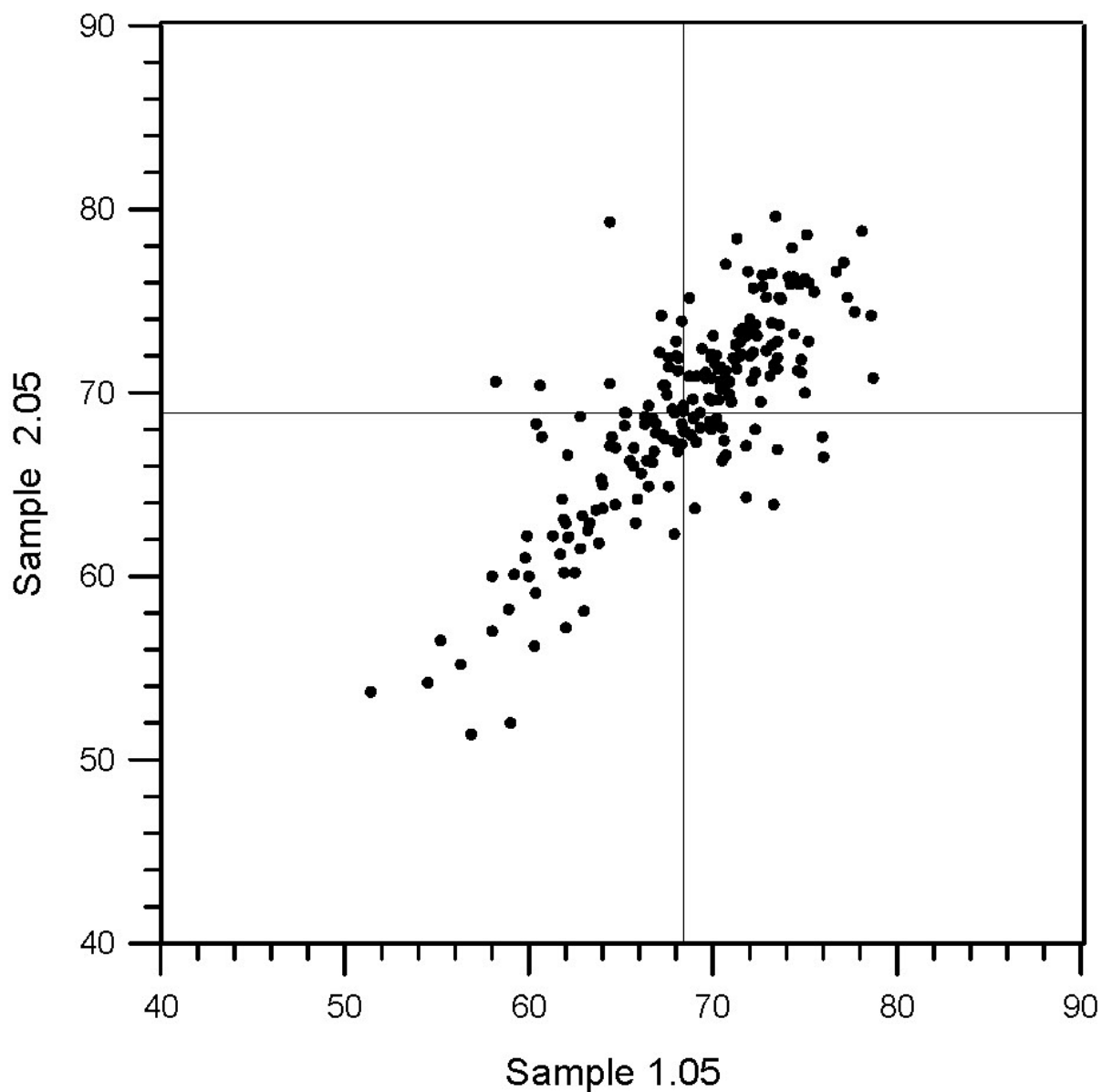


Test 25: Percent Passing the 75 um Sieve

	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

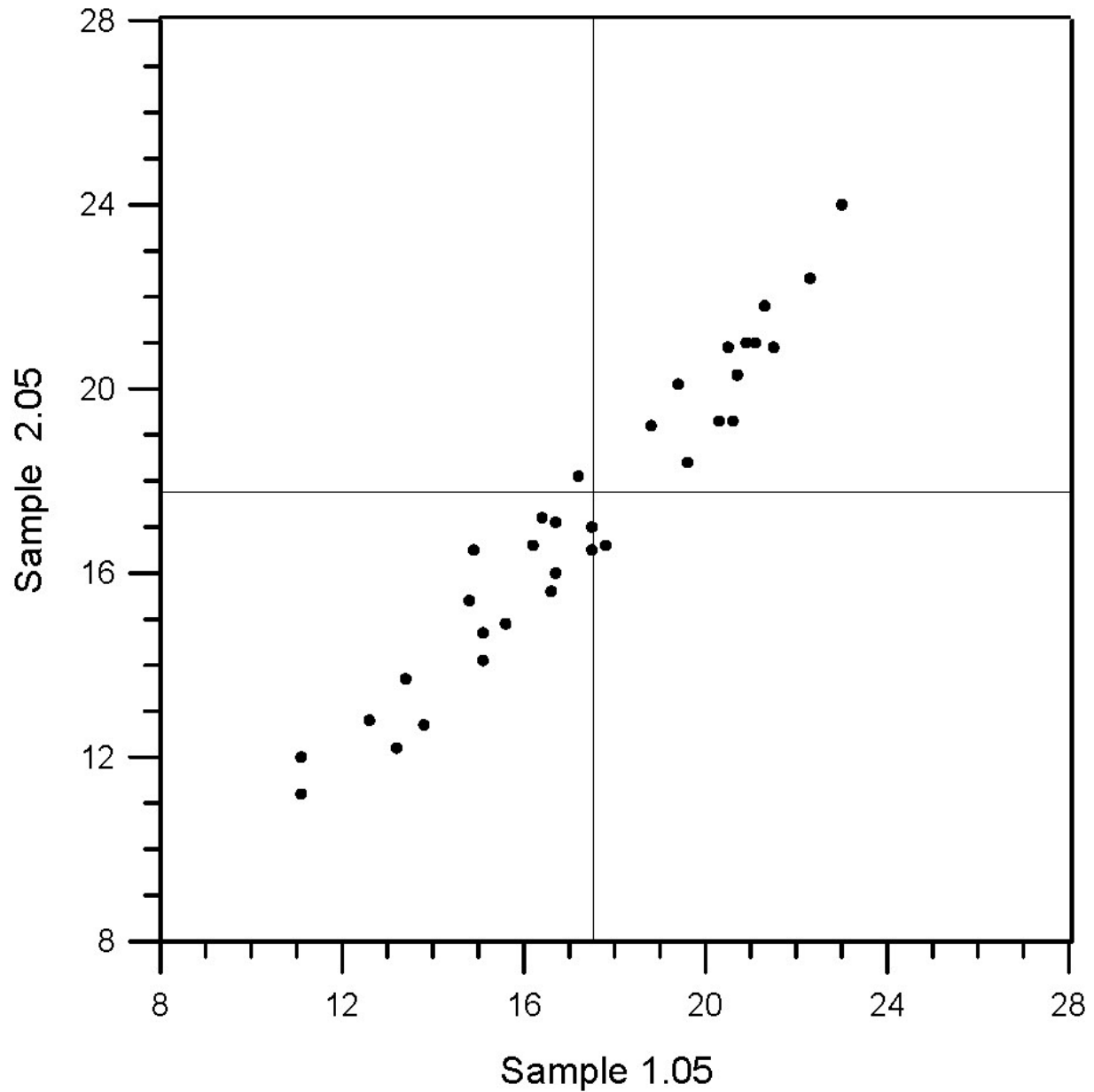


Test 12: Percent Crushed Particles

	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

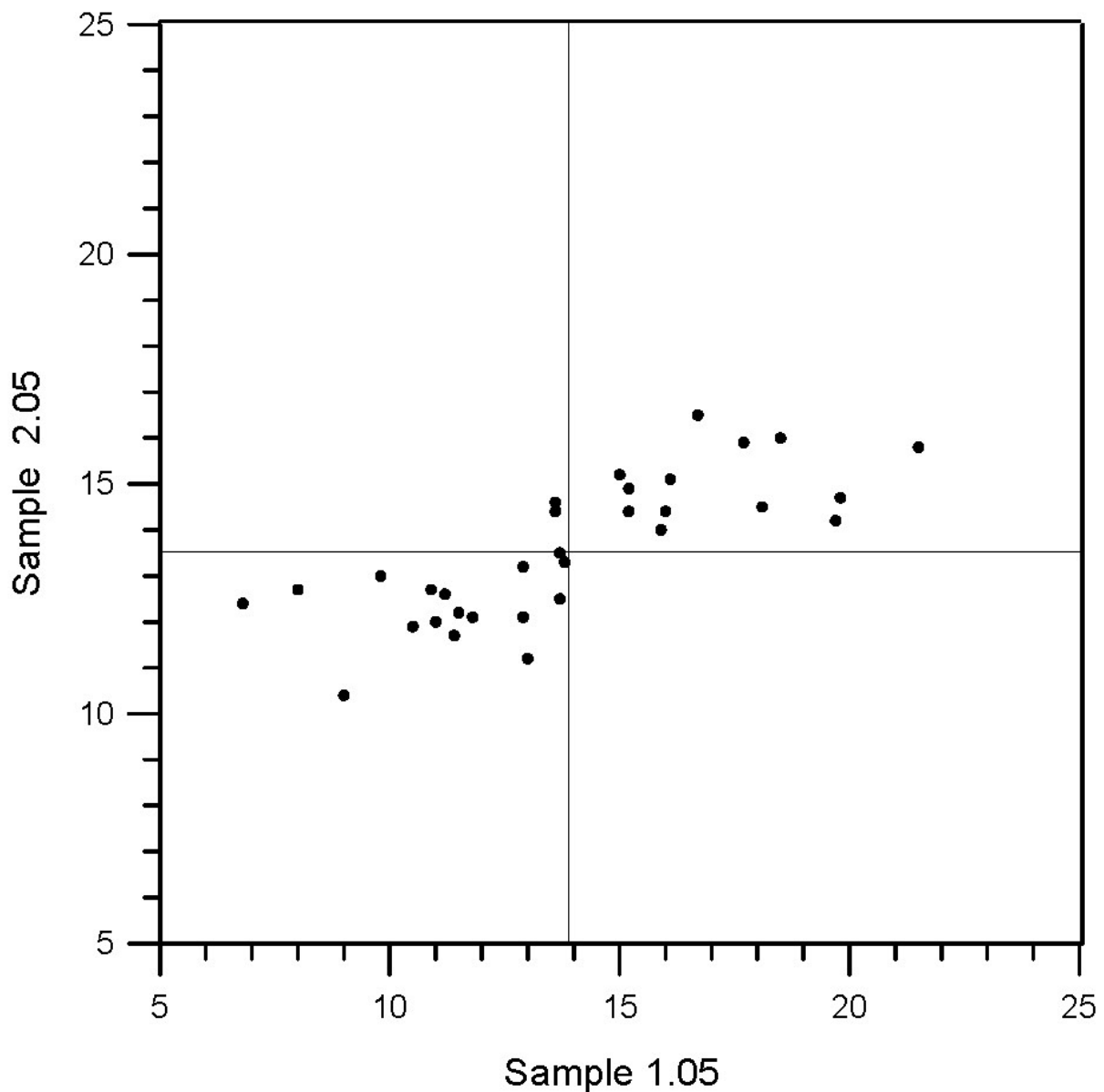


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	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 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 2020 test period. Detailed discussion of petrographic analysis results (LS-609 and LS-616) and materials used 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 a pit source near Kitchener area. 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 from a quarry near Brechin area. 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.
- A quarry source in Ottawa area (provided to participants pre-crushed to P4.75 mm). Accelerated Mortar Bar Test Materials M1 and M2, Acid Insoluble Residue of Aggregates, Potential Alkali-Carbonate Reactivity of Carbonate Rocks by Chemical Composition.
- Coarse aggregate from a carbonate quarry in Kingston area with fine aggregate from a quarry on the Niagara Escarpment. LS-635 Concrete Prism Test, **2020 Mix 1**, procedure for length change due to alkali-aggregate reaction in concrete prisms at 38°C).
- Coarse aggregate from a gravel deposit located northeast of Sudbury area with fine aggregate from a Southwestern Ontario pit source. LS-635 Concrete Prism Test, **2020 Mix 2**, procedure for length change due to alkali-aggregate reaction in concrete prisms at 38°C).
- Soil from Heidelberg Clay.

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 bagging system which includes a hopper and a bagging unit. The bagging system was developed and built by staff of MTO Soils and Aggregates Office in 2019. Prior to the use of this new system, bulk samples were prepared using a large spinning riffler and a bobcat loader was used to move aggregates from the stockpile to a small hopper which fed materials 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.

Over the past decade, the annual proficiency testing program has grown considerably, due to addition of tests in the program and the increasing number of participating laboratories. The success of the program requires more aggregates than ever before to be processed. Hence, the continued use of the traditional turntable system was unsustainable.

Comparisons of data using the bagging system with the use of the spinning riffler showed that the variation in data was not abnormally different regardless of the technique used.

In the 2020 program, an engineering stockpile with a footprint of 16ft by 21ft was constructed to minimize segregation and produce more homogeneous samples. The dimension of the footprint was also designed according to the reach of the loader so as to eliminate the need for the loader to drive on and degrade the material. A front-end loader was used to take a bucket of material from the bottom to the top of the original stockpile that was delivered to MTO preparation site from a select source. This bucket of material was then spot dumped on the ground and bladed level with the loader bucket to a height of approximately 0.3m to 0.4m. Buckets of materials were successively taken and placed on the ground uniformly, until the footprint (16ft by 21ft) was filled. Same approach was followed to build the 2nd layer of the engineering stockpile on top of the first layer with a slightly smaller footprint; care was taken to avoid any material of the 2nd layer overrunning down to the slope of the first layer. In total 3 layers were constructed. Each layer was levelled prior to placing the succeeding layer. A bobcat loader was used to take small scoops of materials from the engineering stockpile to fill the hopper of the bagging system. The materials were moved on a conveyor belt inside the hopper to fill a bag secured at the discharge point of the bagging unit. A built-in weighing unit equipped with the bagging unit automatically measured the weight of each bag and stopped the conveyor once the set target weight (30 kg) was reached. This system is capable of filling a sample bag with 30-32 kg of material with a production rate of up to 20 tonnes/day. Sample weight was monitored by

randomly weighing one sample out of every 30 with a separate portable scale (underweight or overweight bags were rejected). With this efficient and effective system, MTO is confident of meeting the demands of our industry partners even with future expansion of this successful program.

In total, thirteen hundred and seventy ~30 kg samples of Granular A were prepared for the coarse and fine aggregate tests. The samples were randomized in pairs for distribution to participating laboratories across Canada. Each participant was responsible for the preparation of their own fine aggregate samples (3.20 and 4.20) from the pair of Granular A samples supplied. These samples were marked with “A” on the sample bags.

In addition to the Granular A samples, a coarse aggregate with approximately 95% material retained on 4.75 mm sieve was also supplied. Each sample bag was filled to approximately 30-32 kg. In total, nine hundred and thirty ~30 kg samples were prepared and randomized in pairs for distribution to participating laboratories. These samples were marked with “ST” on the sample bags.

The bagging system was power washed clean of any residual aggregate particles prior to preparation of a different material. Such care was taken to eliminate cross contamination of materials.

Soil material was air-dried and mechanically broken down and passed through a 4.75mm sieve to remove oversized particles. The passed 4.75mm 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.

Materials for Accelerated Mortar Bar Test were mechanically crushed to pass through a 4.75 mm sieve and placed in 25kg 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 ~6 kg samples that were then randomized in pairs for distribution to participating laboratories.

The material evaluated by Concrete Prism Test 2020 Mix 1 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 2 fractions (P13.2 mm/R9.5 mm, and P9.5 mm/R4.75 mm) by splitting and sieving. The P13.2 mm/R9.5 mm fraction weighed approximately 9 kg, and P9.5 mm/R4.75 mm fraction weighed approximately 12 kg. The

coarse aggregate samples (each containing the 2 fractions) were then randomized in pairs for distribution to participating laboratories.

The material evaluated by Concrete Prism Test 2020 Mix 2 was a coarse aggregate with approximately 95% material retained on 4.75 mm sieve. The aggregate samples were not pre-graded. Each sample bag was filled to approximately 30-32 kg. The samples 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 G and Appendix H. 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 E and Appendix F. Along with the comparison made to ASTM, AASHTO or MTO 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 eleven laboratories reported results for this test in 2020. Seventeen outliers were identified and rejected using the iterative technique. The standard deviations of 0.153 and 0.171 obtained in 2020 are slightly higher than the values in the past three years. The standard deviations obtained in 2020 are 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 2020 consisted of approximately 0.93%

material finer than 75 μm , which is in line with the values for which the ASTM and MTO precision statements were established. Further, the coefficient of variation of 17.4% obtained in 2020 is lower than the values reported in the past year 2019. The scatter diagram provided in the Appendix G 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 3.20 and 4.20) 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 by Vogler and Spellenberg (Vogler & Spellenberg).

The Granular A samples 1.20A and 2.20A supplied for the sieve analysis test consisted of approximately 56% 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 using the live bottom hopper as described in Section 3.2.

The standard deviations obtained in 2020 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 16 mm and 13.2 mm sieves that are lower than the corresponding variation in the ASTM C 136.

Two hundred and eleven laboratories reported results for the sieve analysis test in 2020. 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 is five for each of the three larger sieves (19.0 mm, 16.0 mm and 13.2 mm) and nine for each of the smaller sieves (9.5 mm and 4.75 mm).

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 (use 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

Fourteen laboratories reported results for this test in 2020. One outlying laboratory was detected by the use of iterative technique method. Considering the number of observations (14) used, the analysis may not yield any meaningful or representative statistical data. The scatter diagram shows a strong between laboratory bias and unequal variation for each material. The standard deviations obtained in 2020 showed improvement from the 2019 program, and comparable to the values reported in 2018.

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 23.0% in this test is within the range of values for which ASTM C 131 data was established. This year's coefficient of variation (average 4.13%) is lower 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.

Ninety-nine laboratories reported results for these tests in 2020. Four laboratories for relative density and three laboratories for absorption were identified as outliers using the iterative technique. The standard deviations of 0.006 obtained for bulk relative density in 2020 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 2020 are one-half of the value of 0.013 published in ASTM C 127. In the case of absorption test, the standard deviations of 0.074 and 0.076 obtained this year are in line with the precision estimate of 0.09 provided in the LS-604. The average coefficient of variation of 10.6% for Test No. 10 obtained in 2020 is higher than the values reported in the past three years. The scatter diagrams for both tests show a combination of random variation and laboratory bias for some laboratories.

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

Thirty-nine laboratories reported results for this test in 2020. No 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 9.2%-9.3% in this test is close to the lower side of the range of values (9% to 20%) for which the ASTM C 88 precision estimate was established. The average coefficient of variation of 31.0% obtained in 2020 is higher than the value of 28.6% obtained in the 2019 study, but lower than the values in 2017 and 2018 studies. 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 2020 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 eleven 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 Granular A sample shall be used in calculation of the weighted average of percent flat and elongated particles, as specified in the instructions. Twenty-one laboratories were selected as outliers by employing the iterative technique. The standard deviations of 1.499 and 1.248 obtained in 2020 are lower than the precision estimate of 4.7 published in the MTO LS-607 and lower than the values reported in the past three years. The standard deviations obtained in 2020 are lower than the value of 6.0 obtained during the 1989 MTO workshop. The average mean value of 99% in this test is beyond 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 2020 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 ten 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 4.75mm with percent flat and elongated particles ranging from 0.8% to 4.8%. The standard deviations of 0.623 and 0.573 obtained in 2020 are lower comparable to the values reported in past three years. The multi-laboratory variations obtained in 2020 are lower than the precision estimate of 2.3 published in LS-608. The average mean value of 1.36% in this test is below 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 G shows random variation with little laboratory bias. In general, the 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 µm 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 two outliers from the results for percentage of residue retained 75 µm were removed. The scatter plot for Test NO. 15 shows a combination of random variation and laboratory operator bias for some laboratories. The scatter plot for Test NO. 98 shows a strong laboratory bias.

The standard deviations of 0.60 and 0.73 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 intermediate level of insoluble residue, represented by 25.3% as per D3042, was found to have the highest variability. In the case of percentage of insoluble residue retained 75 µm, the standard deviations 0.93 and 0.85 obtained are significantly 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

Seventy-Eight 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 the laboratories reported control sample result within the established range for the material. Three outlier was 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 8.2% and 8.1% in 2020 is within the range of values for which the precision estimates were established. The average coefficient of variation of 7.0% obtained in 2020 is higher than the value of 5.4% published in LS-618. It is in line with the values of 6.7% and 7.5% reported in 2018 and 2019, respectively. 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 2020 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 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-Seven laboratories reported results for this test in 2020. 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). Five 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 2.988% in this test is close to the range (3% to 18%) for which the LS-614 precision estimate was established. The average coefficient of variation of 27.6% obtained in 2020 is higher than the value of 21.6% published in the LS-614 and the value of 23.6% reported in 2019, but lower than the values of 29.8% 2018. The scatter plot for this test shows a combination of random variation and laboratory bias for some laboratories.

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 2020 are lower than the values reported in the past two years. For the multi-laboratory variations, the average standard deviations obtained in 2020 (0.93 to 1.96) for all the sieves, except 150 μm and 75 μm , are higher than the values published in the ASTM C 136 precision statements. For 150 μm , the average standard deviation of 0.62 is in line with the value of 0.65 published by ASTM. For 75 μm , the average standard deviation of 0.43 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.

Total two hundred eleven laboratories participated on the test. The number of outliers identified varies from sieve to sieve, and ranges from twelve for each of the three sieves (2.36 mm, 1.18 mm and 600 μ m) to a maximum of sixteen for the 150 μ m sieve. Outlier laboratories with a very low percent passing the 75 μ m 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 μ m from the test specimen by washing. LS-605 requires the test specimens to be prepared in duplicate and washed on the 75 μ m sieve until all of the material finer than 75 μ m is removed. The presence of material finer than 75 μ m 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-seven laboratories reported results for these tests in 2020. Eight outliers for relative density (Test No. 27) and eleven 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 2020 for both relative density (0.007 and 0.008) and absorption (0.096 and 0.083) are lower than 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 2020 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 0.875% and 0.857% reported by the laboratories are within 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 eleven laboratories reported results for this test in 2020. Eighteen laboratories were identified as outliers using the iterative technique. Scatter diagram provided in the Appendix G 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 45.3% and 44.8% reported by the laboratories are beyond the range of values for which the precision estimate was developed. The standard deviations of 2.528 and 2.699 obtained in 2020 are lower than the precision estimate of 3.9 published in the LS-621 and consistent with the results for 2019 and 2018. 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 1.20P and 2.20P supplied.

One hundred and twenty-nine laboratories reported results for this test in 2020. Seven outliers for the wet density (Test No. 31), nine outliers for the dry density (Test No. 32), and eleven outliers for optimum moisture (Test No. 33) determinations were rejected using the iterative technique. The standard deviations obtained in 2020 for maximum wet density (Test No. 31) is consistent with the values reported in the past three years. The standard deviations obtained in 2020 for maximum dry density (Test No. 32) and optimum moisture (Test No. 33) are lower than the values reported in the past three

years. The standard deviations 0.027 obtained in 2020 for maximum dry density (Test No. 32) is 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 and reports precision estimates for maximum dry unit weight in pcf and optimum moisture content from the tests conducted only on clayey soils. Considering the difference in the materials and reported units in 2020 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 sub specimen 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 3.20A and 4.20 A which are prepared from supplied samples 1.20A and 2.20A. Seventy-eight laboratories reported results for this test in 2020. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. Three 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 9.5% obtained in 2020 is higher than the precision estimate of 7.6% published in LS-619 and the values of 7.8%, 8.4% and 6.6% reported in 2019, 2018 and 2017 respectively. 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 fine aggregate samples 1.20M1, 2.20M1, 1.20M2 and 2.20 M2. Both M1 and M2 material sets contain a representative sample of the fine aggregate that was prepared by MTO using a crusher and a spinning riffler.

In 2020, twenty-one laboratories reported their test results for M1 and Twenty-one laboratories reported their test results for M2. The participants were asked to test three mortar bars made with each of the aggregate samples supplied. Standard cement was also supplied for the 2020 study.

The participants reported expansion of the individual bars and the average of three bars after 1, 3, 7, 13, 14 days. The average expansions of Test No. 123 and 124 after 14 days were shown on the scatter diagrams in the Appendix G.

Iterative technique was employed to reject one outlier from the data set for Test No. 123. The scatter diagram indicates a strong laboratory bias. The mean expansion of M1 at 14 days obtained from this study is 0.372% and 0.367%. The standard deviations obtained are 0.027 and 0.034, respectively.

Two outliers were identified from the data set for Test No. 124 using the iterative technique. The scatter diagram indicates a strong laboratory bias. The mean expansion of M2 set at 14 days obtained from this study is 0.307% and 0.320% for 1.20M2 and 2.20M2, respectively. The standard deviations obtained are 0.040 and 0.028, respectively.

The standard deviations obtained for both M1 and M2 sets in 2020 study are higher than the values reported in 2019. The average coefficients of variation for both M1 (8.3%) and M2 (10.9%) in 2020 are smaller than the values reported in the past three years, as well as the precision statement (15.2%) published by ASTM C1260. The mean expansions of both M1 and M2 sets are larger than 0.1% for which the ASTM precision estimate was developed. A lower coefficient of variation obtained in 2020 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 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 LS-635- Concrete Prism – Test No. 122 and 125

Since 2017, Concrete Prism test 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 2020 test were supplied with coarse and fine aggregate samples 1.20 and 2.20. This test takes a year to complete. Eight laboratories reported their test results in 2021 for the 2020 test. The participants were asked to test three prisms made with each 1.20 and 2.20 samples supplied.

The participants reported expansion of the individual bars 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 G. One outlier for M1 and two outliers for M2 were identified using Iterative technique. The scatter diagrams indicate strong laboratory biases. Considering the number of observations (9) used, the analysis may not yield any meaningful or representative statistical data.

The mean expansions after 52 weeks obtained from this study are 0.169% and 0.166% for T122 M1, and 0.109% and 0.101% for T125 M2. The average coefficients of variation

for M1 and M2 (5.1% and 9.8% respectively) obtained in 2020 study are comparable to the values reported in 2019 (6%), and lower than the value in 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. In 2020 it was continued and the participants were supplied with a pair of fine aggregate samples, 1.20ACR and 2.20ACR. 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.

Nine (9) laboratories reported their test results in 2020. All participants utilized wavelength dispersive x-ray fluorescence as the analytical method for this test. Considering the number of observations (9) 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 2020 for Al_2O_3 was (74.5%) and MgO (67%) are higher than the values reported in 2019 for Al_2O_3 (12.3%) and MgO (5.2%), as well as the values of 13% and 6.9% reported in LS-615 Rev. 33 precision statements. The average coefficient of variation obtained for CaO in 2020 (7.6%) are higher than the value reported in 2019 (1.7%) and the value of 1.5% reported in LS-615. 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-four laboratories participated in the hydrometer test in 2020. All the laboratories reported results ranging from 99.7% 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 to a maximum of thirteen for percent passing 75 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 2020 for all the particle sizes passing are smaller than the values reported in the past three years. 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 eight laboratories reported results for Atterberg limit tests in 2020. Three outliers for liquid limit (Test No. 46), five for plastic limit test (Test No. 47) and ten 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 2020 is a low to intermediate plasticity clay (CL) with liquid limit in the neighbourhood of 35 ($LL = 35 \pm$). In view of this, the multi-laboratory variations (1s) published in the ASTM for low to medium plastic clay (CL) with a liquid limit of 33.3 and plastic limit of 19.9 are used to evaluate the performance of the participants in the 2020 program. The standard deviations obtained in 2020 for liquid limit are higher than the values published in the ASTM precision statements, but the standard deviations of plastic limit and plasticity index are lower than the values published in the ASTM precision statements (refer Appendix E). The standard deviations for liquid limit are higher than the values reported in 2017 where a clay of intermediate plasticity (CI) with liquid limit of 39 ($LL = 39$) was used, but the standard deviations of plastic limit and plasticity index are lower than the values reported in 2017. The standard deviations for all three index tests in 2020 are lower than the variations reported in 2019 where a low plastic clay (CL) with liquid limit in the neighbourhood of 30 ($LL = 32$) was used. The clay (CL-CI) supplied in 2020 was different from those supplied in 2018 where clay of high plasticity (CH) was used.

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-four laboratories reported results for this test in 2020. Nine 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 0.023 and 0.018 obtained in 2020 are in line with the results reported in the past three years. LS-705 is similar to that of AASHTO T 100, which reports a multi-laboratory standard deviation of 0.04. As in the past three studies, the standard deviations obtained in 2020 are lower than that of the precision estimate published in the AASHTO T 100.

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 AASHTO T 304. In order to minimize 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 1.20 and 2.20.

Sixty-eight laboratories submitted results for this test in 2020. Four laboratories were identified as outliers using the iterative technique. The scatter diagram indicates a combination of random variation and laboratory bias for some laboratories. The standard deviations of 0.488 and 0.533 obtained in 2020 show improvement over the values obtained in 2019 and in line with the values reported in 2018 and 2017. 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-seven laboratories reported results for this test in 2020. Four outliers were identified by the use of iterative technique. The scatter diagram shows a pronounced laboratory bias. The standard deviations of 3.485 and 3.804 obtained in 2020 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. Sixty-eight laboratories submitted results for this test in 2020. Eight outliers were detected using the iterative technique. The scatter diagram shows random variation with little laboratory bias. The standard deviations (3.201 and 3.075) obtained in 2020 are lower than the precision estimate of 5.2 published by ASTM. ASTM has not conducted inter-laboratory studies to determine

a precision estimate and currently publishes statistical data provided by MTO. The standard deviations obtained in 2020 are lower than the values 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.

Sixty-eight laboratories reported results for this test in 2020. Five 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 0.162 and 0.241 obtained in 2020 are lower than the values reported in the past three years. The average coefficient of variation of 64.1% obtained in 2020 is higher than the values reported in the past three years, but lower than the 88.5% published by the ASTM Method. The scatter plot for this test shows combination of random variation and laboratory bias for some laboratories.

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 1.20, plus -5 for wash pass 75 μm on sample 2.20, 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 5 to Figure 8. The rating system for “Full Service Laboratory” (Type D) shows that 51% of the participating laboratories in 2020 obtained a rating higher than 90 and, in the case of “Production Laboratory” (Type C), 46% of the participants obtained an overall laboratory rating higher than 90. The rating system for soil tests show 45% of the participants obtained an overall rating higher than 90, and in the case of consensus property tests (Superpave), 58% of the participants obtained an overall laboratory rating higher than 90. The laboratory rating system data is reported in the Appendix I, Appendix J, Appendix K, and Appendix L.

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.

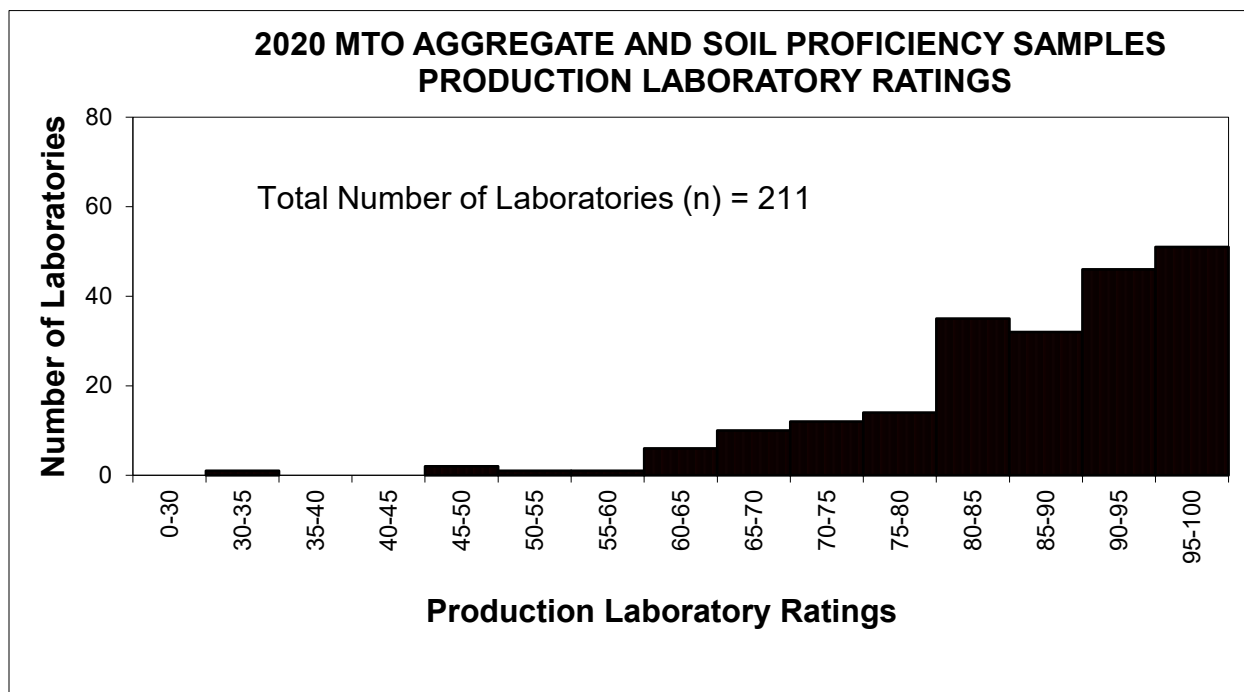


Figure 5. Production Laboratory Ratings

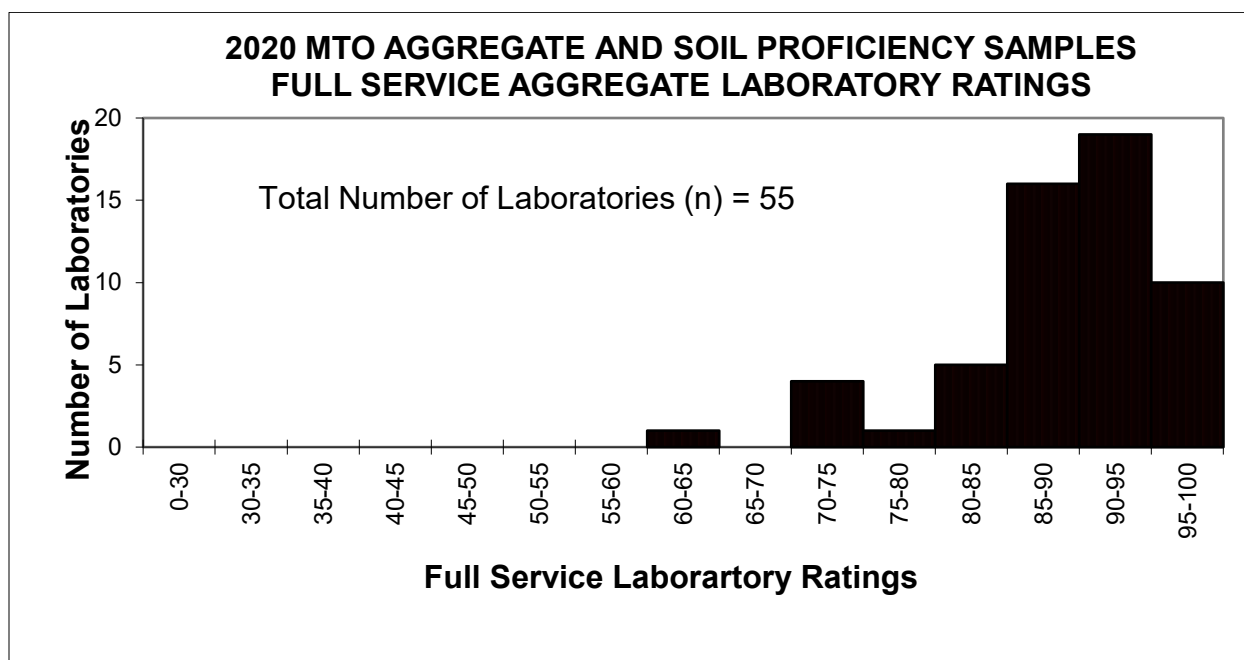


Figure 6. Full Service Laboratory Ratings

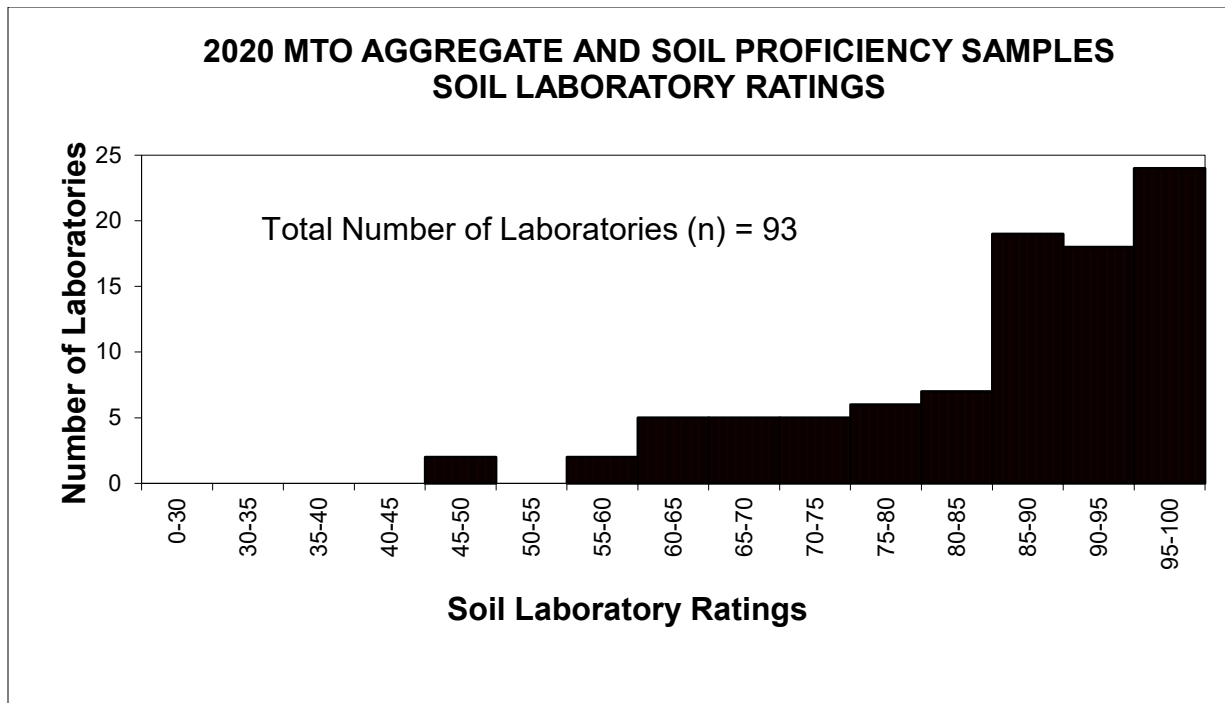


Figure 7. Soil Laboratory Ratings

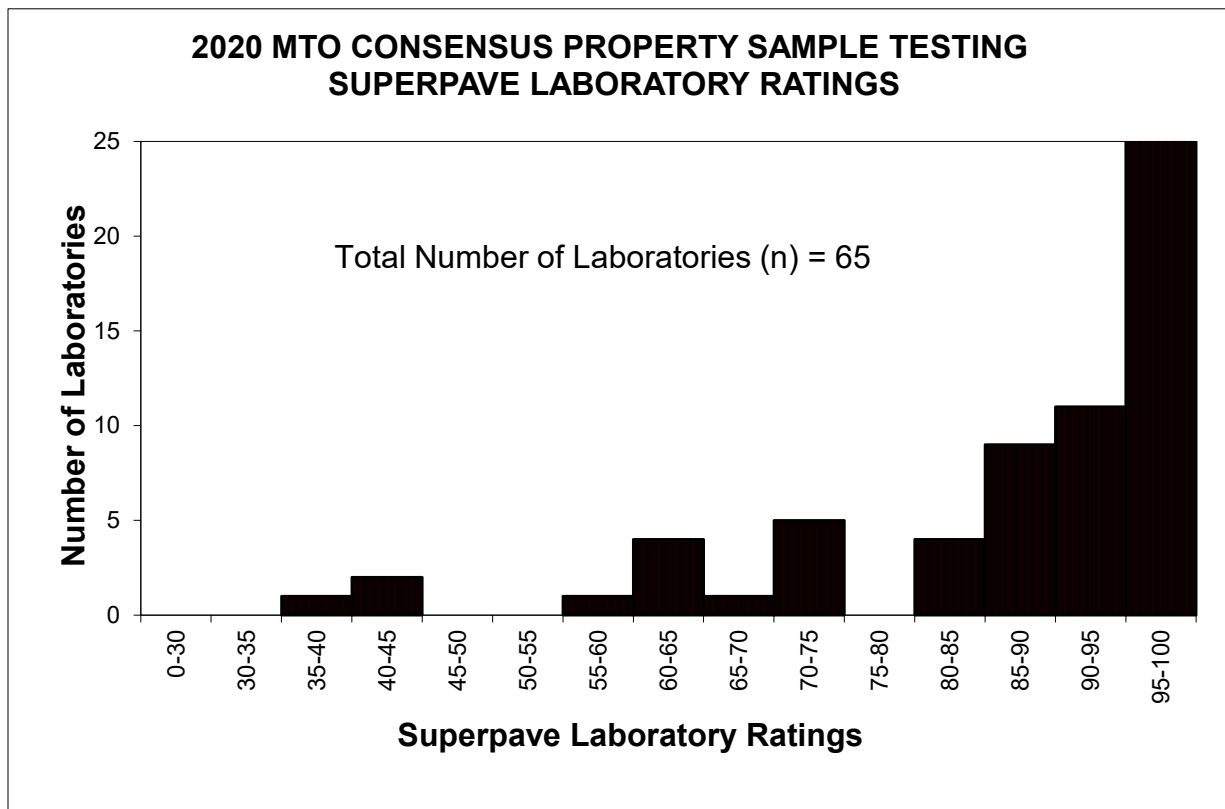


Figure 8. Superpave Laboratory Ratings

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in almost identical mean gradation values for samples 1.20 and 2.20. 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 new 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 2020 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 ASTM, AASHTO, MTO 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 thirteen of the laboratories that reported test results in the aggregate tests are CCIL Type C (Production) certified, and fifty-five of those are also CCIL Type D (Full Service) certified. CCIL is responsible to inspect 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-three laboratories participated in all three soil tests. For particle size analysis of soil and Atterberg limits of soils, the variations found in 2020 are either consistent with or lower than the variations reported in 2017 and 2019 where the classifications of the clay were similar. The scatter diagrams of all three 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-five laboratories participated in all four Superpave consensus property tests. The results of 2020 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 obtained in 2019 and in line with the values reported in 2018 and 2017. The multi-laboratory variations of sand equivalent

value (D2419) and Percent Fractured Particles (D5821) show noticeable improvements over the values reported in the past three years and the precision estimates published by ASTM. Another improvement over the past years is that only the scatter diagrams for ASTM D2419 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 ASTM, AASHTO, MTO or CSA, strong laboratory biases still remain in a few of the aggregate tests, one of the Superpave property test procedures and some of the soil tests. 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 2020 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 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 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.

7. References

- American Society for Testing and Materials. (n.d.). *Annual Book of ASTM Standards* (Vols. 04.02, Concrete and Aggregate).
- American Society for Testing and Materials. (n.d.). *Annual Book of ASTM Standards* (Vols. 14.02, Statistical Methods).
- Grubbs, F. E. (1969). *Procedures for Detecting Outlying Observations in Samples* (Vols. 11, No.4). Technometrics.
- Grubbs, F. E., & Beck, G. (1972). *Extension of Sample Sizes and Percentage Points* (Vols. 14, No. 4). Technometrics.
- Manchester, L. (1979). *The Development of an Interlaboratory Testing Program*. Downsview: Ministry of Transportation, Ontario.
- MTO. (2020). MTO Laboratory Testing Manual. Ontario, Canada: Ministry of Transportation, Materials Engineering and Research Office. Retrieved from <https://www.library.mto.gov.on.ca/SydneyPLUS/TechPubs/Portal/tp/tdViews.aspx>
- Vasavithasan, M., & Rutter, B. (2004). *“User’s Manual for Soils and Aggregates Sample Testing (SASTP) Computer Program*. Ministry of Transportation, Ontario.
- Vogler, R., & Spellenberg, P. (n.d.). *AASHTO T 27 – Sieve Analysis of Fine and Coarse Aggregate*. AASHTO Technical Section 1c.

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 1.20 and 2.20	Lab Data	Lab Data	Lab Mean	Lab Mean	Std. Dev.	Std. Dev	Rating	Rating
Standard	Test Method:	1.20	2.20	1.20	2.20	1.20	2.20	1.20	2.20
LS-601	Wash Pass 75 μ m (Coarse Aggregate)	0.920	0.920	0.924	0.938	-0.026	-0.104	-5	-5
LS-602 (CA)	% Passing 19.0mm	85.700	86.200	86.460	85.518	-0.496	-0.203	-5	-5
LS-602 (CA)	% Passing 16.0mm	76.800	77.300	77.544	77.816	-0.390	-0.262	-5	-5
LS-602 (CA)	% Passing 13.2mm	69.100	69.400	69.921	70.215	-0.374	-0.366	-5	-5
LS-602 (CA)	% Passing 9.5mm	58.600	57.900	58.805	59.062	-0.094	-0.543	-5	-5
LS-602 (CA)	% Passing 4.75mm	44.300	43.200	44.101	44.415	-0.097	-0.655	-5	-5
LS-603	LA Abrasion, %	24.000	23.800	23.031	22.923	0.938	1.012	5	4
LS-606 (CA)	Coarse Aggregate MgSO ₄ , Soundness Loss, %	13.400	13.000	9.151	9.318	1.480	1.292	4	4
LS-607	% Crushed Particles	100.00	100.00	99.709	99.601	0.630	0.643	5	5
LS-608	% Flat & Elongated Particles	1.100	1.380	1.403	1.361	-0.445	0.030	-5	5
LS-609	Petrographic Number CA	147.000	145.000	120.444	122.367	3.216	1.800	-	-
LS-614	Freeze-Thaw Loss, %	2.900	2.700	2.897	3.079	0.005	-0.394	5	-5
LS-618	Micro-Deval Abrasion Loss (Coarse Aggregate)	7.600	7.500	8.243	8.123	-1.202	-1.010	-4	-4
LS-620	Accelerated Mortar Bar (14 Days)	-	-	-	-	-	-	-	-
LS-706	Maximum Wet Density (t/cm ³)	2.444	2.436	2.437	2.438	0.239	-0.087	5	-5
LS-706	Maximum Dry Density (t/cm ³)	2.316	2.311	2.337	2.335	-0.753	-0.899	-5	-5
LS-706	Optimum Moisture, %	5.490	5.430	5.415	5.376	0.185	0.119	5	5
LS-604 (CA)	Relative Density (O.D.)	2.661	2.663	2.665	2.664	-0.619	-0.203	-5	-5
LS-604 (CA)	Absorption	0.700	0.690	0.702	0.706	-0.026	-0.153	-5	-5

Lab 47	Samples 1.20 and 2.20	Lab Data	Lab Data	Lab Mean	Lab Mean	Std. Dev.	Std. Dev.	Rating	Rating
Standard	Test Method:	1.20	2.20	1.20	2.20	1.20	2.20	1.20	2.20
LS-621	Asphalt Coated Particles, %	48.676	45.267	45.278	44.770	1.340	0.182	4	5
LS-605 (FA)	Relative Density (O.D.)	2.700	2.700	2.691	2.692	1.313	1.053	4	4
LS-605 (FA)	Absorption	0.790	0.820	0.874	0.856	-0.881	-0.427	-5	-5
LS-619 (FA)	Micro-Deval Abrasion	11.300	11.400	12.171	12.275	-0.689	-0.827	-5	-5
LS-602 (FA)	% Passing 2.36 mm	35.200	35.500	36.258	36.460	-0.517	-0.523	-5	-5
LS-602 (FA)	% Passing 1.18 mm	28.100	28.990	29.315	29.501	-0.636	-0.300	-5	-5
LS-602 (FA)	% Passing 600 µm	19.800	20.700	20.545	20.714	-0.502	-0.010	-5	-5
LS-602 (FA)	% Passing 300 µm	12.700	13.400	13.181	13.240	-0.510	0.173	-5	5
LS-602 (FA)	% Passing 150 µm	8.600	9.100	8.717	8.787	-0.178	0.532	-5	5
LS-602 (FA)	% Passing 75 µm	5.840	6.050	5.855	5.889	-0.033	0.380	-5	5
LS-702	% Passing 2.00mm	100.00	100.00	99.995	99.992	0.248	0.224	-	-
LS-702	% Passing 425 µm	98.300	98.500	98.253	98.256	0.277	1.212	5	4
LS-702	% Passing 75 µm	95.500	95.500	95.319	95.314	0.866	0.903	5	5
LS-702	% Passing 20 µm	85.310	85.120	98.529	88.760	-1.172	-1.372	-4	-4
LS-702	% Passing 5 µm	60.320	59.320	64.147	64.086	-1.266	-1.536	-4	-3
LS-702	% Passing 2 µm	42.030	41.260	45.520	45.515	-1.519	-1.689	-3	-3
LS-703	Liquid Limit, %	35.570	35.880	35.026	34.973	0.369	0.648	5	5
LS-704	Plastic Limit, %	16.480	16.330	16.819	16.870	-0.345	-0.467	-5	-5
LS-704	Plasticity Index, %	19.100	19.550	17.933	18.038	0.967	1.109	5	4
LS-705	Specific Gravity of Soil	2.720	2.726	2.742	2.744	-0.997	-0.984	-5	-5
Superpave	Uncompacted Void Content	42.000	42.100	41.889	41.933	0.234	0.319	-5	5
Superpave	Sand Equivalent Value	43.100	42.400	37.842	38.180	1.525	1.119	3	4
Superpave	% Fractured Particles	52.000	51.800	52.155	52.088	-0.050	-0.093	-5	-5
Superpave	% Flat and Elongated	0.030	0.074	0.271	0.333	-1.537	-1.062	-3	-4

Blank spaces represent not tested.

* - Calculation considered outlier

∅ - Outliers by Manual Deletion

Appendix C. List of Participants – Aggregates

Table 2. List of Participants – Aggregates and Soil

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
A. L. Blair Construction Moose Creek, Ontario Mr. Justin Blair, Tel: (613) 538-2271	✓	✓				✓	✓								✓				
AECOM Canada Limited 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 24-298 Caledon, Ontario Mr. Scott Crowley, Tel: (905) 840-5914	✓	✓				✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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	✓	✓			✓	✓								✓				
	AME Materials Engineering - PN 2 Caledon, Ontario Ms. Jessica Yao, Tel: (905) 840-5914							✓	✓										
	B.I.G. Consulting Inc. Mississauga, Ontario Osbert Benjamin, Tel: (905) 782-0315	✓	✓			✓	✓								✓	✓	✓	✓	✓
	Bare Contracting Services Mississauga, Ontario Mr. Adam Costello, Tel: (416) 677-1782	✓	✓			✓	✓								✓	✓			

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Bruno's Contracting (Thunder Bay) Limited Thunder Bay, Ontario Mr. Dante DiGregorio, Tel: (807) 623-1855	✓	✓			✓	✓								✓				
	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 Co., Limited - Mobile No. 5 Hearst, Ontario Mr. Charles Harris, Tel: (705) 372-1838	✓	✓	✓		✓	✓								✓	✓			
	C.T. Soil & Materials Testing Windsor, Ontario Mr. Thomas J. O'Dwyer, Tel: (519) 966-8863	✓	✓	✓		✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓
	Caledon Sand & Gravel Caledon, Ontario Mr. Leigh Mugford, Tel: (416) 579-9426	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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, 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 Cambridge, Ontario Hashim Anwar, Tel: (519) 496-5346	✓	✓	✓		✓	✓			✓		✓	✓		✓				
	CBM Aggregates Sunderland, Ontario Mr. John Mceachern, Tel: (705) 357-3147	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	CBM Aggregates Westwood, Ontario Mr. Robert Loeters, Tel: (226) 237-6644	✓	✓			✓	✓								✓				
	Central Earth Engineering Barrie, Ontario Alexandar Winkelman Tel: 705-229-4298	✓	✓			✓	✓								✓	✓	✓	✓	
	Chung & Vander Dollen Engineering Limited 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	✓	✓	✓	✓	✓	✓					✓	✓		✓				
	COCO Paving Inc. Ottawa, Ontario Mr. Brad G. Gooderham, Tel: (613) 907-7283	✓	✓	✓		✓	✓					✓	✓		✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	COCO Paving Inc. Tecumseh, Ontario Mr. Harbal Dhaliwal, Tel: (519) 727-3838	✓	✓	✓		✓	✓			✓		✓	✓		✓	✓			
	COCO Paving Inc. Toronto, Ontario Mr. Oussama Ibrahim, Tel: (416) 633-9670	✓	✓	✓		✓	✓					✓	✓		✓	✓			
	Construction Testing Asphalt Cambridge, Ontario Mr. Peter Lung, Tel: (519) 622-7023	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Cornwall Gravel Company Cornwall, Ontario Ms. Billie-Gail Macfarlane, Tel: (613) 930-3530	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓		✓	
	Cox Construction Limited Guelph, Ontario Ms. Alana Smith, Tel: (519) 824-6570	✓	✓			✓	✓	✓							✓				
	CRH Canada Group Inc. PN2 Etobicoke, Ontario Syed Irfan Ali, Tel: (647) 401-5504							✓											
	CRH Canada Group Inc. Etobicoke, Ontario Manisha Nijhawan, Tel: (647) 401-5504							✓											

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	CRH Canada Group Inc. Etobicoke, Ontario Mylene Ite-hughes, Tel: (416) 903-5783	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	D. Crupi & Sons Limited Toronto, Ontario Mr. Pracash Kandasami, 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	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Doughty Aggregates (Peterborough) Limited Lakefield, Ontario Mr. Wayne Rayfuse, Tel: (705) 652-3016	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Drain Bros. Excavating Norwood, Ontario Mr. Elton Neuman, Tel: (705) 639-2301	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	DS Consultants Limited Vaughan, Ontario Mr. Jordan Gadjanov, Tel: (905) 265-9393	✓	✓		✓	✓	✓	✓		✓		✓	✓		✓	✓	✓	✓	✓
	DST Consulting Engineers Inc. Mobile Lab Thunder Bay, Ontario Thomas Milks, Tel: 807 623-2929	✓	✓	✓		✓	✓			✓		✓	✓		✓	✓	✓	✓	✓
	DST Consulting Engineers Inc. Ottawa, Ontario Alexandre Aramouni, Tel: (613) 697-7450	✓	✓			✓	✓								✓				
	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	✓	✓	✓		✓	✓			✓		✓	✓		✓	✓	✓	✓	✓
	Dufferin Aggregates - Flamborough Dundas, Ontario Mr. Gord Taylor, Tel: (905) 308-5324	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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 – Mosoport, Orono, Ontario Ms. Kelly Mercer, Tel: (416) 453-3268	✓	✓			✓	✓								✓				
	Dufferin Aggregates - Paris Paris, Ontario Mr. Gord Taylor, Tel: (905) 308-5324	✓	✓			✓	✓								✓				
	Dufferin Coboconk Coboconk, Ontario Robin Thompson, Tel: (647) 449-5707	✓	✓			✓	✓								✓			✓	
	Dufferin Construction (QC) – Bronte Oakville, Ontario Mr. Ronald Abdul, Tel: (905) 827-5757	✓	✓	✓		✓	✓			✓		✓	✓		✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Dufferin Construction (QC) - Mobile 1 Oakville, Ontario Mr. Ronald Abdul, Tel: (905) 842-2741	✓	✓			✓	✓								✓				
	Dufferin Construction (QC) - Mobile 3 Oakville, Ontario Mr. Ronald Abdul, Tel: (905) 842-2741	✓	✓			✓	✓								✓				
	Dufferin Construction Company - Mobile 4 Oakville, Ontario Ronald Abdul, Tel: (416) 891-0598	✓	✓			✓	✓								✓				
	Dufferin Construction Company - North Mobile 1 King City, Ontario Mr. Chad Henderson, Tel: (905) 833-4666	✓	✓			✓	✓								✓				
	Dufferin Construction Limited (QC) – London, Oakville, Ontario Mr. Ronald Abdul, Tel: (905) 827-5757	✓	✓			✓	✓								✓				
	Duncor Enterprises Inc. Barrie, Ontario Mr. Peter Smith, Tel: (705) 730-1999	✓	✓			✓	✓					✓	✓		✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	E.C. King Contracting Owen Sound, Ontario Mr. Lance Elliott, Tel: (519) 376-6140	✓	✓			✓	✓								✓				
	EnGlobe Corp - Kitchener Kitchener, Ontario Oltion Rexha, Tel: (519) 741-1313	✓	✓	✓		✓	✓					✓	✓		✓	✓	✓	✓	✓
	Englobe Corp. - PN2 Toronto, Ontario Mr. Lok Berma, Tel: (416) 213-1060							✓	✓										
	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	✓	✓	✓	✓	✓	✓			✓					✓	✓	✓	✓	✓
	Engtec Consulting Inc. Vaughan, Ontario Mr. Salman Bhutta, Tel: (905) 856-2988	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	exp Services Inc. Barrie, Ontario Mr. Leigh Knecht, Tel: (705) 716-1100	✓	✓			✓	✓								✓	✓	✓	✓	✓
	exp Services Inc. Brampton, ON, Bernd Hesse, Tel: (905) 793-9800							✓	✓										
	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	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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	✓	✓			✓	✓								✓	✓			
	exp Services Kingston Ontario Michael Roy, Tel: (613) 542-1253	✓	✓			✓	✓								✓	✓			
	Fermar Construction Limited Etobicoke, Ontario Mr. Ramon Meza, Tel: (416) 657-3554	✓	✓	✓		✓	✓								✓	✓			
	Four Corners Engineering Markham, Ontario Ming Zhu, Tel: (905) 475-1004	✓	✓	✓		✓	✓					✓	✓		✓	✓	✓	✓	✓
	Fowler Construction Company Bracebridge, Ontario Mr. Ross Elliott, Tel: (705) 644-4037	✓	✓	✓		✓	✓					✓	✓		✓	✓			

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	G. Tackaberry & Sons Construction Co. Limited Athens, Ontario Mr. Paul Rodgers, Tel: (613) 924-2634	✓	✓			✓	✓								✓	✓			
	Gazzola Paving Etobicoke, Ontario Mr. Solomon Anduaem, Tel: (416) 675-7007	✓	✓			✓	✓								✓				
	GEMTEC Consulting Engineers and Scientists Petawawa, Ontario Allan Brotton, Tel: (613) 585-3626	✓	✓			✓	✓								✓				
	GEMTEC Consulting Engineers and 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	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	GHD Waterloo, Ontario Mr. Abdul H. Khan, Tel: (519) 884-0510	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓
	GHD Ottawa, Ontario Mr. Eric Bennett, Tel: (613) 727-0510	✓	✓			✓	✓								✓				
	GHD St. Catharines, Ontario Mr. Wayne Russell, Tel: (905) 682-0510	✓	✓			✓	✓								✓	✓	✓	✓	✓
	GHD Peterborough, Ontario Mr. Matt Rawlings, Tel: (705) 749-3317	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	GHD Whitby, Ontario Mr. Matt Rawlings, Tel: (705) 761-9047	✓	✓	✓		✓	✓					✓	✓		✓	✓	✓	✓	✓
	GHD Mississauga, Ontario Mr. Raj Kadia, Tel: (905) 712-0510	✓	✓			✓	✓								✓	✓	✓	✓	✓
	GM BluePlan Engineering Limited Owen Sound, Ontario Mr. Derek Brewster, Tel: (519) 376-1805	✓	✓			✓	✓								✓	✓			

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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 Laura Zarlenga, Tel: (519) 250-3733	✓	✓			✓	✓								✓	✓	✓	✓	✓
	Golder Associates Limited. London, Ontario Laura Pryla, Tel: (519) 652-0099	✓	✓		✓	✓	✓			✓		✓	✓		✓	✓	✓	✓	✓
	Graham Bros. Construction Brampton, Ontario Mr. Greg Thompson, Tel: (905) 866-3093	✓	✓	✓		✓	✓					✓	✓		✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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 Limited Kemble, Ontario Mr. Roland Leigh, Tel: (519) 376-3506	✓	✓	✓		✓	✓			✓		✓	✓		✓	✓		✓	
	HATCH Limited 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 Limited Garson, Ontario Ms. Ashley Edwards, Tel: (705) 694-6210	✓	✓	✓		✓	✓	✓				✓	✓		✓	✓		✓	

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete																			
	LS-616 Petrographic Analysis – Fine																			
	LS-614 Freeze-Thaw																			
	LS-613 Insoluble Residue																			
	LS-618 Micro-Deval CA																			
	LS-619 Micro-Deval FA																			
	LS-620 Accelerated Mortar Bar																			
	LS-621 Asphalt Coated Particles																			
	LS-706 Moisture -Density Relationship																			
	LS-702 Particle Size Analysis																			
	LS-703/4 Atterberg Limits																			
	LS-705 Specific Gravity of Soils																			
Interpaving Asphalt and Aggregate Supply Limited Garson, Ontario Ashley Edwards, Tel: (705) 694-6210		✓	✓																	
Intratech Engineering Laboratories Inc. Scarborough, Ontario Mr. Frank Miles, Tel: (416) 754-2077		✓	✓		✓															
J & P Leveque Bros. Limited - Mobile 617, Bancroft, Ontario Mr. Shawn Fransky, Tel: (613) 332-5533		✓	✓											✓						
J & P Leveque Bros. Limited - Mobile 616 Bancroft, Ontario Mr. Shawn Fransky, Tel: (613) 332-5533		✓	✓											✓						
John D. Paterson & Associates Limited Nepean, Ontario Mr. Stephen Walker, Tel: (613) 226-7381		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	John D. Paterson & Associates North Bay, Ontario Mr. Shawn Nelson, Tel: (705) 472-5331	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	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. – Brechin Brechin, Ontario Ms. Christine Crumbie, Tel: (705) 484-5225	✓	✓			✓	✓								✓				
	Lafarge Canada Inc. - Dundas Quarry Dundas, Ontario Mr. Chris Thomas, Tel: (905) 977-7363	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓		✓	

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Lafarge Canada Inc. – London. London, Ontario Ms. Kaitlyn Souter, Tel: (519) 537-0999	✓	✓			✓	✓								✓				
	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. Laval, QC, Arsenio Gonzalez, Tel: (438) 265-1084													✓					

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓			✓	
	Lafarge Canada Inc. Stouffville, Ontario Ms. Christine Crumbie, Tel: (905) 640-5883	✓	✓			✓	✓								✓				
	Lafarge Canda Inc. - West Paris Paris, Ontario Mr. Kaitlyn Souter, Tel: (905) 537-0999	✓	✓			✓	✓								✓				
	Lafarge Construction Materials Limited Brockville, Ontario Mr. Paul Arkeveld, Tel: (613) 349-7422	✓	✓			✓	✓			✓		✓	✓		✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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. Clinton, Ontario Mr. George Brown, Tel: (519) 482-3694	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓			
	Lavis Contracting-PN Clinton, Ontario Sarah Thompson, Tel: (519) 482-3694							✓	✓										
	LRL Associates Limited 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	✓	✓	✓		✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	McIntosh Perry - CCI Group Inc., Woodbridge, Ontario Ms. Liliana Fevga, Tel: (647) 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 Paving Limited Chatham, Ontario Jason Cosby, Tel: (905) 658-6135	✓	✓			✓	✓								✓				
	Miller Paving Limited Markham, Ontario Ms. Carla Hariprashad, Tel: (905) 475-6660	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓			
	Miller Paving Limited Wainfleet, Ontario Mr. Jason Cosby, Tel: (905) 658-6135	✓	✓			✓	✓								✓				
	Miller Paving Limited Whitby, Ontario Mr. John Straub, Tel: (905) 655-3889	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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, EMO Toronto, Ontario Mr. Luke Atkinson, Tel: (416) 235-4901	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
	Nasiruddin Engineering Mississauga, Ontario Mr. Shakeel Nasiruddin, Tel: (416) 882-5136	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓
	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	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Nelson Aggregate Co. Orillia, Ontario Mr. Mike Roote, Tel: (705) 352-2264	✓	✓			✓	✓								✓				
	OGS ASSOCIATES INC. Scarborough, ON, Amjed Siddiqui, Tel: (416) 299-3655	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓
	Orbit Engineering Limited Brampton, Ontario Dr. Aly Ahmed, Tel: (905) 494-0074	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓
	Peto MacCallum Limited Barrie, Ontario Mr. Doug Chisholm, 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	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Pinchin Limited - Waterloo Waterloo, Ontario Vanessa Marshall, Tel: (519) 746-4210	✓	✓			✓	✓								✓	✓	✓	✓	✓
	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	✓	✓	✓		✓	✓								✓	✓			
	PNJ Engineering Inc. Vaughan Ontario Nick Sibilia, Tel: (905) 597-8383	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Port Colborne Quarries Inc. Port Colborne, Ontario Mr. Tim Cassibo, Tel: (905) 834-3647	✓	✓			✓	✓								✓				
	Preston Sand & Gravel Cambridge, Ontario Mr. Matthew Bell, Tel: (519) 242-0902	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓
	Shaba Testing Services Kirkland Lake, Ontario Mr. Lad Shaba, Tel: (705) 567-4187	✓	✓			✓	✓								✓	✓			
	Sirati & Partners Consultants Limited Vaughan, Ontario Andrew Mendonca, Tel: (905) 669-4477	✓	✓			✓	✓								✓	✓	✓	✓	✓
	Smelter Bay Aggregates Inc. Thessalon, Ontario Mr. Jacob King, Tel: (705) 842-2597	✓	✓			✓	✓								✓				
	SNC Lavalin GEM Kingston, Ontario Mr. Jon Ubdegrove, Tel: (613) 389-1781	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
								✓	✓										
		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓		✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓
		✓	✓			✓	✓								✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete																		
	LS-616 Petrographic Analysis – Fine																		
	LS-614 Freeze-Thaw						✓												
	LS-613 Insoluble Residue																		
	LS-618 Micro-Deval CA						✓												
	LS-619 Micro-Deval FA						✓												
	LS-620 Accelerated Mortar Bar						✓												
	LS-621 Asphalt Coated Particles		✓				✓												
	LS-706 Moisture -Density Relationship		✓				✓												
	LS-702 Particle Size Analysis		✓				✓												
	LS-703/4 Atterberg Limits		✓				✓												
	LS-705 Specific Gravity of Soils		✓				✓												
Sola Engineering Vaughan, Ontario Kanthavanam I. Pooranan, Tel: (905) 760-9501		✓	✓					✓											
St. Lawrence Testing & Inspection Co. Ltd Cornwall, Ontario Mr. Gib McIntee, Tel: (613) 938-2521		✓	✓		✓			✓				✓					✓		
St. Marys Leaside Lab Toronto, Ontario Mr. Stephen Parkes, Tel: (416) 423-2439		✓	✓		✓	✓		✓				✓		✓		✓			
Stantec Consulting Limited Markham, Ontario Ms. Eric Fron, Tel: (905) 479-9345		✓	✓					✓								✓	✓		
Stantec Consulting Limited Ottawa, Ontario Mr. Jeff Weng, Tel: (613) 722-4420		✓	✓	✓	✓	✓		✓				✓		✓		✓	✓		
Stantec Consulting Limited Thunder Bay, Ontario Mr. Cliff Long, Tel: (807) 626-5640		✓	✓					✓								✓	✓	✓	
Steed and Evans Limited St. Jacobs, Ontario Mr. Richard Marco, Tel: (519) 699-4646		✓	✓		✓			✓								✓	✓		

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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 Limited Thunder Bay, Ontario Mr. Tim Fummerton, Tel: (807) 624-5162	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
	Teranorth Construction & Engineering Limited Sudbury, Ontario Mr. Edward Carriere, Tel: (705) 523-1540	✓	✓			✓	✓								✓				
	Terrapex Environmental Toronto, Ontario Mr. Demetra Matthews and Mr. Sam Chow, Tel: (905) 474-5265	✓	✓			✓	✓								✓	✓	✓	✓	✓
	Terraprobe Inc. Barrie, Ontario Mr. Jerry Duguid, Tel: (705) 739-8355	✓	✓		✓	✓	✓								✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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	✓	✓			✓	✓								✓	✓	✓	✓	✓
	The Miller Group - Materials Research Lab Stouffville, Ontario Carla Hariprashad, Tel: (905) 726-9518	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓		✓	
	The Murray Group Limited Harriston, Ontario Mr. Jerry Dunham, Tel: (519) 501-0776	✓	✓			✓	✓								✓				
	Thomas Cavanagh Construction Limited Ashton, Ontario Mr. Phil White, Tel: (613) 257-2918	✓	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓		✓	

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Thurber Engineering Limited Oakville, Ontario Mr. Weiss Mehdawi, Tel: (905) 829-8666	✓	✓			✓	✓								✓	✓	✓	✓	✓
	Thurber Engineering Limited Ottawa, Ontario Mr. Fred J. Griffiths , Tel: (613) 247-2121	✓	✓			✓	✓								✓	✓	✓	✓	✓
	Tom Veert Contracting Limited - Mobile TVCL-ML- 001 Fort Frances, Ontario Mr. Tyler Gaspar, Tel: (807) 274-6898	✓	✓			✓	✓								✓				
	Tulloch Engineering Inc. Sault Ste. Marie, Ontario Mr. Adam Byers, Tel: (705) 949-1457	✓	✓	✓		✓	✓					✓	✓		✓	✓	✓	✓	✓
	Vicdom Sand and Gravel Uxbridge, Ontario Mr. Bruno Giordano, Tel: (905) 649-2193	✓	✓			✓	✓								✓				
	Walker Aggregates Inc. Duntroon Lab Duntroon, Ontario Mr. Tom Risi, Tel: (705) 445-2300	✓	✓			✓	✓								✓				

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Walker Aggregates Inc. McGregor Lab Amherstburg, Ontario Mr. Tom Risi, Tel: (519) 726-6882	✓	✓			✓	✓								✓				
	Walker Aggregates Inc. WBQ Lab Niagara Falls, Ontario Mr. Tom Risi, Tel: (905) 227-4142	✓	✓	✓	✓	✓	✓					✓	✓		✓				
	Waynco Limited Cambridge, Ontario Ms. Valerie Snowdon, Tel: (905) 335-5250	✓	✓			✓	✓								✓				
	West Carleton Sand and Gravel Inc. Carp, Ontario Mr. Cameron A. MacDonald, Tel: (613) 880-1164	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓	✓				
	Wood Burlington- PN 9 Burlington , ON, Fatima Kharodia, Tel:							✓	✓										
	Wood Burlington- PN10 Burlington, ON, Graeme Lowry, Tel:							✓	✓										
	Wood Burlington-PN 8 Burlington, ON, Elizabeth Hooper, Tel:							✓	✓										

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	Wood Environment & Infrastructure Solutions - PN4 Burlington, Ontario Mr. Jesse Stickless, Tel: (905) 335-2353							✓	✓										
	Wood Environment & Infrastructure Solutions Burlington, Ontario Mr. Martin Little, Tel: (905) 335-2353							✓	✓										
	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 Lively, Ontario David M Brown, Tel: (705) 682-2632	✓	✓			✓	✓								✓	✓			

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-706 Moisture -Density Relationship	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
	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	✓	✓		✓		✓	✓								✓	✓	✓	✓
	WSP - Ottawa Nepean, Ontario Mr. Nick Krebs, Tel: (613) 228-0065	✓	✓	✓			✓	✓								✓	✓	✓	✓
	WSP Toronto, Ontario Mr. Harun Rashid, Tel: (416) 679-9410	✓	✓				✓	✓								✓	✓	✓	✓
	WSP Canada Inc. Markham, Ontario Marjan Darnahal, Tel: (905) 475-0065	✓	✓		✓	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓

2020 Participants List Ministry of Transportation Aggregate and Soil 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 - Concrete	
	LS-616 Petrographic Analysis – Fine	
	LS-614 Freeze-Thaw	
	LS-613 Insoluble Residue	
	LS-618 Micro-Deval CA	◀
	LS-619 Micro-Deval FA	◀
	LS-620 Accelerated Mortar Bar	
	LS-621 Asphalt Coated Particles	◀
WSP Canada Inc. Peterborough, Ontario Ms. Kasey Conlon, Tel: (705) 743-6850	LS-706 Moisture -Density Relationship	◀
	LS-702 Particle Size Analysis	◀
	LS-703/4 Atterberg Limits	◀
	LS-705 Specific Gravity of Soils	◀

Appendix D. List of Participants – Superpave

Table 3. List of Participants - Superpave

2020 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 Co., Limited Mobile No. 5, 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., 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	✓	✓	✓	✓
Construction Testing Asphalt Lab Limited Cambridge, Ontario Mr. Peter Lung, Tel: (519) 622-7023	✓	✓	✓	✓
Cornwall Gravel Company Limited Cornwall, Ontario Ms. Billie-Gail Macfarlane, Tel: (613) 930-3530	✓	✓	✓	✓

2020 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
D. Crupi & Sons Limited Toronto, Ontario Mr. Pracash Kandasaami, Tel: (416) 677-3037	✓	✓	✓	✓
Davroc Testing Laboratories Inc. Brampton, Ontario Mr. Sal Fasullo, Tel: (905) 792-7792	✓	✓	✓	✓
DS Consultants Limited Vaughan, Ontario Mr. Jordan Gadjanov, Tel: (905) 265-9393	✓	✓	✓	✓
Dufferin Construction (QC) - Bronte Oakville, Ontario Mr. Ronald Abdul, Tel: (905) 827-5757	✓	✓	✓	✓
Duncor Enterprises Inc. Barrie, Ontario Mr. Peter Smith, Tel: (705) 730-1999		✓		
EnGlobe Corp. 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. London, Ontario Mr. David Speller, Tel: (519) 963-3000	✓	✓	✓	✓
exp Services Inc. Ottawa, Ontario Mr. Ismail M. Taki, Tel: (613) 723-2886	✓	✓	✓	✓

2020 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
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	✓	✓	✓	✓
GEMTEC Consulting Engineers and Scientists Limited Ottawa, Ontario Mrs. Krystle Smith, Tel: (613) 836-1422	✓	✓	✓	✓
GeoPro Consulting Limited Richmond Hill, Ontario James Chen, Tel: (905) 237-8336	✓	✓	✓	✓
GHD Peterborough, Ontario Mr. Matt Rawlings, Tel: (705) 749-3317	✓	✓	✓	✓
GHD Whitby, Ontario Mr. Matt Rawlings, Tel: (705) 761-9047	✓	✓	✓	✓
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	✓	✓	✓	✓

2020 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
Graham Bros. Construction Limited Brampton, Ontario Mr. Greg Thompson, Tel: (905) 866-3093	✓	✓	✓	✓
Greenwood Aggregates Amaranth, Ontario Mr. Andrew Raymond, Tel: (519) 941-0732	✓	✓	✓	✓
Harold Sutherland Construction Limited Kemble, Ontario Mr. Roland Leigh, Tel: (519) 376-3506	✓	✓	✓	✓
Interpaving Asphalt & Aggregate Supply Garson, Ontario Ms. Ashley Edwards, Tel: (705) 694-6210	✓	✓	✓	✓
John D. Paterson & Associates Limited 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	✓		✓	✓
Lafarge Canada Inc. Ottawa, Ontario Mr. Gustavo Imoberdorf, Tel: (613) 834-4223	✓	✓	✓	✓
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	✓	✓	✓	✓

2020 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
McAsphalt Engineering Services Toronto, Ontario Mr. Michael Esenwa, Tel: (416) 281-8181	✓	✓	✓	✓
Mill-Am Corporation - Mobile 890901 Windsor, Ontario Mr. Abdul R. Saifan, Tel: (519) 791-2753				✓
Miller Paving Limited Markham, Ontario Ms. Carla Hariprashad, Tel: (905) 475-6660	✓	✓	✓	✓
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, EMO, Toronto, Ontario Mr. Luke Atkinson, Tel: (416) 235-4901	✓	✓	✓	✓
OGS ASSOCIATES INC. Scarborough, Ontario Amjed Siddiqui, Tel: (416) 299-3655	✓	✓	✓	✓
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	✓	✓	✓	✓

2020 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. 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	✓	✓	✓	✓
PNJ Engineering Inc. Vaughan ON, Nick Sibilia, Tel: (905) 597-8383	✓	✓	✓	✓
R. W. Tomlinson Limited Ottawa, Ontario Mr. Paul Charbonneau, Tel: (613) 822-0543	✓	✓	✓	✓
SNC Lavalin GEM Kingston, Ontario Mr. Jon Ubdegrove, Tel: (613) 389-1781	✓	✓	✓	✓
SNC-Lavalin Gem Ontario Inc. Vaughan, Ontario Mr. Zlatko Brcic, Tel: (905) 851-0090	✓	✓	✓	✓
St. Lawrence Testing & Inspection Co. Cornwall, Ontario Mr. Gib McIntee, Tel: (613) 938-2521	✓	✓	✓	✓
Stantec Consulting Limited Ottawa, Ontario Mr. Jeff Weng, Tel: (613) 722-4420	✓	✓	✓	✓
Steed and Evans Limited St. Jacobs, Ontario Mr. Richard Marco, Tel: (519) 699-4646	✓		✓	✓

2020 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
TBT Engineering Limited Mobile Lab 4 Thunder Bay, Ontario Tim Fummerton, Tel: (807) 624-5162				✓
TBT Engineering Limited Thunder Bay, Ontario Mr. Tim Fummerton, Tel: (807) 624-5162	✓	✓	✓	✓
Terraprobe Inc., Brampton, Ontario Mr. Vishnu Goswami, Tel: (905) 796-2650	✓	✓	✓	✓
The Miller Group - Materials Research Lab Stouffville, Ontario Carla Hariprashad, Tel: (905) 726-9518	✓	✓	✓	✓
Thomas Cavanagh Construction Limited Ashton, Ontario Mr. Phil White, Tel: (613) 257-2918	✓	✓	✓	✓
West Carleton Sand and Gravel Inc. Carp, Ontario Mr. Cameron A. MacDonald, Tel: (613) 880-1164	✓	✓	✓	✓
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	✓	✓	✓	✓
WSP Canada Inc. Markham, Ontario Marjan Darnahal, Tel: (905) 475-0065	✓	✓	✓	✓

Appendix E. Multi-Laboratory Precision

Table 4. Multi-Laboratory Precision for Proficiency Tests

Test 1:	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
WP	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	MTO LS-601
Mean	0.72	0.73	0.88	0.88	0.46	0.46	0.92	0.94	< 2.5
1S	0.13	0.12	0.15	0.14	0.09	0.09	0.15	0.17	0.20
D2S	0.38	0.33	0.42	0.40	0.25	0.25	0.43	0.48	0.58
Test 2:	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM C136 ^A
Mean	98.6	98.3	91.3	91.1	95.3	95.3	86.46	86.54	95 - 85
1S	0.38	0.45	1.8	1.7	0.85	0.93	1.53	1.58	1.37
D2S	1.08	1.27	5.09	4.81	2.40	2.63	4.32	4.46	3.9
Test 3	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 16.0	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM C136 ^A
Mean	90.9	90.0	82.8	84.5	88.4	88.4	77.5	77.8	80 – 60
1S	0.9	1.2	1.3	1.6	1.5	1.6	1.9	2.0	2.82
D2S	2.6	3.4	3.7	4.4	4.24	4.53	5.38	5.59	8.0
Test 4	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 13.2	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM C136 ^A
Mean	78.9	78.9	68.7	68.0	81.5	81.5	69.9	70.2	80 – 60
1S	1.78	1.78	3.8	3.8	2.0	2.1	2.2	2.2	2.82
D2S	5.03	5.03	10.75	10.75	5.66	5.94	6.19	6.32	8.0
Test 5	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 9.5	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM C136 ^A
Mean	62.8	60.2	53.0	52.2	70.1	70.2	58.8	59.1	60 – 20
1S	2.22	1.94	3.8	3.9	2.2	2.3	2.174	2.155	1.97
D2S	6.27	5.48	10.75	11.03	6.22	6.51	6.15	6.10	5.6
Test 6	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 4.75	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM C136 ^A

Mean	45.1	43.1	38.2	37.8	53.0	53.2	44.092	44.437	60 – 20	
1S	1.94	1.62	3.1	3.4	1.9	2.2	2.0	1.9	1.97	
D2S	5.49	4.58	8.77	9.62	5.37	6.22	5.75	5.46	5.6	
Test 8 L. A	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	ASTM
	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V	σ^*
Mean	22.3	22.3	26.7	26.7	24.8	25.1	23.0	22.9	10-45	25.0
1S	0.73	0.78	1.1	0.6	1.9	1.5	1.0	0.9	4.5%	1.1
D2S	2.06	2.21	3.11	1.70	5.37	4.24	2.92	2.45	12.7%	3.1
Test 9 RD	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	MTO LS-604	
Mean	2.648	2.650	2.708	2.707	2.665	2.664	2.665	2.664	N/A	
1S	0.006	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.006	
D2S	0.020	0.010	0.020	0.020	0.020	0.020	0.017	0.017	0.016	
Test 10 ABS	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	MTO LS-604	
Mean	1.067	1.052	1.213	1.216	1.446	1.434	0.703	0.707	< 2%	
1S	0.070	0.077	0.094	0.092	0.091	0.086	0.074	0.076	0.09	
D2S	0.197	0.22	0.266	0.260	0.257	0.243	0.209	0.215	0.25	
Test 11 MgSO ₄	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	ASTM C88
	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V	σ^*
Mean	2.300	2.335	4.2	4.1	6.8	6.8	9.2	9.3	9-20%	2.3
1S	0.766	0.823	1.3	1.3	2.2	1.7	2.9	2.9	25%	0.6
D2S	2.166	2.327	3.7	3.7	6.2	4.8	8.1	8.1	71%	1.7
Test 12 %	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	MTO LS-607	
Mean	64.79	65.42	96.9	97.0	77.6	77.6	99.0	99.2	55% - 85%	
1S	5.471	5.572	2.0	2.0	4.5	4.3	1.5	1.2	4.7	
D2S	15.474	15.759	5.7	5.7	12.7	12.2	4.2	3.5	13.2	
Test 13 % F & E	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	MTO LS-608	
Mean	4.188	4.067	4.2	4.1	6.9	6.8	1.4	1.4	2.0% - 9.5%	

1S	1.236	1.167	1.3	1.2	1.8	2.0	0.6	0.6	2.3	
D2S	3.49	3.30	3.7	3.4	5.1	5.7	1.8	1.6	6.4	
Test 16	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	MTO LS-
MDA,	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V	σ^*
Mean	11.024	11.059	10.5	10.4	11.1	11.0	8.2	8.1	5-23%	8.8
1S	0.633	0.700	0.66	0.74	0.85	0.80	0.54	0.62	5.4%	0.48
D2S	1.79	1.98	1.87	2.09	2.40	2.26	1.51	1.75	15.2%	1.34
Test 17	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	MTO LS-
Freeze/t	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V	σ^*
Mean	5.147	4.966	2.80	2.76	6.39	6.28	2.90	3.08	3-18%	1.73
1S	1.328	5.400	0.86	0.79	1.8	1.2	0.7	1.0	21.6%	0.37
D2S	3.76	3.45	2.43	2.23	5.09	3.39	1.95	2.72	61.0%	1.06
Test 20	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 2.36	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM C136 ^A	
Mean	35.52	34.14	30.9	30.5	42.6	45.2	36.2	36.4	60 - 20	
1S	1.955	1.489	2.7	2.7	2.2	2.4	2.0	1.9	1.41	
D2S	5.53	4.21	7.6	7.6	6.2	6.8	5.8	5.3	4.0	
Test 21	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 1.18	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM C136 ^A	
Mean	28.51	27.57	24.9	24.6	34.8	34.8	29.3	29.5	60 - 20	
1S	1.874	1.419	2.4	2.2	2.1	2.1	1.9	1.7	1.41	
D2S	5.30	1.01	6.8	6.2	5.9	5.9	5.4	4.9	4.0	
Test 22	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 600	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM C136 ^A	
Mean	21.62	21.12	19.0	18.8	28.5	28.3	20.5	20.7	20 - 15	
1S	1.612	1.220	1.8	1.8	1.7	1.9	1.5	1.4	1.10	
D2S	4.56	3.45	5.1	5.1	4.8	5.4	4.2	3.9	3.1	
Test 23	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 300	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM C136 ^A	
Mean	11.02	10.73	12.9	12.9	21.6	21.6	13.2	13.2	15 - 10	
1S	0.764	0.653	1.2	1.2	1.2	1.4	0.9	0.9	0.73	

D2S	2.16	1.85	3.4	3.4	3.4	4.0	2.7	2.6	2.1
Test 24	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 150	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM C136 ^A
Mean	6.12	5.99	9.0	9.0	14.1	14.1	8.7	8.8	10 - 2
1S	0.447	0.362	0.9	0.8	0.8	0.9	0.7	0.6	0.65
D2S	1.26	1.02	2.5	2.3	2.3	2.5	1.9	1.7	1.8
Test 25	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 75	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM C136 ^A
Mean	4.85	4.73	6.1	6.1	9.2	9.3	5.9	5.9	10 - 2
1S	0.355	0.281	0.5	0.5	0.5	0.6	0.4	0.4	0.65
D2S	1.00	0.79	1.4	1.4	1.4	1.7	1.3	1.2	1.8
Test 27	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
RD	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	MTO LS-605
Mean	2.631	2.631	2.696	2.696	2.687	2.687	2.691	2.692	N/A
1S	0.011	0.010	0.011	0.009	0.009	0.010	0.007	0.008	0.012
D2S	0.03	0.03	0.031	0.025	0.025	0.028	0.020	0.023	0.034
Test 28	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
ABS	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	MTO LS-605
Mean	1.365	1.349	0.969	0.986	1.225	1.213	0.875	0.857	< 2.0%
1S	0.116	0.120	0.123	0.147	0.148	0.148	0.096	0.0831	0.16
D2S	0.33	0.34	0.35	0.42	0.42	0.42	0.27	0.24	0.44
Test 30	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
% ACP	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	MTO LS-621
Mean	59.3	61.8	44.1	43.8	38.4	37.2	45.3	44.8	25% - 55%
1S	4.852	4.404	2.841	2.616	2.123	2.838	2.528	2.699	3.9
D2S	13.72	12.46	8.0	7.4	6.0	8.0	7.2	7.6	11.1
Test 31	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
MWD	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	LS-706
Mean	2.384	2.386	2.451	2.449	2.457	2.458	2.437	2.439	N/A
1S	0.034	0.041	0.035	0.038	0.028	0.030	0.029	0.028	N/A
D2S	0.09	0.12	0.099	0.107	0.079	0.085	0.082	0.079	N/A

Test 32	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
MDD	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	LS-706	
Mean	2.228	2.230	2.333	2.338	2.330	2.335	2.337	2.336	N/A	
1S	0.031	0.036	0.033	0.031	0.032	0.033	0.027	0.027	N/A	
D2S	0.09	0.10	0.093	0.088	0.091	0.093	0.076	0.076	N/A	
Test 33	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
OMC	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	LS-706	
Mean	6.91	6.90	5.88	5.83	6.05	6.02	5.41	5.38	N/A	
1S	0.79	0.77	0.71	0.71	0.64	0.56	0.41	0.45	N/A	
D2S	2.22	2.19	2.01	2.01	1.81	1.58	1.15	1.28	N/A	
Test 34	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	MTO LS-
MDA,	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	C of V	σ^*
Mean	15.0	15.1	13.7	13.8	19.6	20.1	12.2	12.3	7-18%	15.8
1S	1.0	1.0	1.1	1.2	1.7	1.4	1.3	1.1	7.6%	1.2
D2S	2.80	2.9	3.1	3.4	4.8	4.0	3.6	3.0	21.4%	3.4
Test 40	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 2.0	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	MTO LS-702	
Mean	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	No Precision Statements	
1S	0.07	0.06	0.07	0.06	0.05	0.06	0.02	0.04	No Precision Statements	
D2S	0.19	0.16	0.2	0.2	0.14	0.2	0.1	0.1	No Precision Statements	
Test 41	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 425	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	MTO LS-702	
Mean	99.0	99.0	98.6	98.6	97.6	97.3	98.3	98.3	No Precision Statements	
1S	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2	No Precision Statements	
D2S	0.6	0.6	0.6	0.8	0.8	0.6	0.5	0.5	No Precision Statements	
Test 42	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	
P 75	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	MTO LS-702	
Mean	97.5	97.6	95.3	95.3	90.4	89.1	95.3	95.3	No Precision Statements	
1S	0.3	0.2	0.4	0.6	1.0	0.9	0.2	0.2	No Precision Statements	
D2S	0.8	0.5	1.1	1.7	2.8	2.5	0.6	0.6	No Precision Statements	
Test 43	2017	2017	2018	2018	2019	2019	2020	2020	Standard:	

P 20	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	MTO LS-702
Mean	82.3	82.7	86.9	86.3	81.7	79.9	88.5	88.8	No Precision Statements
1S	3.3	3.3	3.4	3.1	3.2	3.2	2.7	2.6	No Precision Statements
D2S	9.4	9.3	9.5	8.6	9.1	9.1	7.7	7.5	No Precision Statements
Test 44	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 5 μ m	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	MTO LS-702
Mean	72.9	73.2	76.8	75.8	56.1	54.1	64.2	64.1	No Precision Statements
1S	3.0	3.1	3.5	3.2	3.3	3.4	3.0	3.1	No Precision Statements
D2S	8.4	8.9	10.0	9.1	9.3	9.6	8.5	8.8	No Precision Statements
Test 45	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P 2 μ m	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	MTO LS-702
Mean	43.7	43.7	68.9	69.5	34.4	35.6	45.5	45.6	No Precision Statements
1S	3.7	3.2	3.5	3.5	3.0	3.1	2.3	2.5	No Precision Statements
D2S	10.5	9.1	9.9	9.9	8.5	8.8	6.5	7.2	No Precision Statements
Test 46	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
L. L	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	ASTM D4318
Mean	39.0	39.0	51.4	51.6	32.2	31.4	35.1	35.0	33.3
1S	1.3	1.4	2.4	2.4	1.6	1.8	1.5	1.4	0.8
D2S	3.6	3.9	6.8	6.8	4.5	5.1	4.2	4.0	2.0
Test 47	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P. L	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	ASTM D4318
Mean	20.5	20.7	22.2	22.3	17.5	17.1	16.8	16.9	19.9
1S	1.3	1.4	1.9	1.9	1.3	1.2	1.0	1.2	1.3
D2S	3.8	4.0	5.4	5.4	3.7	3.4	2.8	3.4	4
Test 48	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
P. I	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	ASTM D4318
Mean	18.453	18.164	29.2	29.5	14.9	14.5	17.9	18.0	13.4
1S	1.811	1.950	2.3	2.1	1.8	1.6	1.2	1.4	1.6
D2S	5.12	5.52	6.5	5.9	5.1	4.5	3.4	3.9	4
Test 49	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
SG of	5.17	6.17	5.18	6.18	5.19	6.19	5.20	6.20	AASHTO T 100

Mean	2.775	2.775	2.767	2.764	2.771	2.766	2.743	2.744	N/A
1S	0.030	0.028	0.018	0.022	0.024	0.028	0.023	0.018	0.04
D2S	0.08	0.07	0.051	0.062	0.068	0.079	0.065	0.051	0.11
Test 95	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
UC Void	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	AASHTO T 304
Mean	42.4	42.5	42.9	43.0	44.4	44.5	41.9	41.9	N/A
1S	0.49	0.48	0.48	0.44	0.59	0.57	0.49	0.53	0.33%
D2S	1.39	1.35	1.36	1.24	1.67	1.61	1.38	1.51	0.93%
Test 96	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
SE	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM D2419
Mean	53.7	53.3	42.1	42.2	39.0	38.5	37.9	38.3	< 80
1S	8.6	8.7	5.5	5.0	4.6	4.2	3.5	3.8	8.0
D2S	24.5	24.6	15.5	14.0	13.0	11.9	9.9	10.8	22.6
Test 97	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
%	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM D5821
Mean	65.719	66.259	71.7	71.7	78.2	77.6	52.1	52.1	76.0%
1S	5.2	5.0	6.0	5.7	3.4	3.6	3.2	3.1	5.2%
D2S	14.8	14.1	17.0	16.1	9.6	10.2	9.1	8.7	14.7%
Test 99	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
% F & E	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	ASTM D4791
Mean	1.36	1.24	1.25	1.32	2.32	2.33	0.28	0.34	19.0 -12.5 mm
1S	0.47	0.46	0.52	0.53	1.02	1.09	0.16	0.24	88.5%
D2S	1.33	1.29	1.47	1.5	2.88	3.08	0.46	0.68	250.3%
Test 15	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
%	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM D3042
Mean	26.9	26.6	29.7	28.9	10.3	10.4	48.8	48.6	48.2%
1S	1.4	1.1	2.3	1.9	0.5	0.7	0.6	0.7	2.7
D2S	4.0	3.1	6.5	5.4	1.4	2.0	1.7	2.1	7.7
Test 98	2017	2017	2018	2018	2019	2019	2020	2020	Standard:
%	3.17	4.17	3.18	4.18	3.19	4.19	3.20	4.20	ASTM D3042
Mean	24.8	24.8	27.8	27.1	4.0	4.3	46.8	46.5	N/A

1S	0.9	1.0	1.7	1.6	2.2	2.4	0.9	0.9	3.1
D2S	2.61	2.79	4.8	4.5	6.2	6.8	2.6	2.4	8.9
Test123	2017	2017	2018	2018	2019	2019	2020	2020	ASTM C1260 **
Mortar	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	0.152	0.160	0.328	0.327	0.081	0.081	0.372	0.367	>0.1%
1S	0.037	0.031	0.056	0.051	0.008	0.009	0.027	0.034	15.2%
D2S	0.105	0.090	0.158	0.144	0.023	0.025	0.076	0.096	43%
Test124	2017	2017	2018	2018	2019	2019	2020	2020	ASTM C1260 **
Mortar	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	NA	NA	NA	NA	0.334	0.336	0.307	0.320	>0.1%
1S	NA	NA	NA	NA	0.049	0.049	0.040	0.028	15.2%
D2S	NA	NA	NA	NA	0.139	0.139	0.113	0.079	43%
Test122	2017	2017	2018	2018	2019	2019	2020	2020	CSA A23.2-14A
Conc.	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	NA	NA	NA	NA	NA	NA	0.169	0.166	>0.014%
1S	NA	NA	NA	NA	NA	NA	0.010	0.007	23%
D2S	NA	NA	NA	NA	NA	NA	0.028	0.200	65%
Test125	2017	2017	2018	2018	2019	2019	2020	2020	CSA A23.2-14A
Conc.	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	0.026	0.027	0.033	0.036	0.184	0.187	0.109	0.101	>0.014%
1S	0.009	0.007	0.005	0.011	0.015	0.007	0.007	0.016	23%
D2S	0.026	0.021	0.014	0.031	0.042	0.020	0.020	0.045	65%
Test 126	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
SiO ₂	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	7.540	7.537	7.586	7.687	No Precision Statements
1S	NA	NA	NA	NA	0.701	0.751	0.909	0.806	No Precision Statements
D2S	NA	NA	NA	NA	1.983	2.125	2.572	2.281	No Precision Statements
Test 127	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
SiO ₂	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	0.097	0.093	0.048	0.044	No Precision Statements
1S	NA	NA	NA	NA	0.012	0.015	0.038	0.034	No Precision Statements
D2S	NA	NA	NA	NA	0.034	0.042	0.107	0.096	No Precision Statements

Test 128	2017	2017	2018	2018	2019	2019	2020	2020	LS-615 Rev. 33
Al ₂ O ₃	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	NA	NA	NA	NA	2.157	2.162	1.104	1.084	2
1S	NA	NA	NA	NA	0.259	0.272	0.843	0.787	13%
D2S	NA	NA	NA	NA	0.733	0.769	2.385	2.227	37%
Test 129	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
Fe ₂ O ₃	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	0.833	0.837	0.520	0.478	No Precision Statements
1S	NA	NA	NA	NA	0.097	0.102	0.285	0.247	No Precision Statements
D2S	NA	NA	NA	NA	0.275	0.289	0.807	0.699	No Precision Statements
Test 130	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
MnO	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	0.042	0.040	0.032	0.033	No Precision Statements
1S	NA	NA	NA	NA	0.029	0.029	0.004	0.005	No Precision Statements
D2S	NA	NA	NA	NA	0.082	0.082	0.011	0.014	No Precision Statements
Test 131	2017	2017	2018	2018	2019	2019	2020	2020	LS-615 Rev. 33
MgO	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	NA	NA	NA	NA	6.323	6.360	3.299	3.082	6
1S	NA	NA	NA	NA	0.336	0.329	2.290	1.990	6.9%
D2S	NA	NA	NA	NA	0.951	0.931	6.481	5.632	20%
Test 132	2017	2017	2018	2018	2019	2019	2020	2020	LS-615 Rev. 33
CaO	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	C of V
Mean	NA	NA	NA	NA	41.867	41.900	46.291	46.627	43
1S	NA	NA	NA	NA	0.734	0.669	3.742	3.290	1.5%
D2S	NA	NA	NA	NA	2.077	1.893	10.589	9.311	4.3%
Test 133	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
Na ₂ O	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	0.110	0.110	0.055	0.061	No Precision Statements
1S	NA	NA	NA	NA	0.036	0.040	0.028	0.031	No Precision Statements
D2S	NA	NA	NA	NA	0.102	0.113	0.079	0.088	No Precision Statements
Test 134	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
K ₂ O	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements

Mean	NA	NA	NA	NA	0.728	0.735	0.324	0.314	No Precision Statements
1S	NA	NA	NA	NA	0.065	0.067	0.315	0.297	No Precision Statements
D2S	NA	NA	NA	NA	0.184	0.190	0.891	0.840	No Precision Statements
Test 135	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
P ₂ O ₅	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	0.038	0.038	0.158	0.154	No Precision Statements
1S	NA	NA	NA	NA	0.031	0.031	0.084	0.082	No Precision Statements
D2S	NA	NA	NA	NA	0.088	0.088	0.238	0.232	No Precision Statements
Test 136	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
% Loss	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	39.85	39.85	40.088	40.089	No Precision Statements
1S	NA	NA	NA	NA	0.493	0.399	0.404	0.420	No Precision Statements
D2S	NA	NA	NA	NA	1.395	1.129	1.143	1.189	No Precision Statements
Test 137	2017	2017	2018	2018	2019	2019	2020	2020	No Precision Statements
% total	1.17	2.17	1.18	2.18	1.19	2.19	1.20	2.20	No Precision Statements
Mean	NA	NA	NA	NA	99.483	99.690	99.780	99.877	No Precision Statements
1S	NA	NA	NA	NA	0.458	0.726	0.206	0.140	No Precision Statements
D2S	NA	NA	NA	NA	1.296	2.055	0.583	0.396	No Precision Statements

A – AMRL reports percent passing inch series equivalent sieves.

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

Appendix F. Number of Laboratories Excluding Outliers over Outliers

Table 5. Number of laboratories excluding outliers(n) over Outliers(Out); (n/Out)

Year	2017	2018	2019	2020
Test 1 WP 75 µm	220/20	219/18	208/19	194/17
Test 2 P 19.0 mm	229/11	230/7	221/8	206/5
Test 3 P 16.0 mm	218/8	211/12	222/7	206/5
Test 4 P 13.2 mm	227/13	235/2	225/4	206/5
Test 5 P 9.5 mm	233/7	234/3	221/8	202/9
Test 6 P 4.75 mm	230/10	235/2	214/15	202/9
Test 8 L.A	10/0	10/2	11/0	13/1
Test 9 RD (O.D.)	98/5	100/4	100/2	95/4
Test 10 ABS	91/12	100/4	98/4	96/3
Test 11 MgSO ₄	37/1	38/0	39/2	39/0
Test 12 % Crush	212/28	201/36	218/9	190/21
Test 13 % F & E	200/38	231/6	218/10	200/10
Test 16 MDA, CA	73/2	74/1	78/3	75/3
Test 17 Freeze/thaw	55/3	58/1	54/4	52/5
Test 20 P 2.36 mm	229/10	232/5	218/9	198/13
Test 21 P 1.18 mm	231/8	232/5	215/13	199/12
Test 22 P 600 µm	231/8	233/4	213/15	199/12
Test 23 P 300 µm	224/15	230/7	209/19	198/13
Test 24 P 150 µm	227/12	227/10	215/13	195/15
Test 25 P 75 µm	222/17	223/14	214/14	196/14
Test 27 RD (O.D.)	95/3	92/7	87/12	89/8
Test 28 ABS	92/6	93/5	94/5	86/11
Test 30 % ACP	214/24	220/16	204/21	193/18
Test 31 MWD	124/17	122/12	125/15	122/7
Test 32 MDD	125/15	120/14	135/5	120/9
Test 33 OMC	138/2	132/2	137/3	118/11
Test 34 MDA, FA3	72/3	75/0	75/5	75/3
Test 40 P 2.0 mm	97/0	95/0	95/0	94/0
Test 41 P 425 µm	87/10	90/5	87/8	87/7
Test 42 P 75 µm	90/7	92/3	88/7	81/13
Test 43 P 20 µm	83/2	85/5	91/4	89/5
Test 44 P 5 µm	83/2	86/4	92/3	91/3
Test 45 P 2 µm	90/7	91/4	92/3	90/4
Test 46 L. L	107/7	102/8	104/5	105/3
Test 47 P. L	111/3	106/4	107/2	103/5
Test 48 P. I	110/4	104/6	105/4	98/10
Test 49 SG of Soils	74/22	81/14	90/5	84/10

Year	2017	2018	2019	2020
Test 95 UC Void	58/7	66/2	65/5	64/4
Test 96 SE Value	62/0	61/2	66/3	63/4
Test 97 % Fractured	70/2	67/2	73/2	60/8
Test 99 % F & E	66/9	68/2	71/2	63/5
Test 15 % Residue	14/3	13/3	12/4	12/4
Test 98 % Retained	16/1	15/1	15/1	14/2
Test 123 Mortar Bar	24/1	22/1	21/0	20/1
Test 124 Mortar Bar	N/A	N/A	17/2	19/2
Test 122 Conc.Prism	N/A	N/A	N/A	8/1
Test 125 Conc.Prism	11/0	10/2	10/2	7/2
Test126 % SiO ₂	N/A	N/A	6/0	9/0
Test 127 %TiO ₂	N/A	N/A	6/0	9/0
Test 128 % Al ₂ O ₂	N/A	N/A	6/0	9/0
Test 129 %Fe ₂ O ₂	N/A	N/A	6/0	9/0
Test 130 % MnO	N/A	N/A	6/0	9/0
Test 131 % MgO	N/A	N/A	6/0	9/0
Test 132 % CaO	N/A	N/A	6/0	9/0
Test 133 % Na ₂ O	N/A	N/A	6/0	9/0
Test 134 % K ₂ O	N/A	N/A	6/0	9/0
Test 135 % P ₂ O ₅	N/A	N/A	6/0	9/0
Test 136 % Loss	N/A	N/A	6/0	9/0
Test 137 % Total	N/A	N/A	6/0	9/0

Appendix G. Scatter Diagrams – Soils and Aggregates

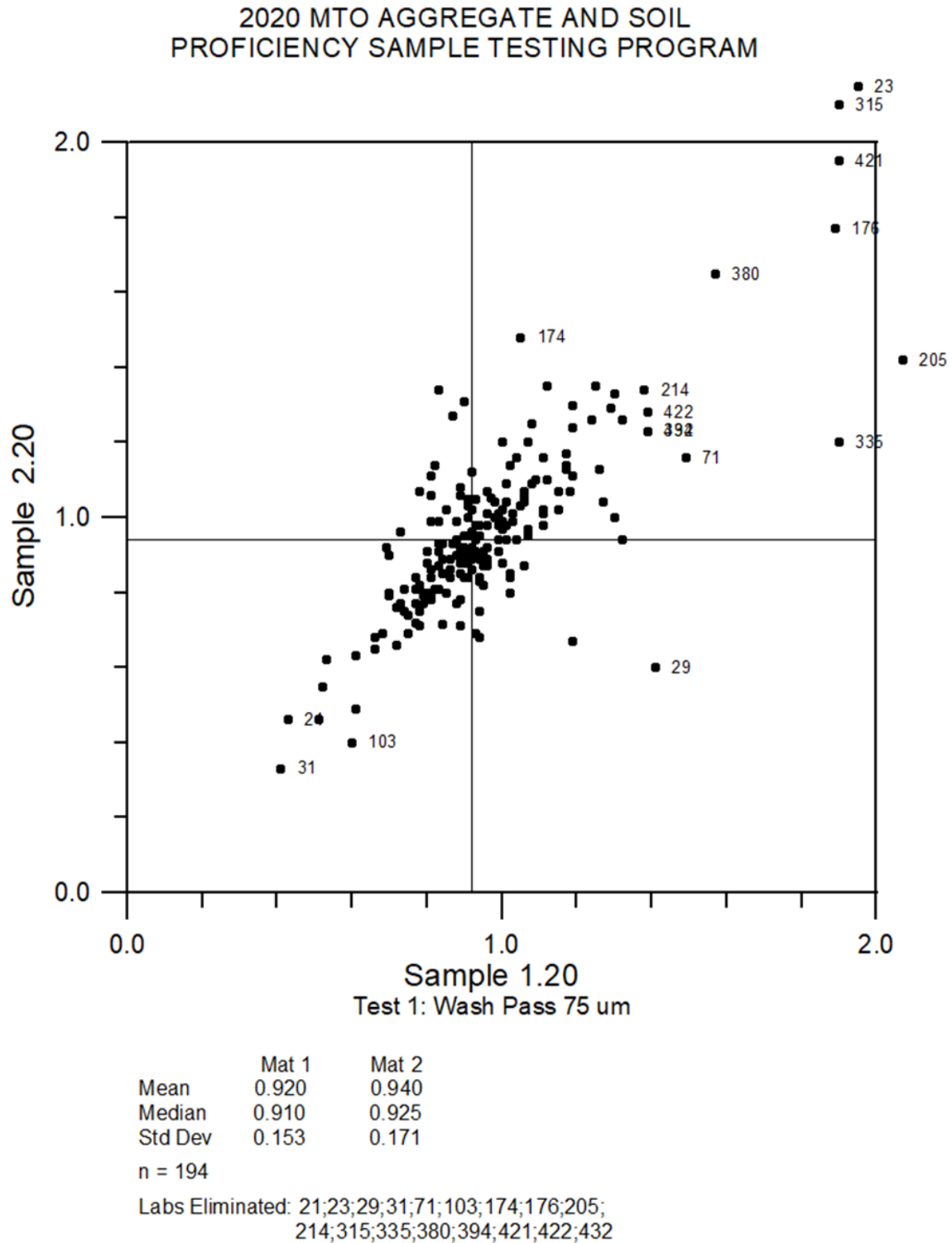
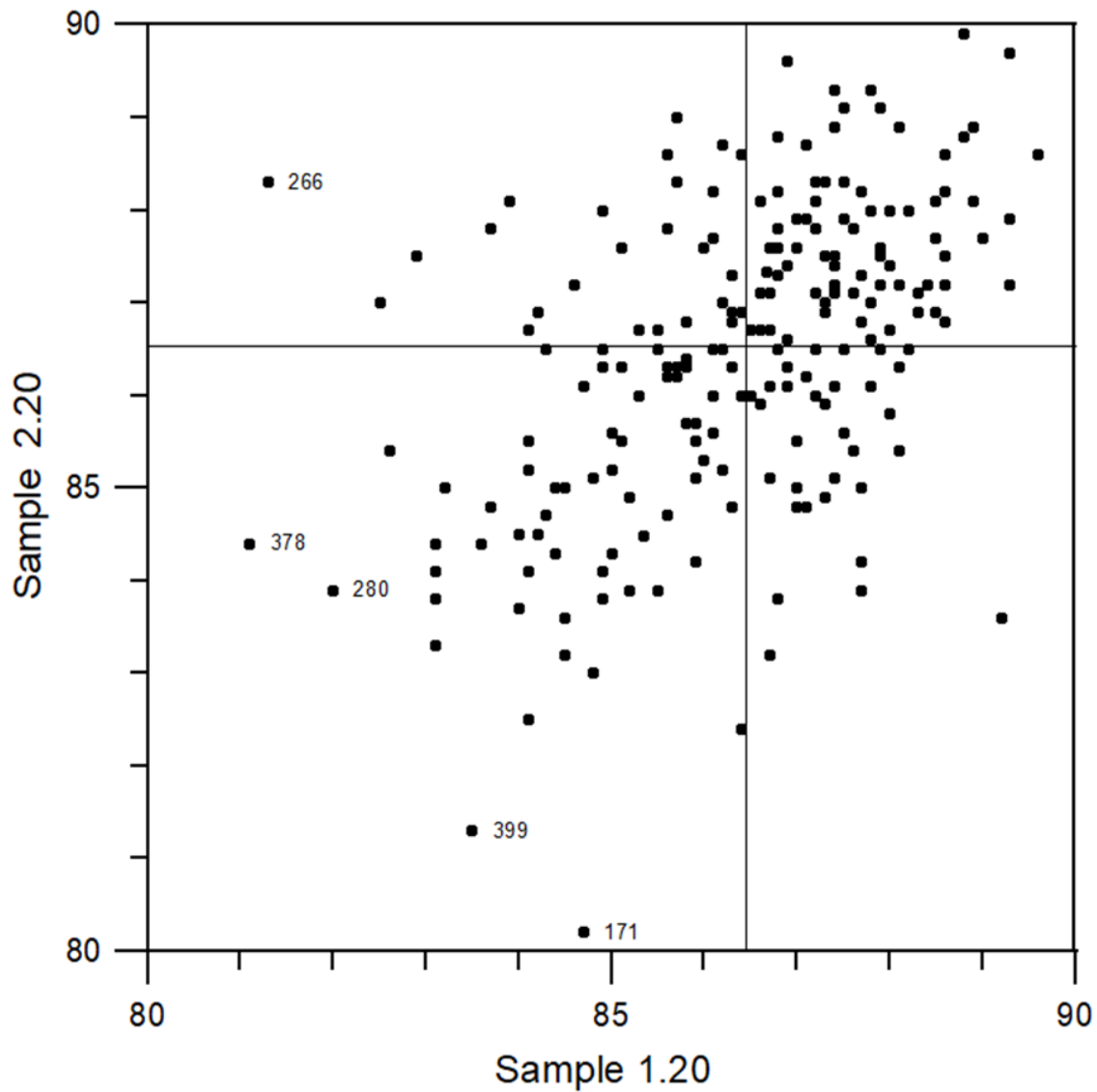


Figure 9. Scatter Diagram: Test 1 WP 75 mm

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 2: Percent Passing the 19.0 mm Sieve

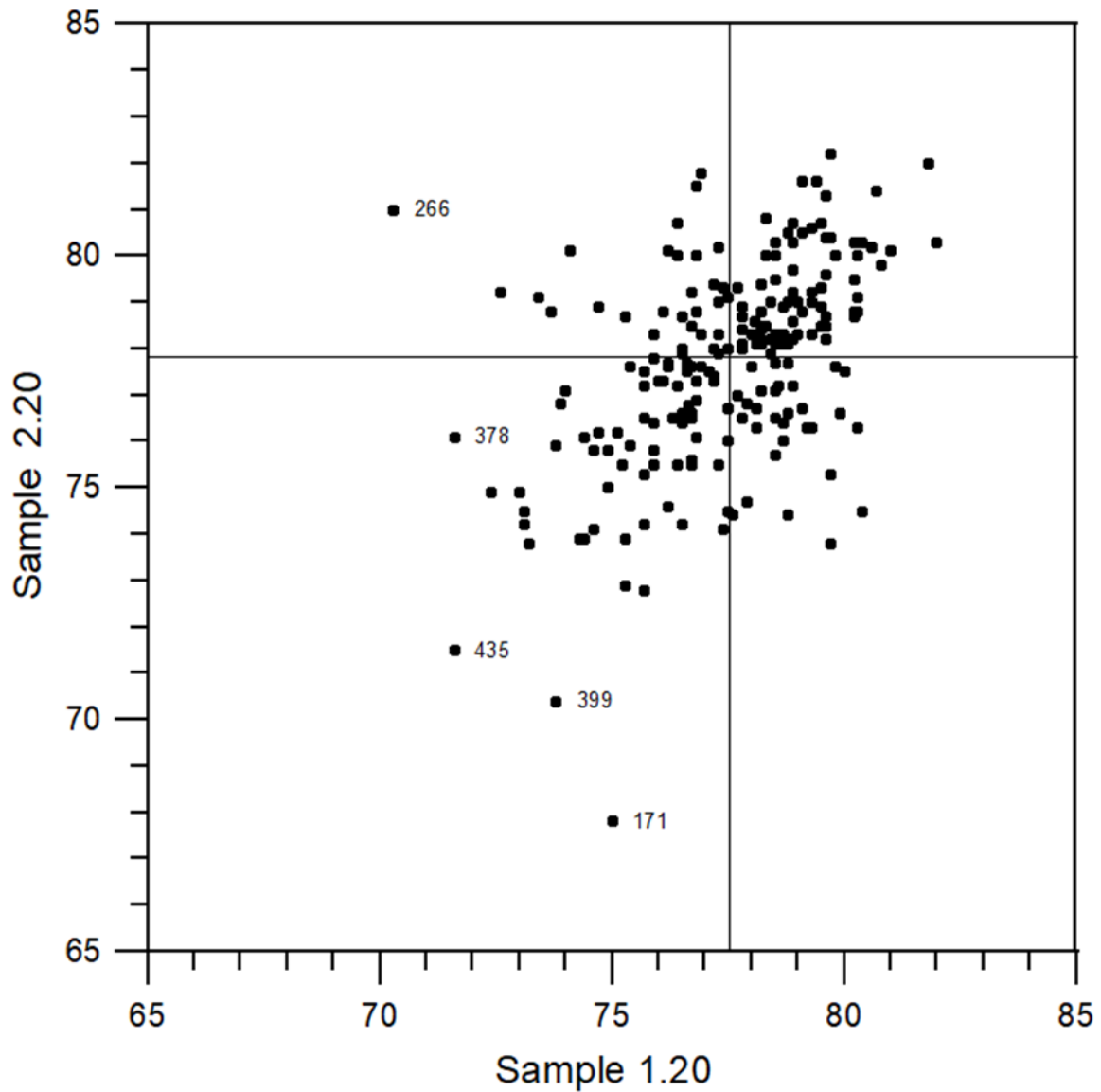
	Mat 1	Mat 2
Mean	86.46	86.54
Median	86.700	86.700
Std Dev	1.526	1.578

n = 206

Labs Eliminated: 171; 266; 280; 378; 399;

Figure 10. Scatter Diagram: Test 2 P 19.0 mm

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 3: Percent Passing the 16.0 mm Sieve

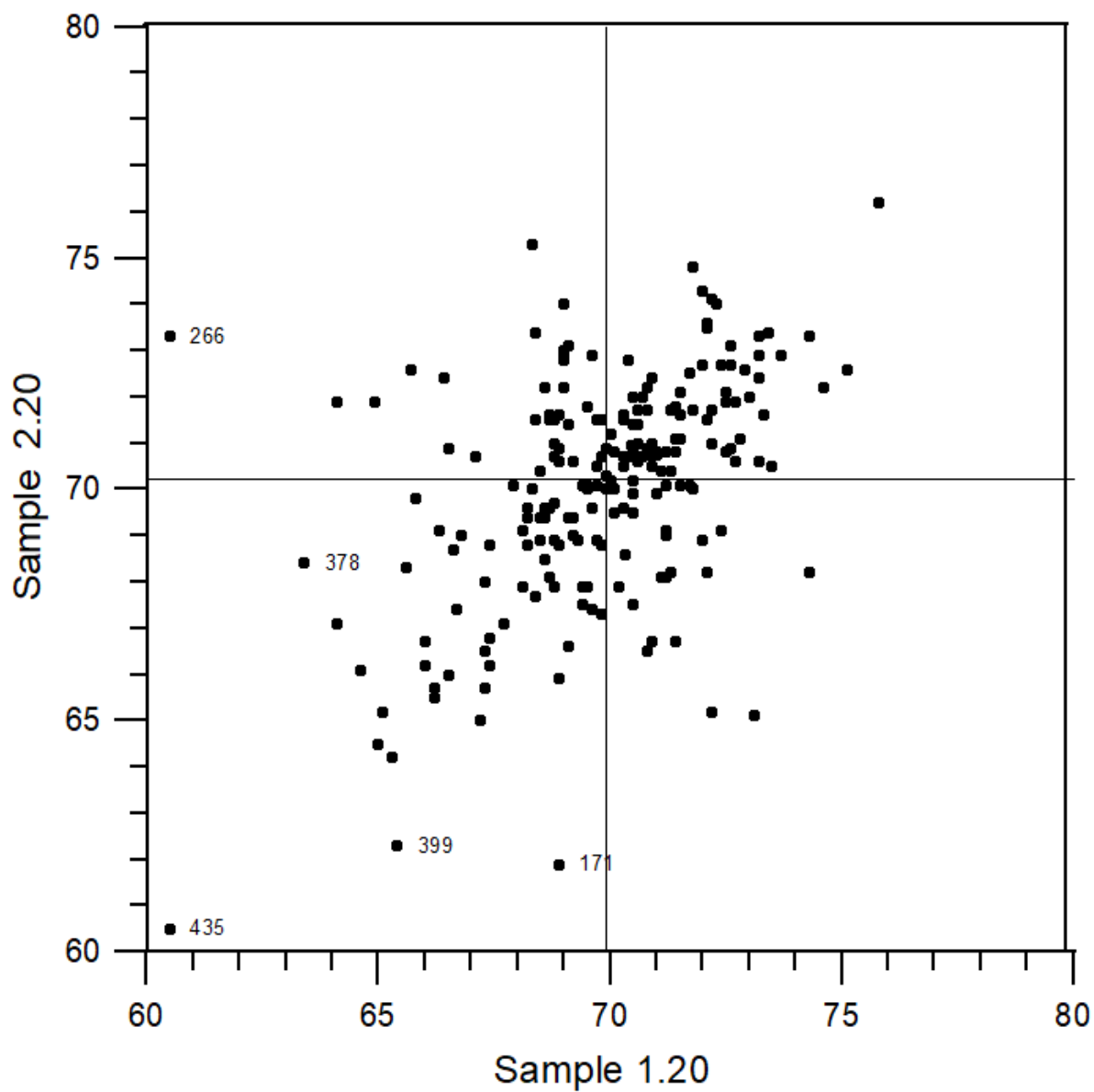
	Mat 1	Mat 2
Mean	77.536	77.833
Median	77.800	78.000
Std Dev	1.901	1.977

n = 206

Labs Eliminated: 171; 266; 378; 399; 435;

Figure 11. Scatter Diagram: Test 3 P 16.0 mm

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 4: Percent Passing the 13.20 mm Sieve

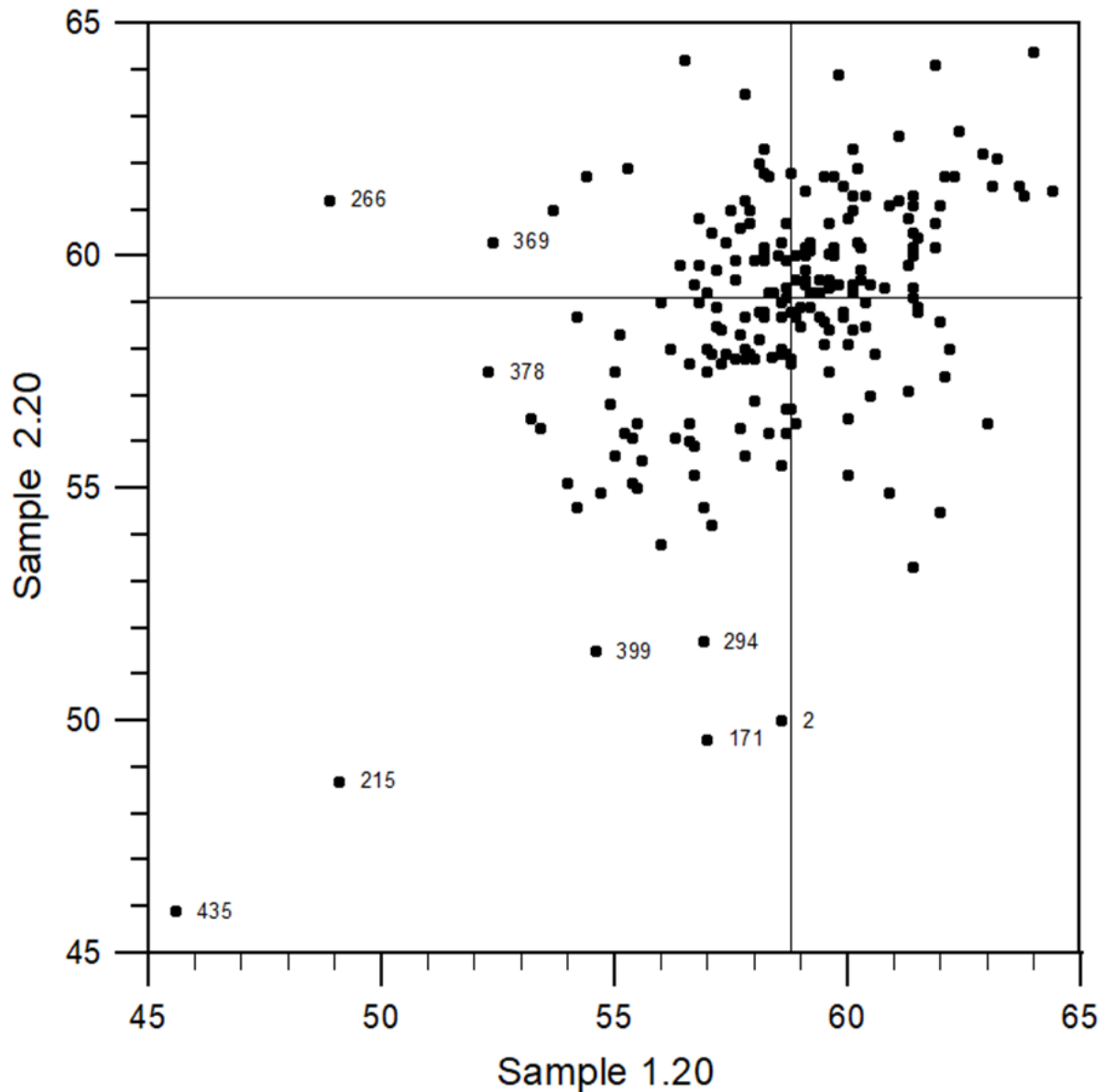
	Mat 1	Mat 2
Mean	69.908	70.230
Median	70.050	70.600
Std Dev	2.189	2.233

n = 206

Labs Eliminated: 171;266;378;399;435;

Figure 12. Scatter Diagram: Test 4 P 13.2 mm

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 5: Percent Passing the 9.5 mm Sieve

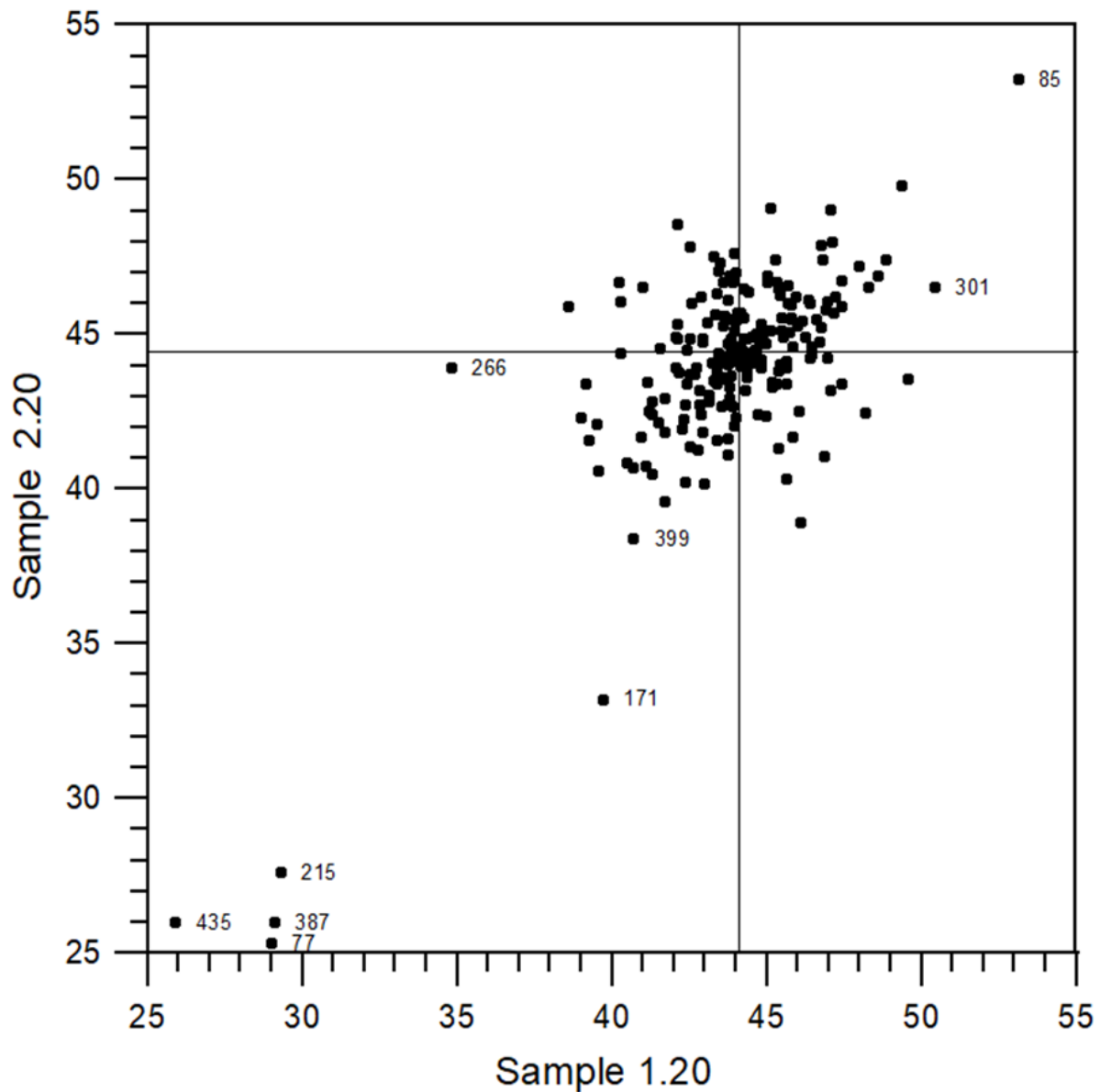
	Mat 1	Mat 2
Mean	58.797	59.095
Median	58.800	59.200
Std Dev	2.174	2.155

n = 202

Labs Eliminated: 2; 171; 215; 266; 294; 369; 378; 399; 435;

Figure 13. Scatter Diagram: Test 5 P 9.5 mm

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 6: Percent Passing the 4.75 mm Sieve

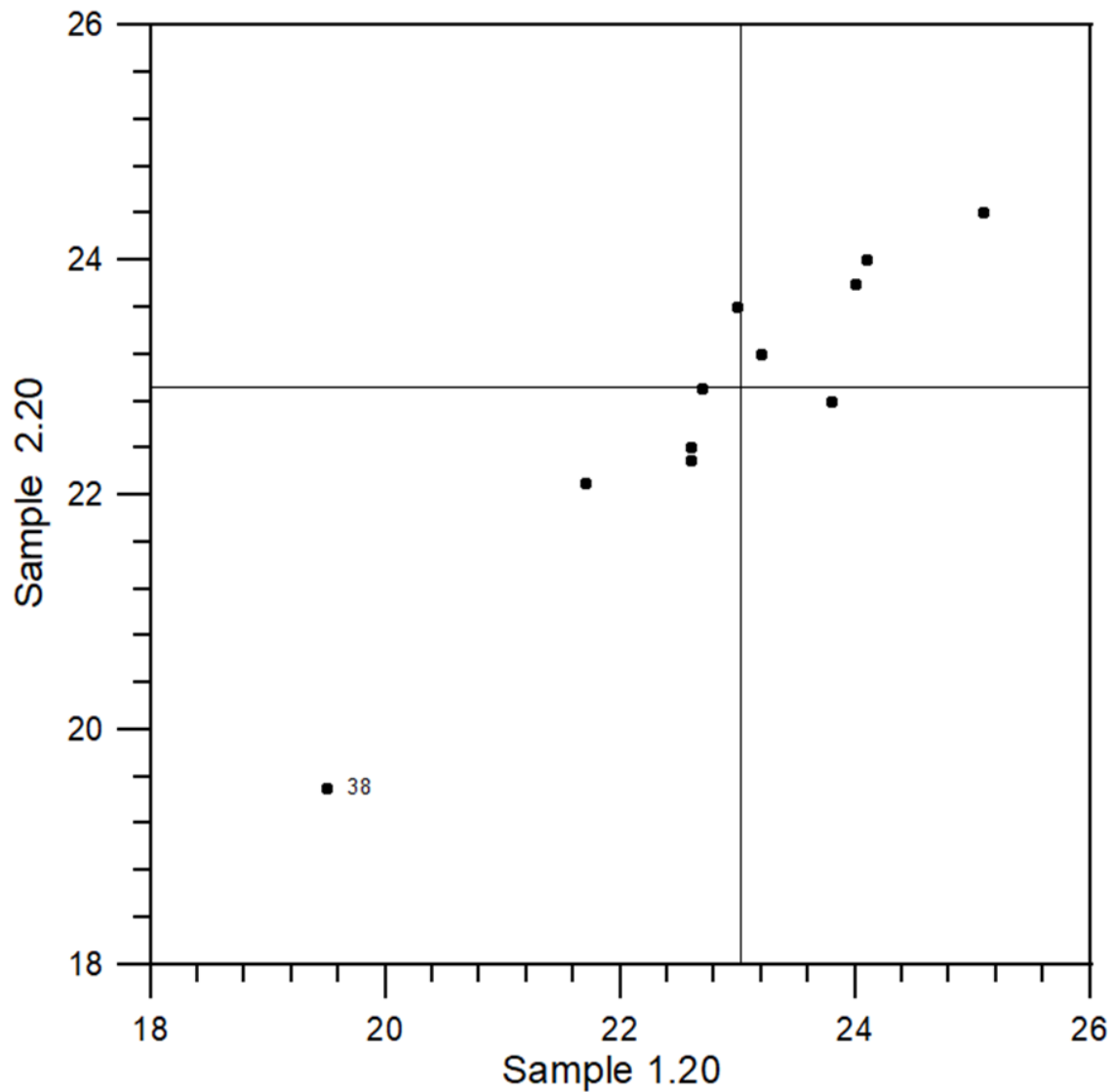
	Mat 1	Mat 2
Mean	44.092	44.437
Median	43.985	44.485
Std Dev	2.034	1.932

n = 202

Labs Eliminated: 77; 85; 171; 215; 266; 301; 387; 399; 435;

Figure 14. Scatter Diagram: Test 6 P 4.75 mm

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 8: Los Angeles Abrasion Loss, %

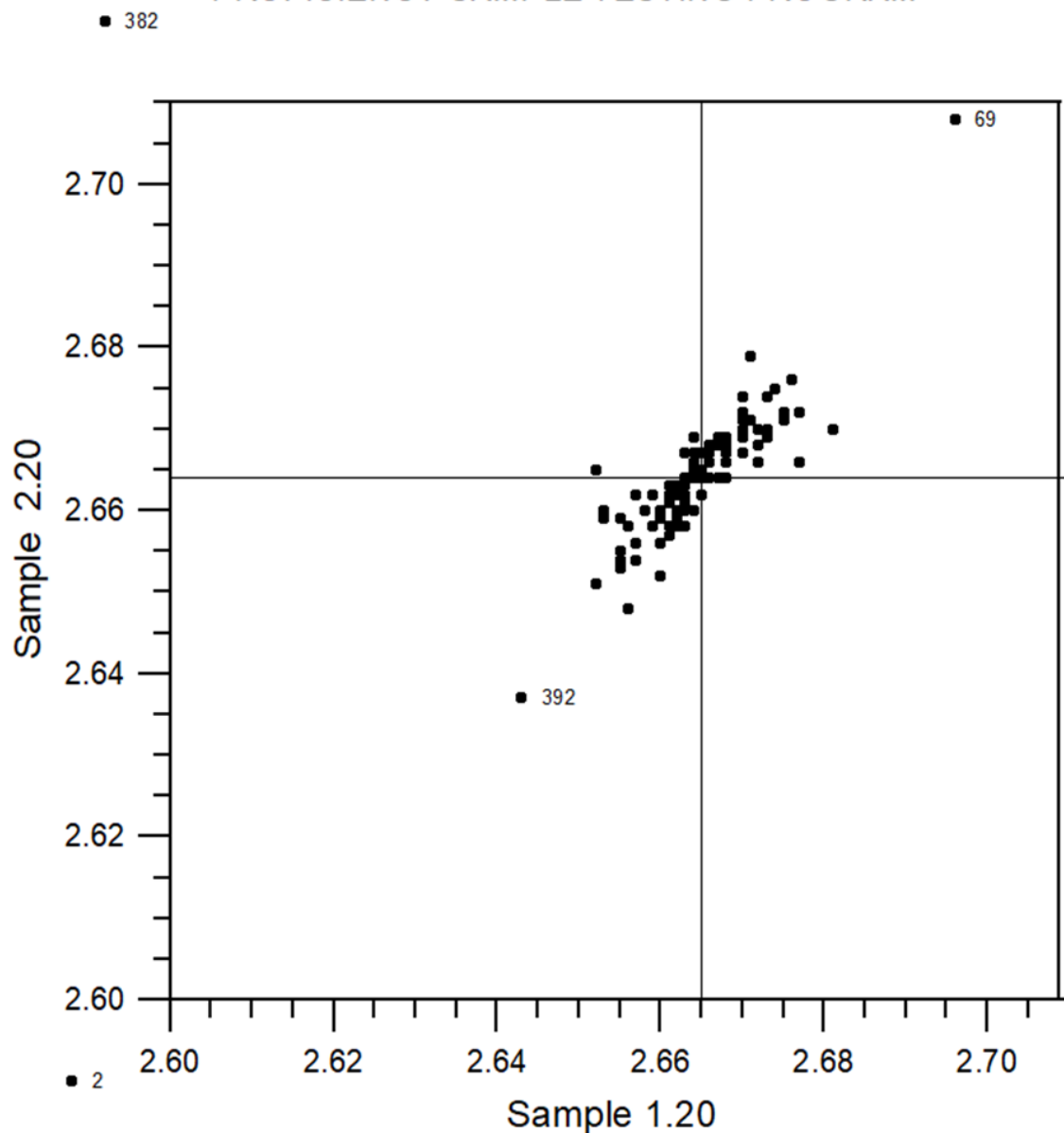
	Mat 1	Mat 2
Mean	23.031	22.923
Median	23.000	22.900
Std Dev	1.033	0.866

n = 13

Labs Eliminated: 38;

Figure 15. Scatter Diagram: Test 8 L. A

2020 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	2.665	2.664
Std Dev	0.006	0.006

n = 95

Labs Eliminated: 2; 69; 382; 392;

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

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

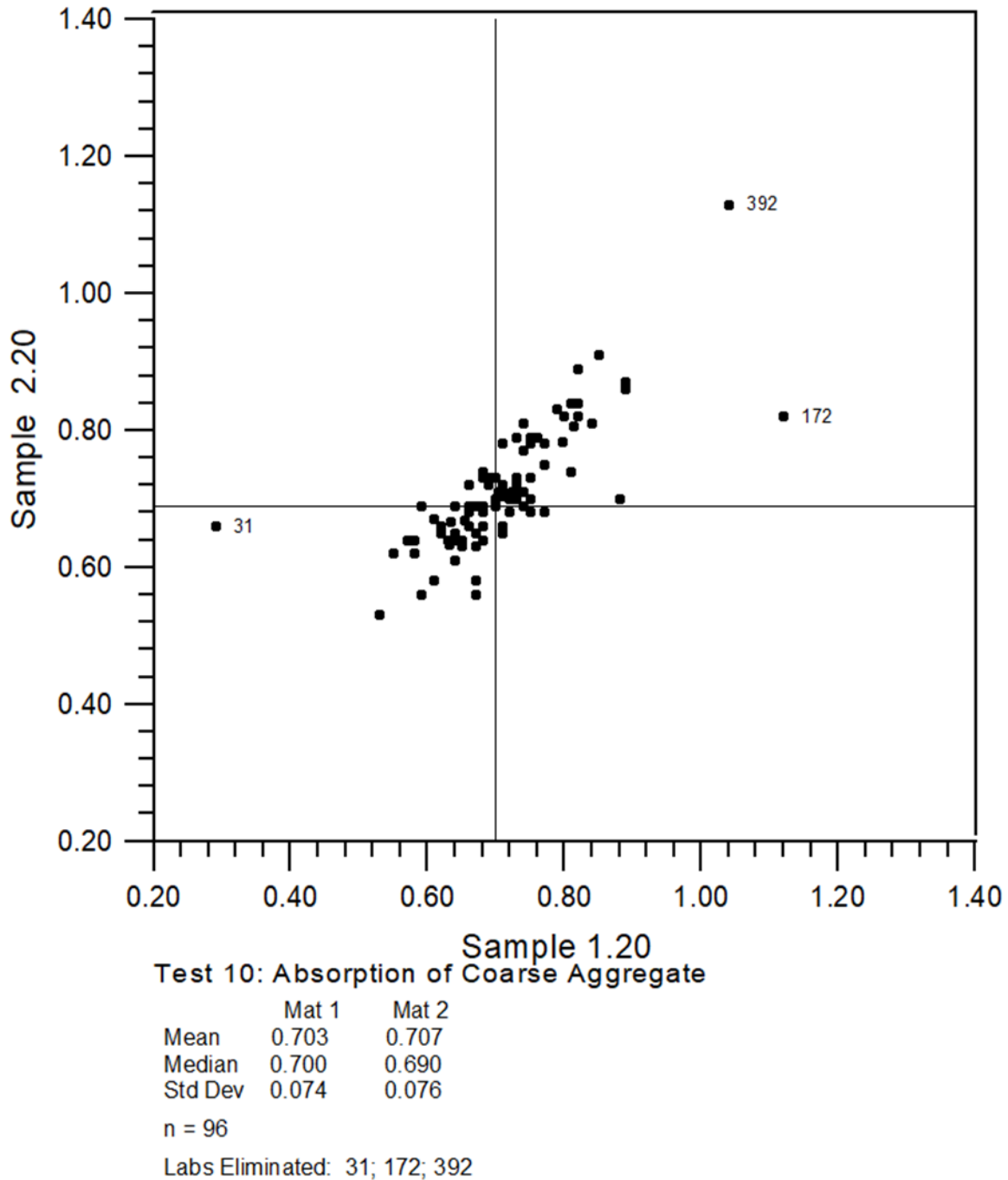
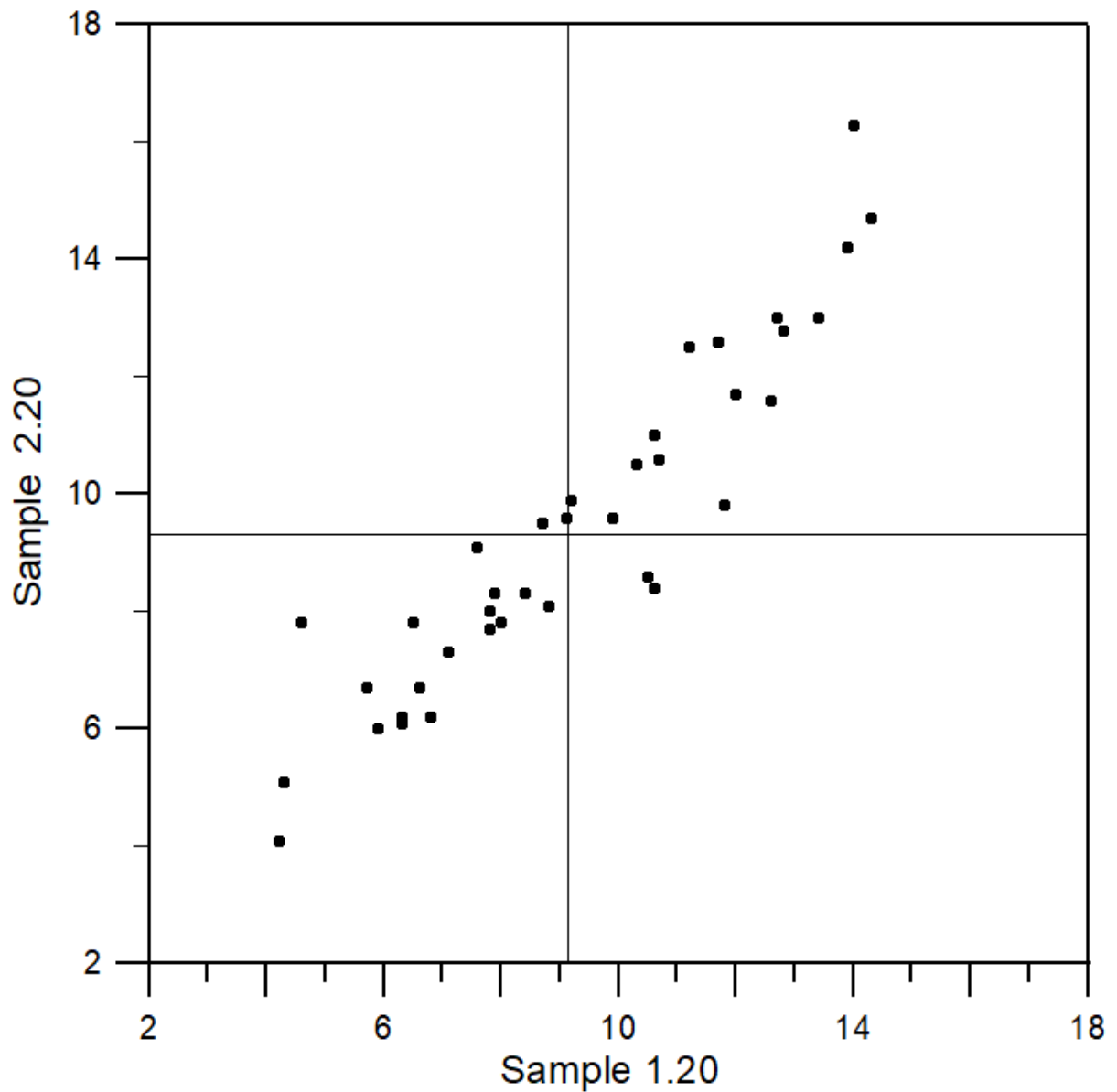


Figure 17. Scatter Diagram: Test 10 Absorption of CA

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 11: MgSO₄ Soundness of Coarse Aggregate, % Loss

	Mat 1	Mat 2
Mean	9.151	9.318
Median	8.800	8.600
Std Dev	2.871	2.850

n = 39

Labs Eliminated: None

Figure 18. Scatter Diagram: Test 11 MgSO₄

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

• 369

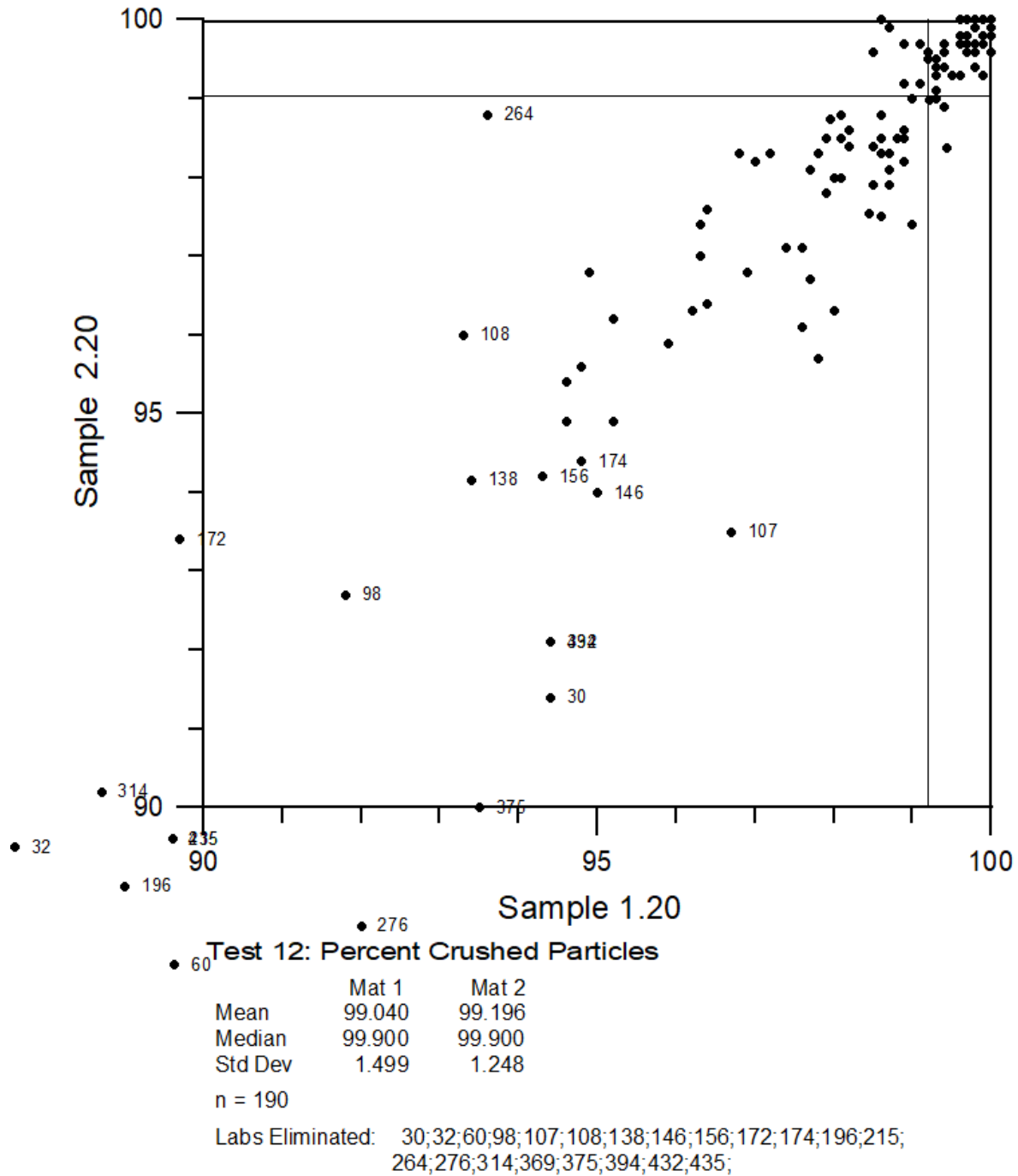
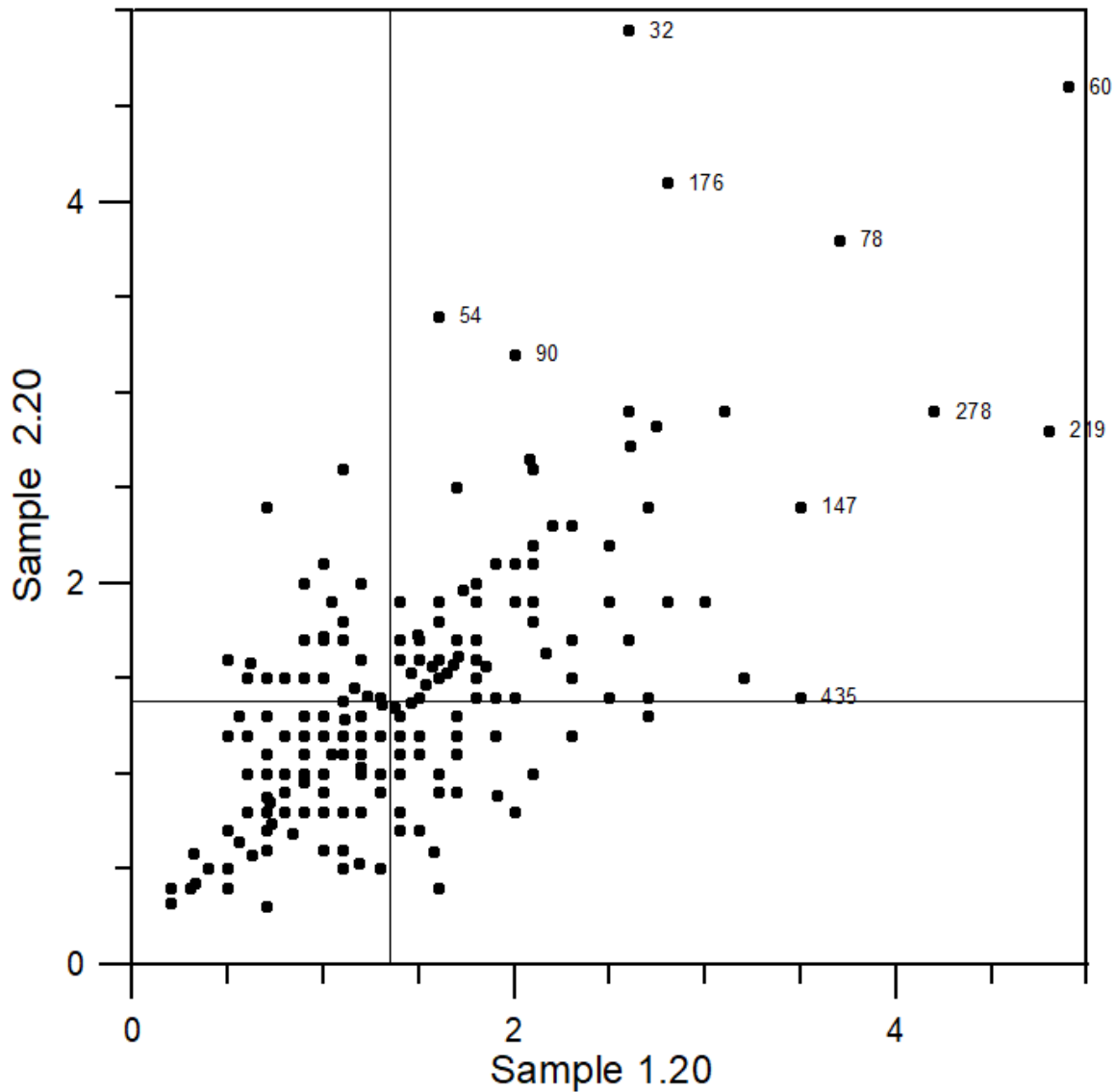


Figure 19. Scatter Diagram: Test 12 % Crush

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 13: Percent Flat and Elongated Particles

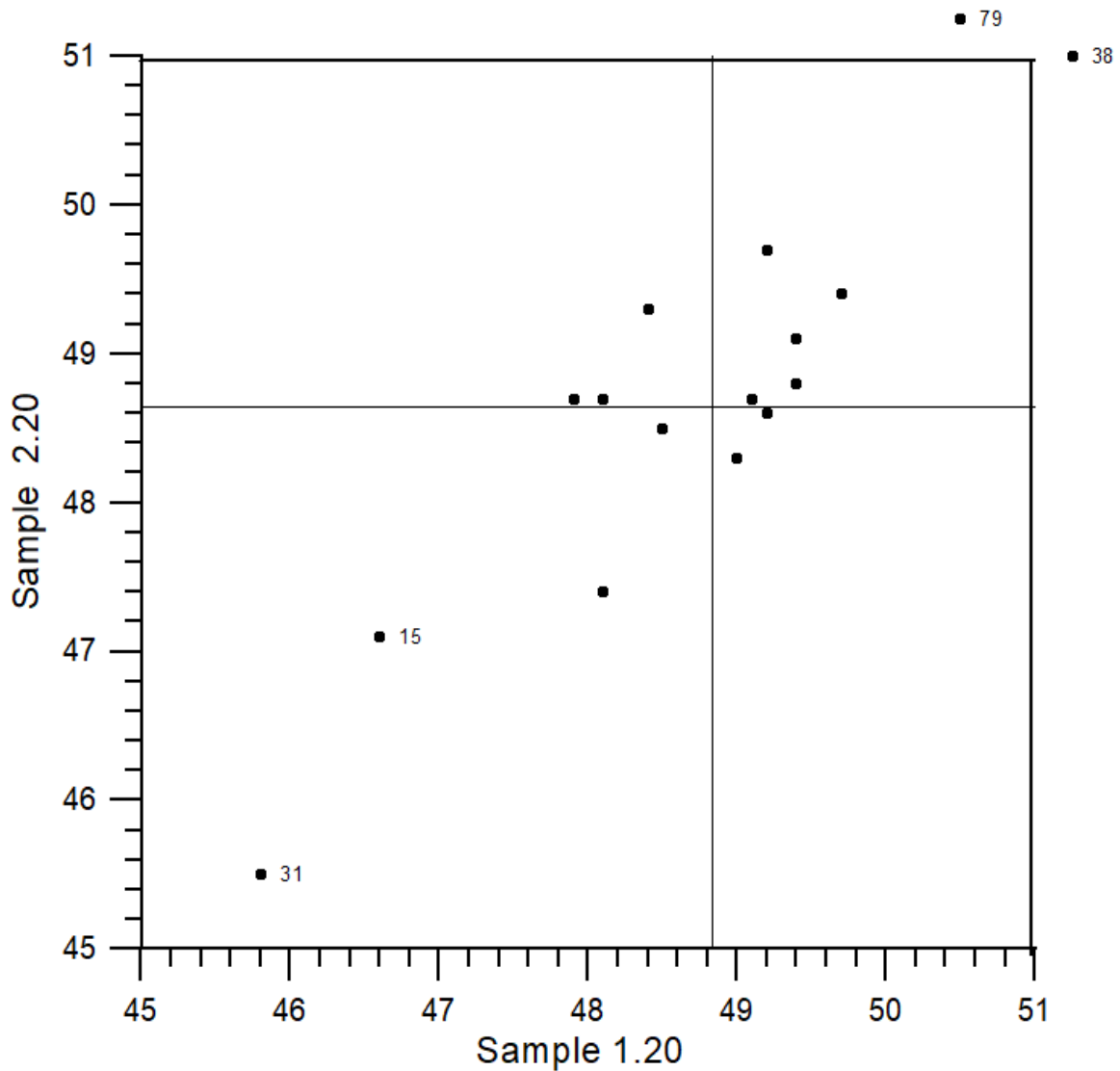
	Mat 1	Mat 2
Mean	1.378	1.350
Median	1.300	1.300
Std Dev	0.623	0.573

n = 200

Labs Eliminated: 32,54,60,78,90,147,176,219,278,435;

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

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 15: Total Percentage of Insoluble Residue

	Mat 1	Mat 2
Mean	48.833	48.638
Median	49.050	48.700
Std Dev	0.603	0.732

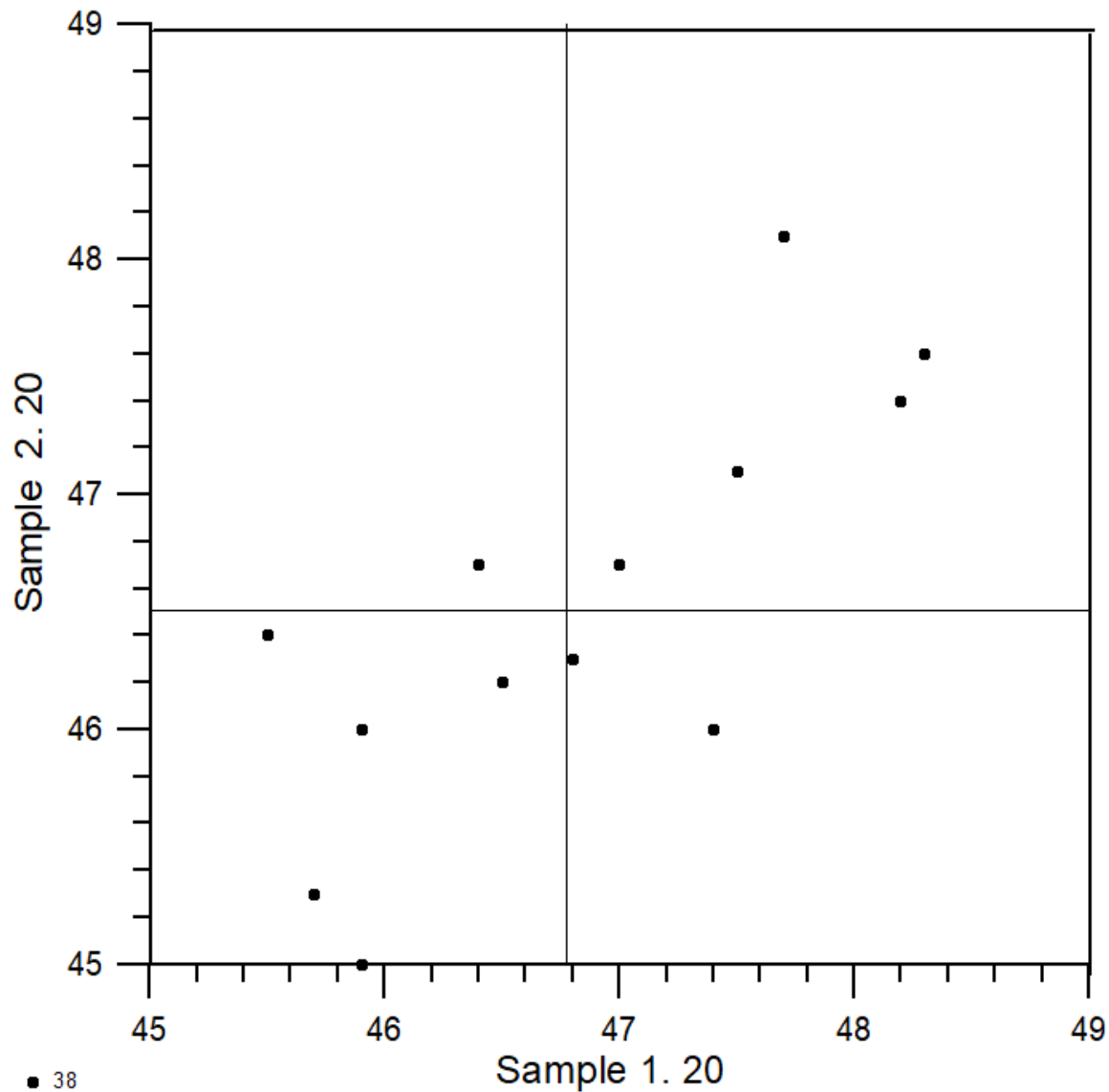
n = 12

Lab Eliminated: 15; 31; 38;79

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

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

● 15



● 38

Test 98: Percentage of Insoluble Residue Retained 75_{μm}

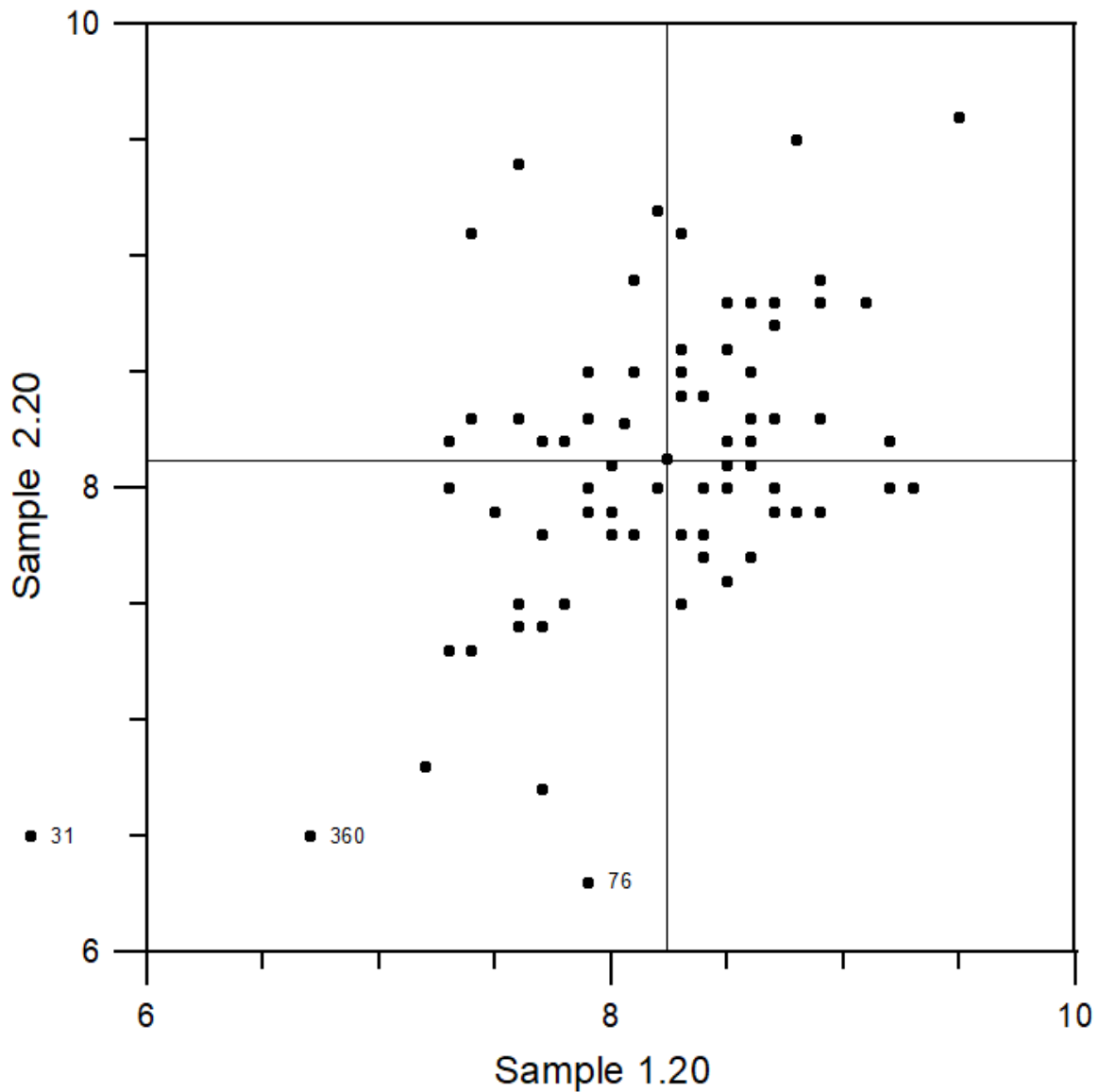
	Mat 1	Mat 2
Mean	46.771	46.507
Median	46.650	46.350
Std Dev	0.933	0.850

n = 14

Labs Eliminated: 15;38;

Figure 22. Scatter Diagram: Test 98 % Insoluble Residue

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

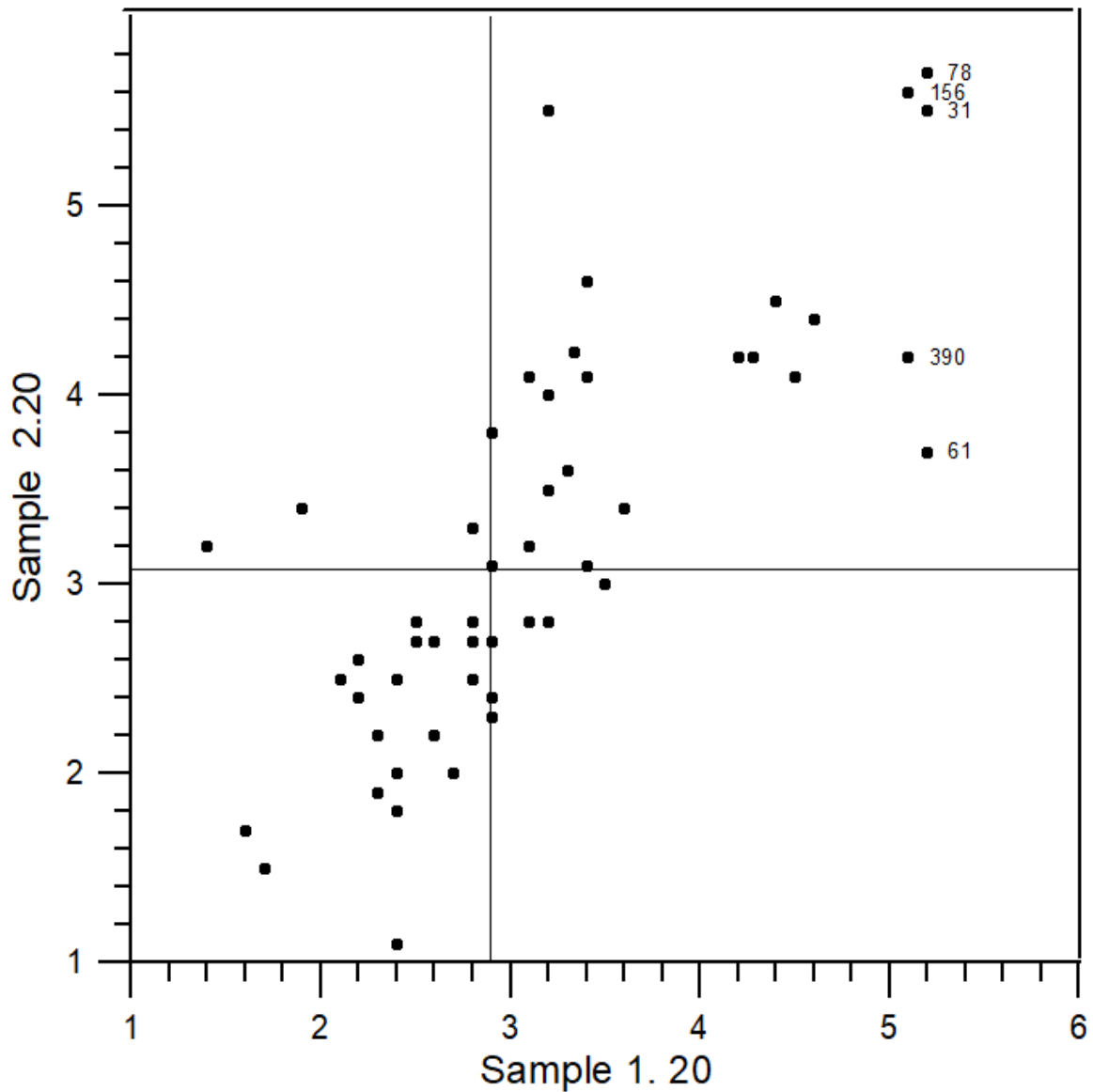
	Mat 1	Mat 2
Mean	8.243	8.123
Median	8.300	8.100
Std Dev	0.535	0.617

n = 75

Labs Eliminated: 31;76;360;

Figure 23. Scatter Diagram: Test 16 MDA, CA

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 17: Freeze-Thaw Loss, %

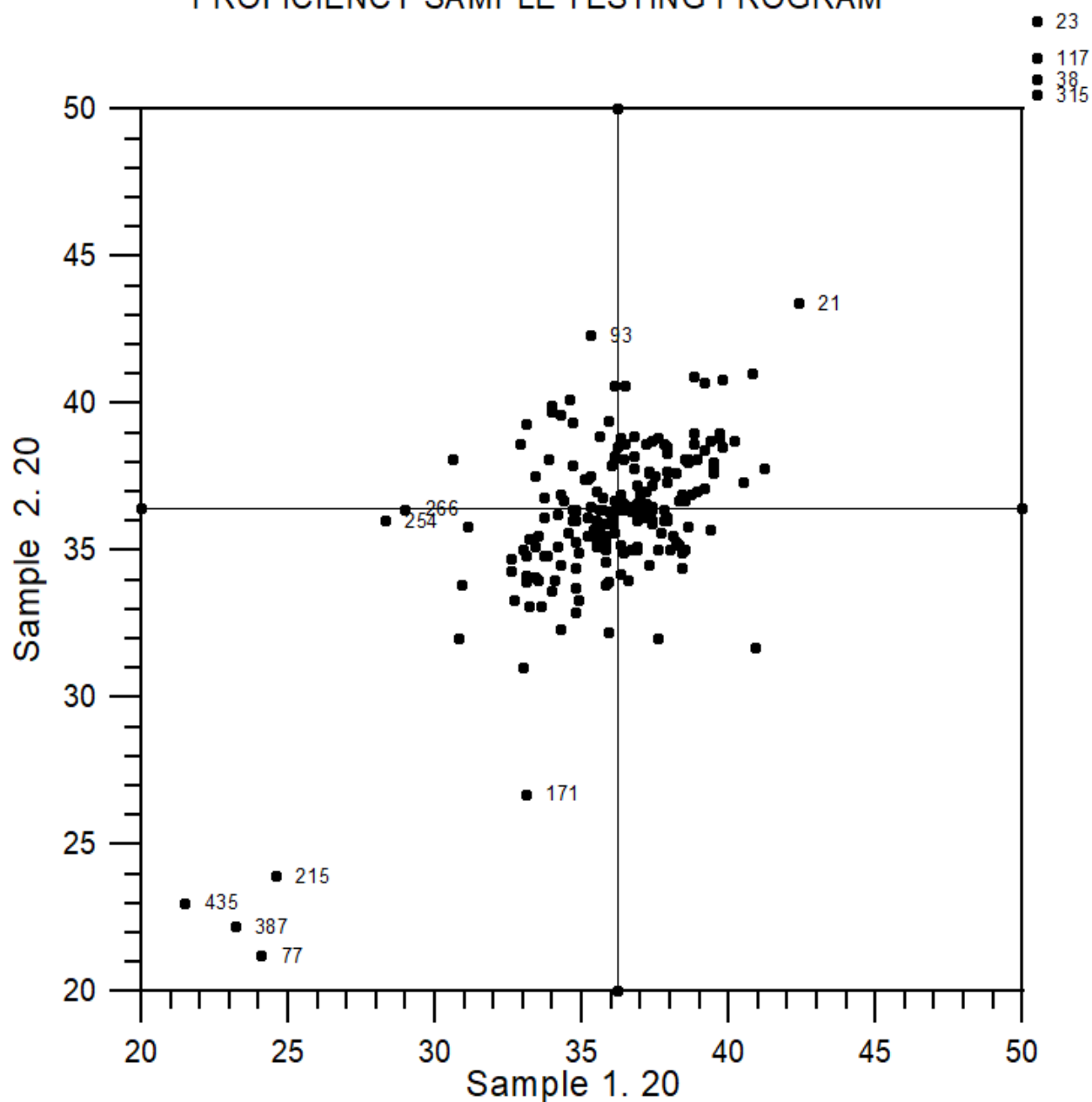
	Mat 1	Mat 2
Mean	2.897	3.079
Median	2.800	2.800
Std Dev	0.691	0.962

n = 52

Labs Eliminated: 31;61;78;156;390;

Figure 24. Scatter Diagram: Test 17 Freeze-Thaw

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 20: Percent Passing the 2.36 mm Sieve

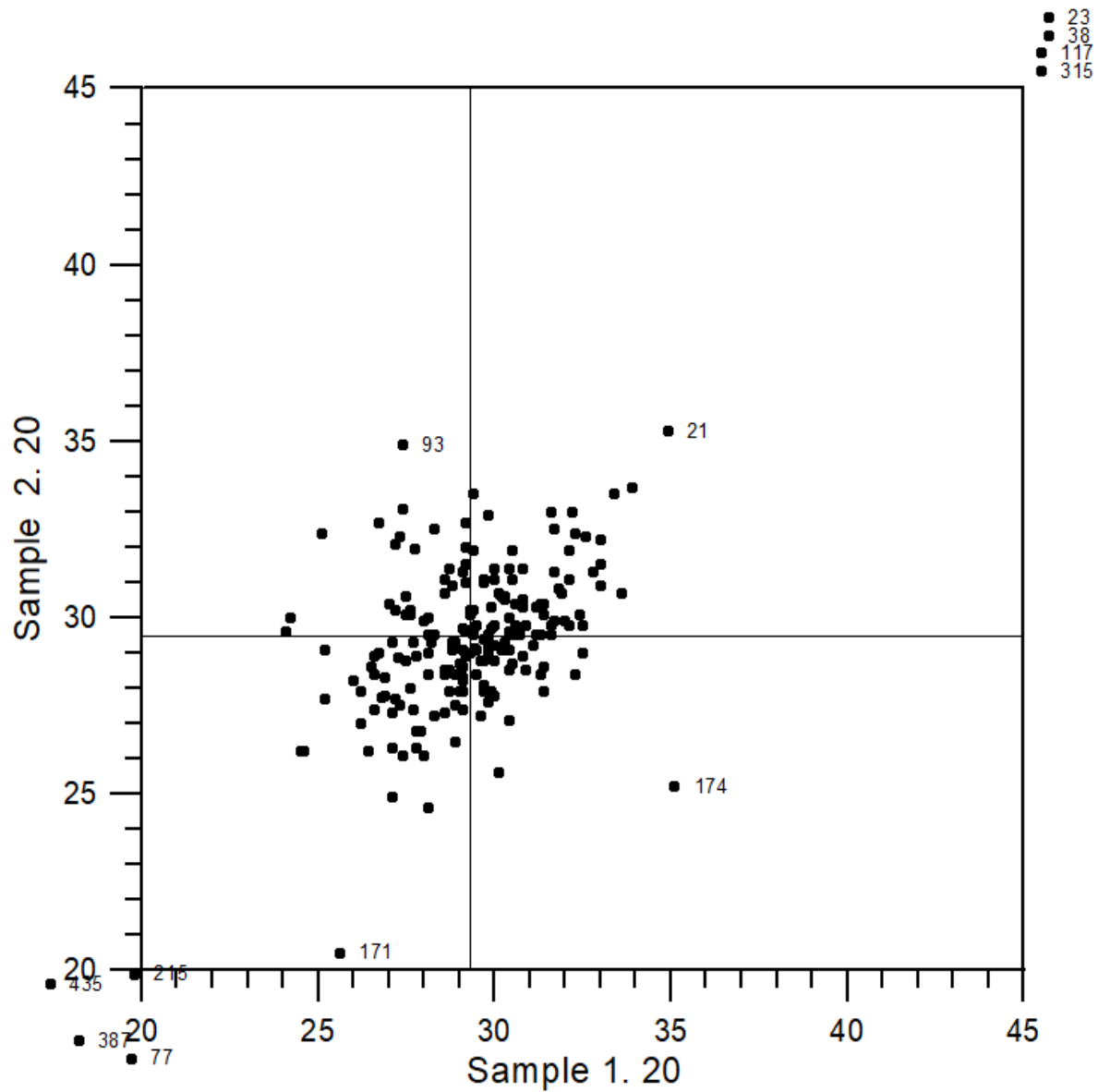
	Mat 1	Mat 2
Mean	36.239	36.447
Median	36.300	36.400
Std Dev	2.046	1.878

n = 198

Labs Eliminated: 21;23;38;77;93;117;171;215;254;266;315;387;435;

Figure 25. Scatter Diagram: Test 20 P 2.36 mm

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 21: Percent Passing the 1.18 mm Sieve

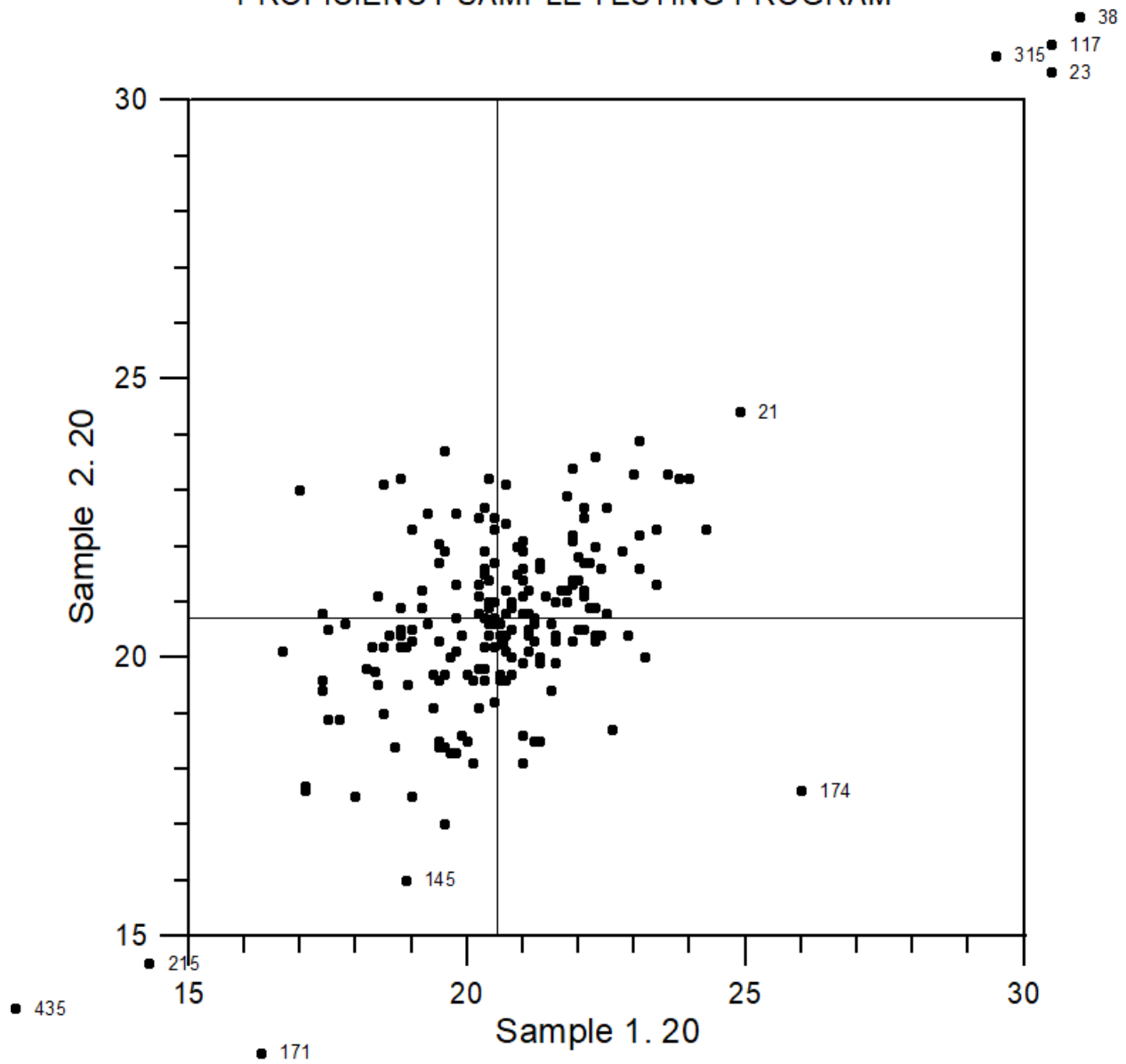
	Mat 1	Mat 2
Mean	29.300	29.490
Median	29.400	29.500
Std Dev	1.910	1.735

n = 199

Labs Eliminated: 21;23;38;77;93;117;171;
174;215;315;387;435;

Figure 26. Scatter Diagram: Test 20 P 1.18 mm

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	20.533	20.718
Median	20.600	20.600
Std Dev	1.482	1.383

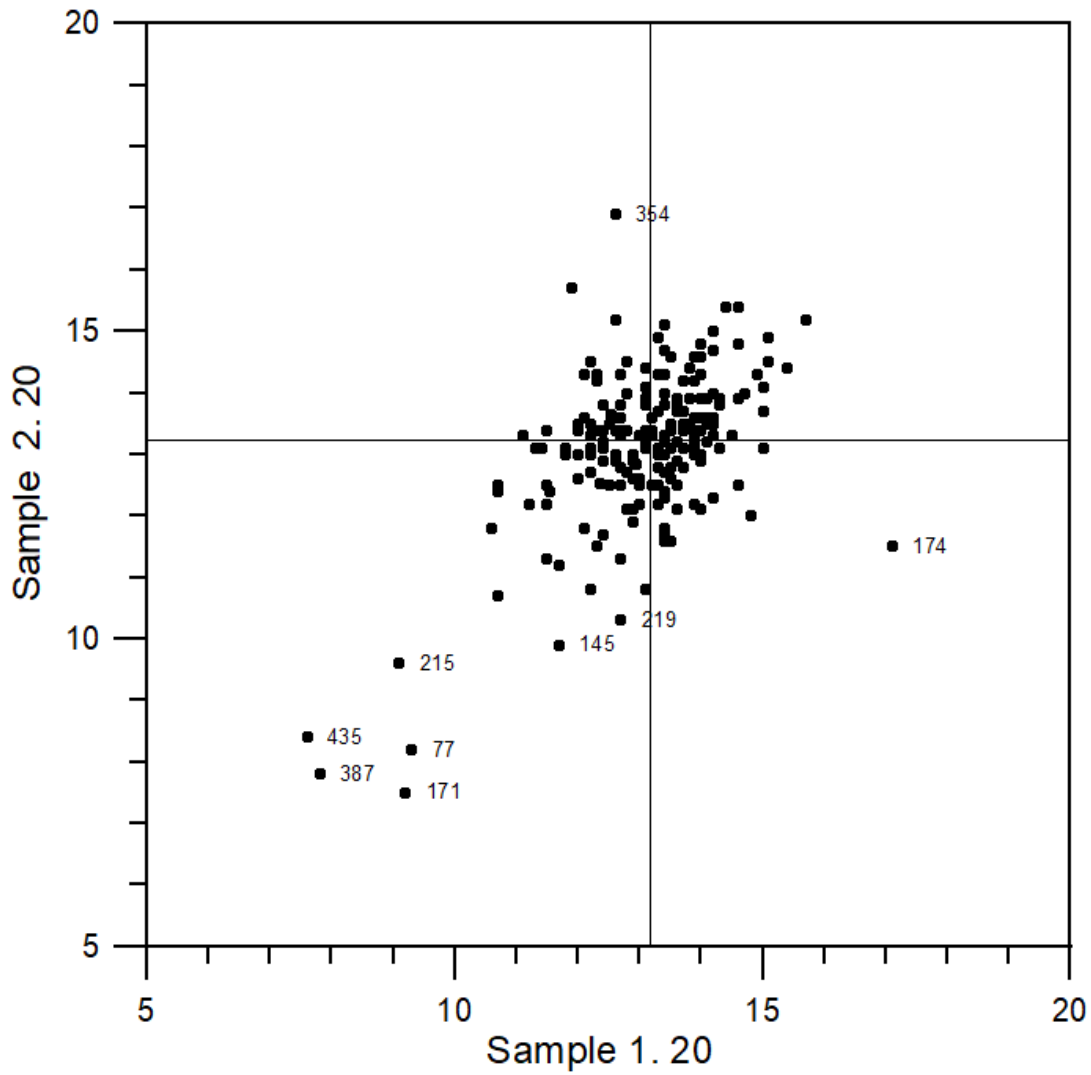
n = 199

Labs Eliminated: 21;23;38;77;117;145;171;174;
215;315;387;435;

Figure 27. Scatter Diagram: Test 22 P 600 μ m

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

■ 38
■ 23
■ 315
■ 117



Test 23: Percent Passing the 300 um Sieve

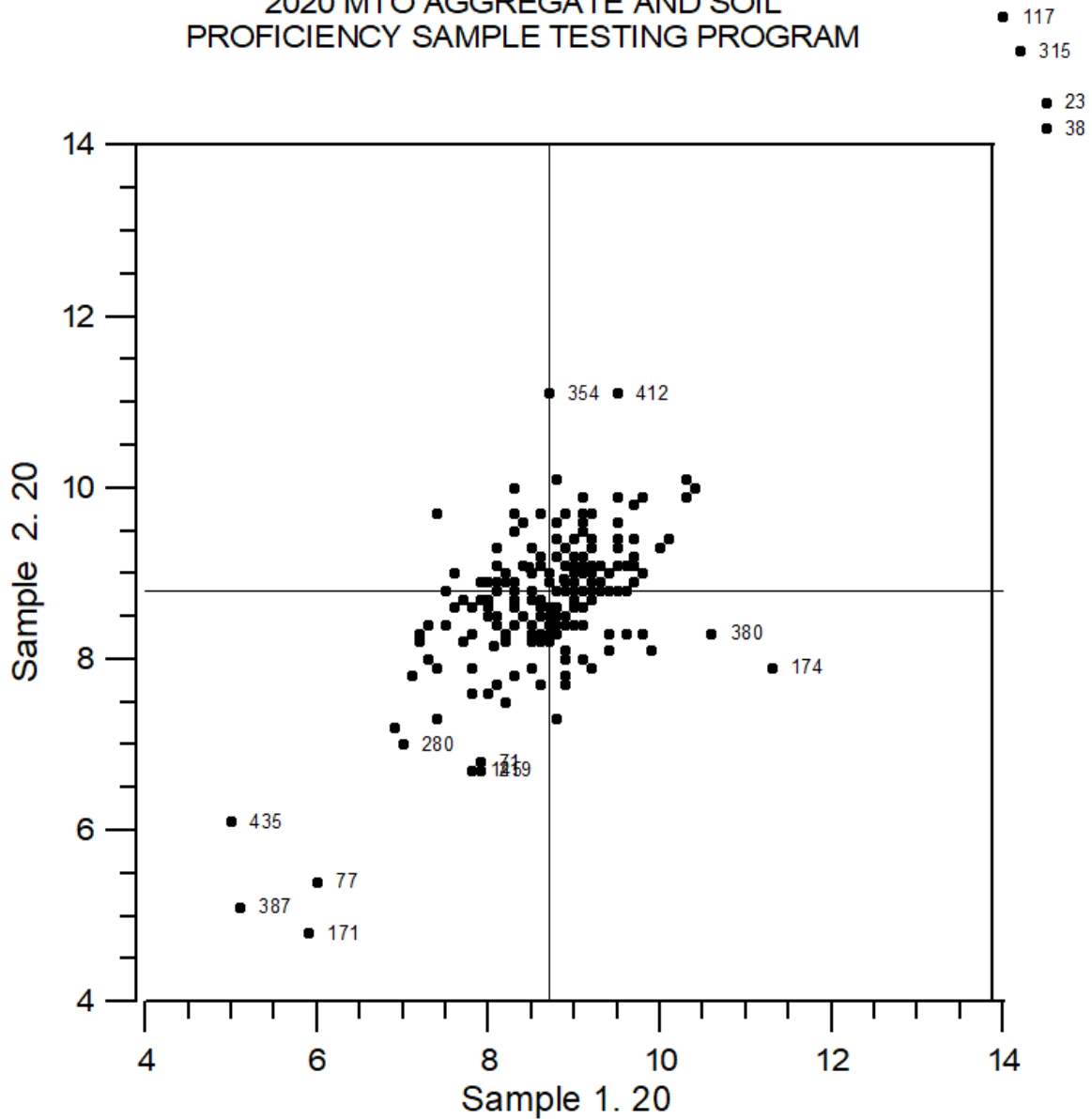
	Mat 1	Mat 2
Mean	13.177	13.246
Median	13.300	13.300
Std Dev	0.941	0.923

n = 198

Labs Eliminated: 23;38;77;117;145;171;174;215;
219;315;354;387;435;

Figure 28. Scatter Diagram: Test 23 P 300 μ m

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



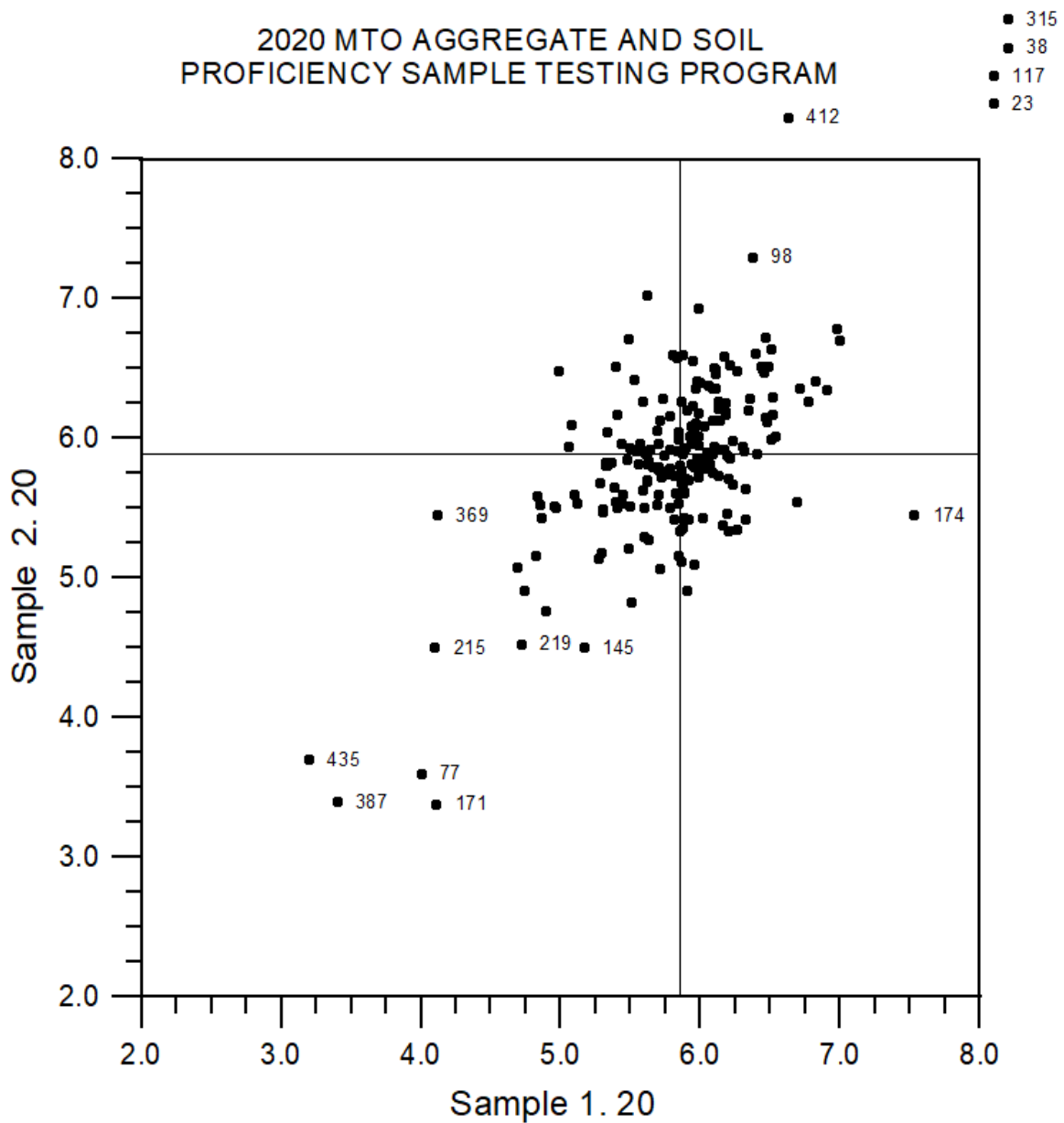
Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	8.714	8.795
Median	8.800	8.800
Std Dev	0.659	0.587

n = 195

Labs Eliminated: 23;38;71;77;117;145;171;174;219;280;
315;354;380;387;412;435;

Figure 29. Scatter Diagram: Test 24 P 150 μ m



Test 25: Percent Passing the 75 um Sieve

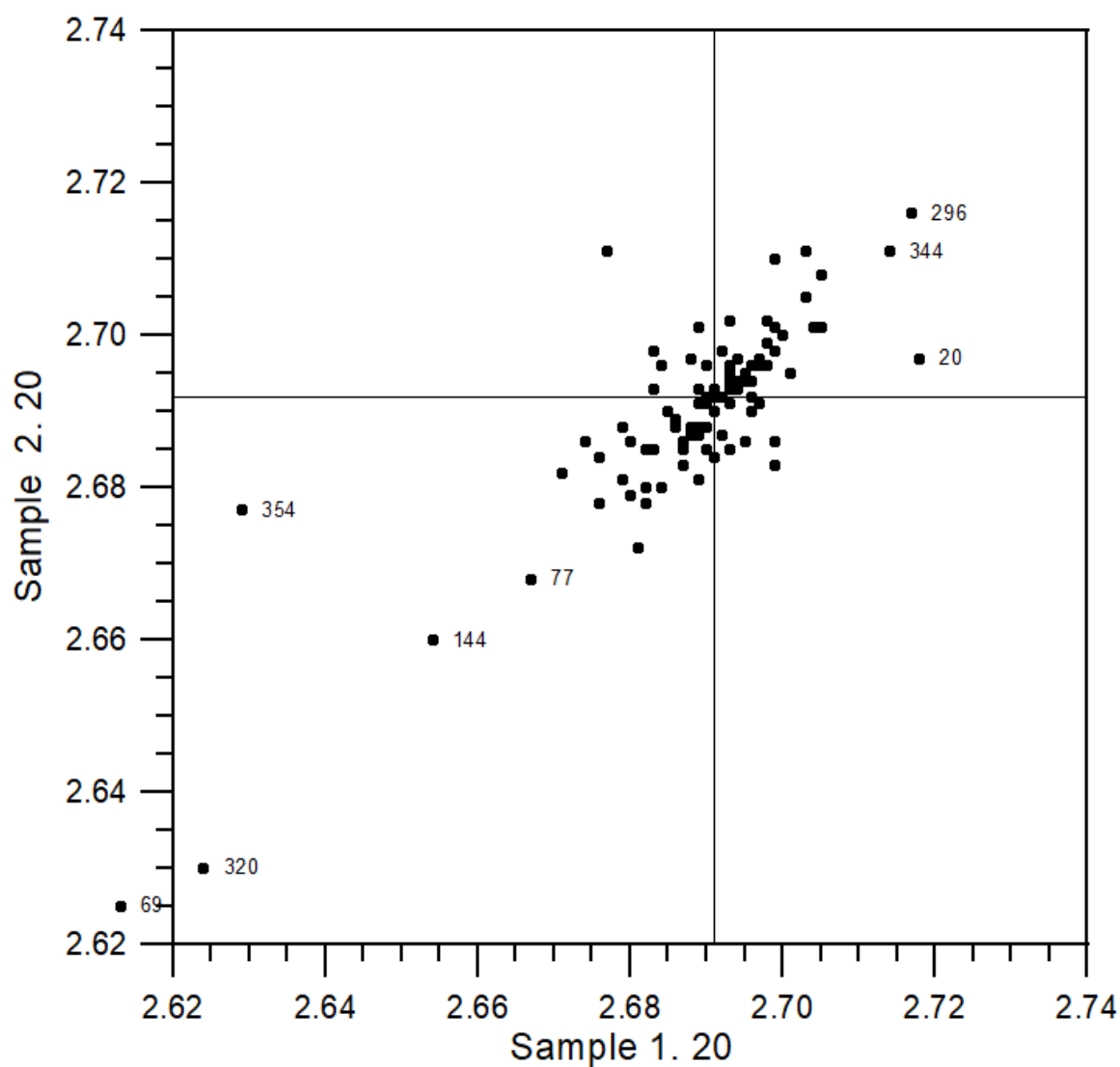
	Mat 1	Mat 2
Mean	5.852	5.892
Median	5.880	5.870
Std Dev	0.443	0.424

n = 196

Labs Eliminated: 23;38;77;98;117;145;171;174;215;
219;315;369;387;412;435;

Figure 30. Scatter Diagram: Test 25 P 75 μ m

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

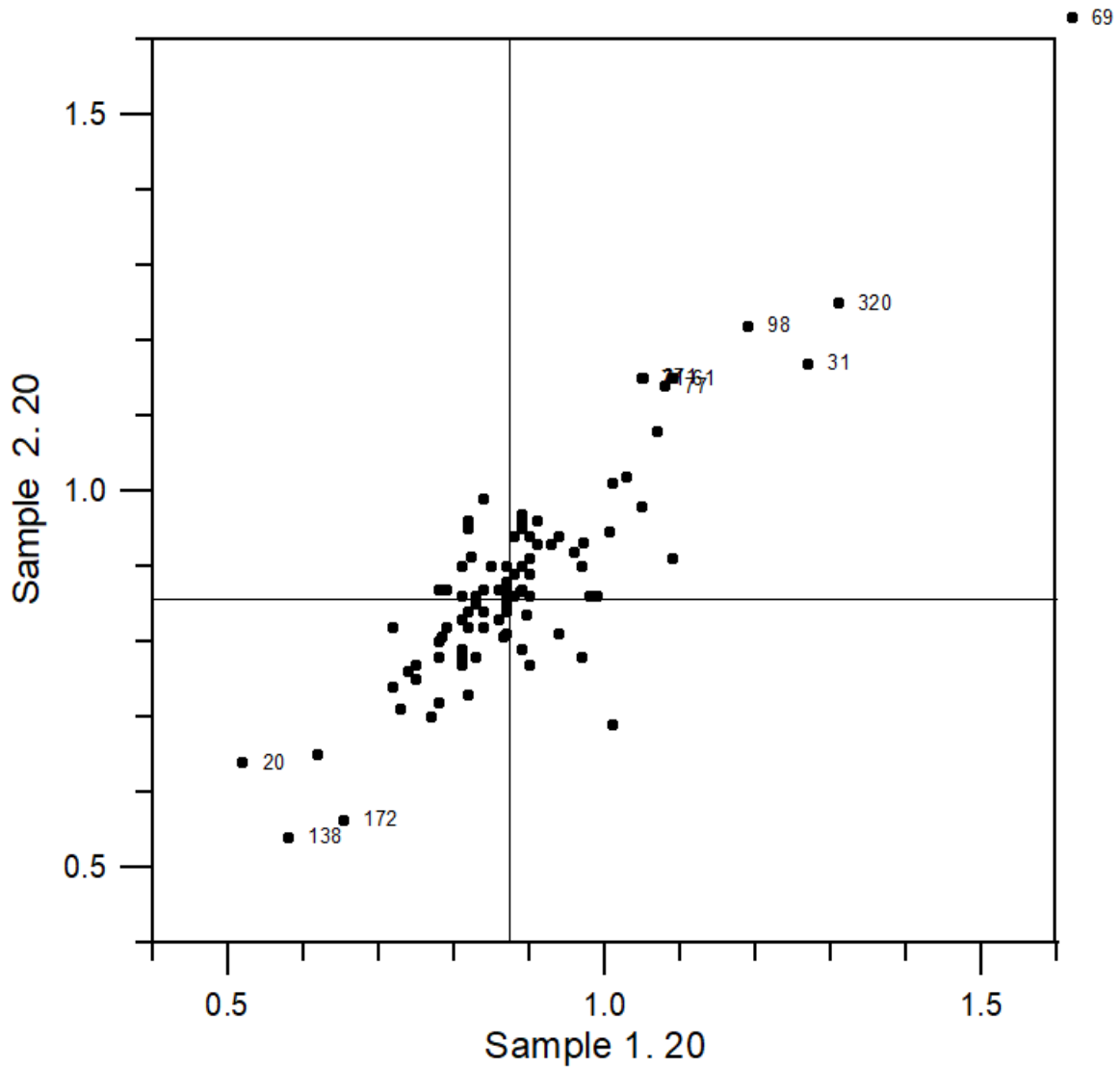
	Mat 1	Mat 2
Mean	2.691	2.692
Median	2.691	2.692
Std Dev	0.007	0.008

n = 89

Labs Eliminated: 20;69;77;144;296;320;344;354;

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

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 28: Absorption of Fine Aggregate

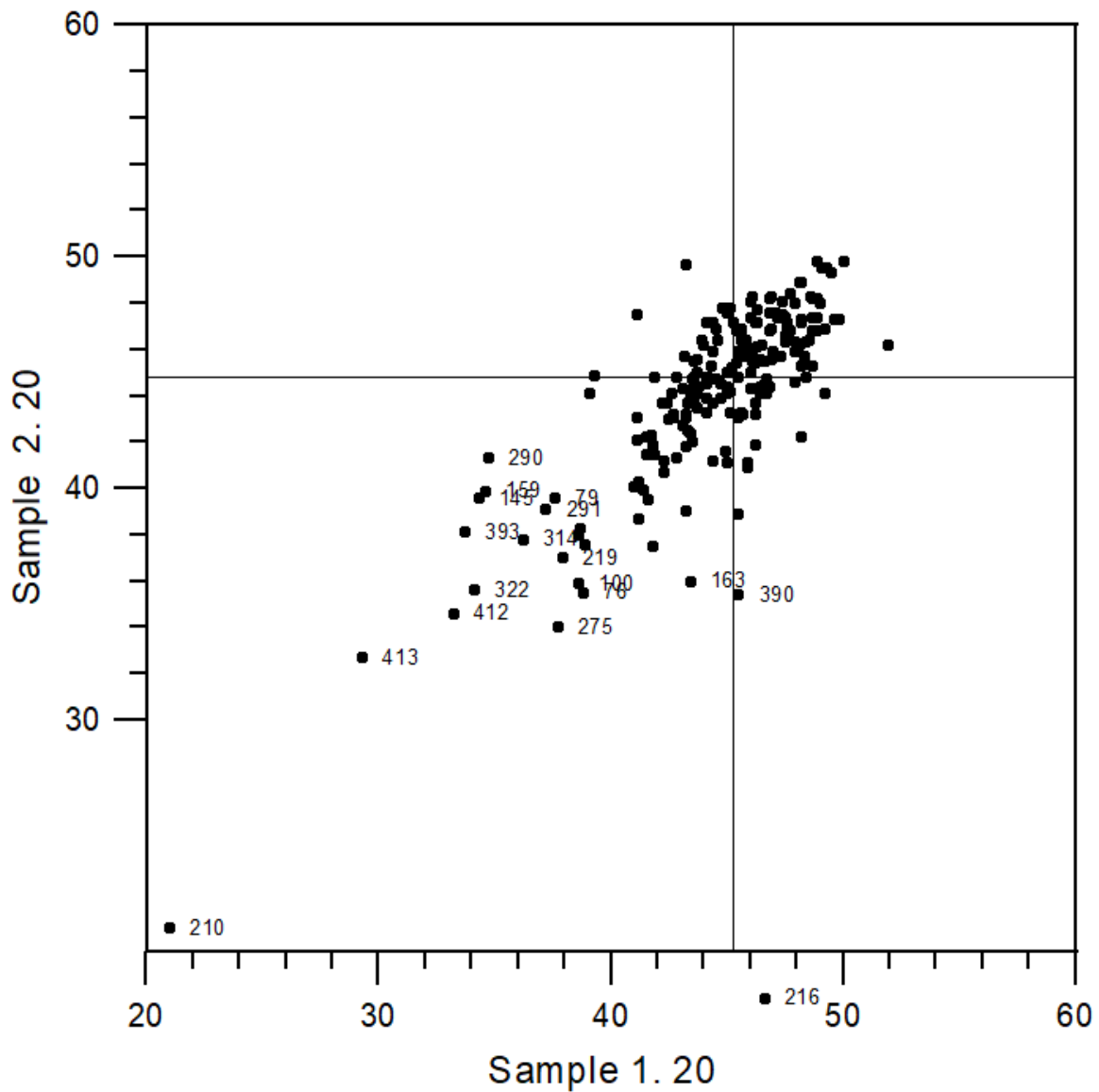
	Mat 1	Mat 2
Mean	0.875	0.857
Median	0.870	0.857
Std Dev	0.096	0.0831

n = 86

Labs Eliminated: 20;31;61;69;71;77;98;138;172;271;320;

Figure 32. Scatter Diagram: Test 28 Absorption of FA

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 30: Percent Asphalt Coated Particles

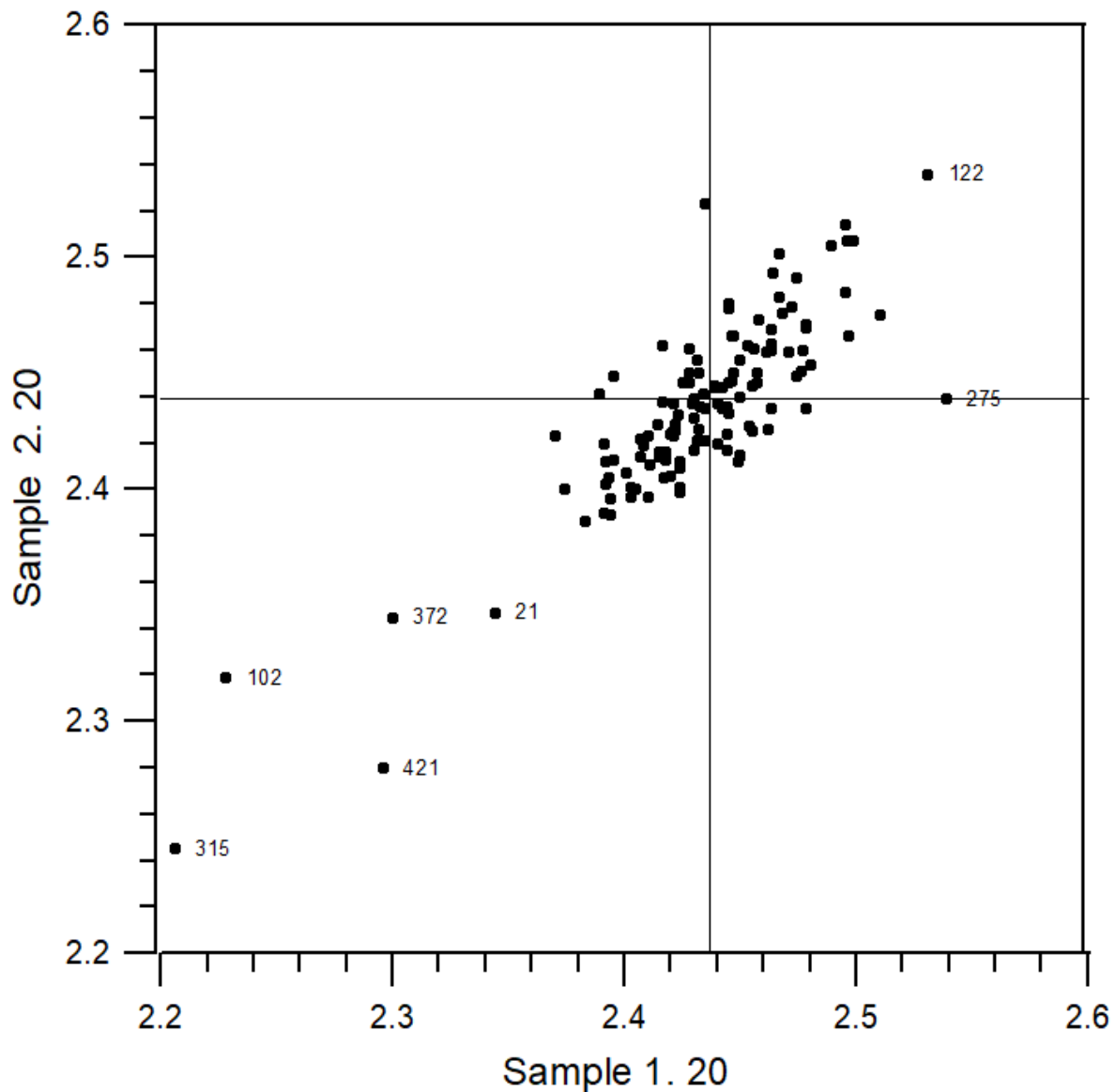
	Mat 1	Mat 2
Mean	45.273	44.779
Median	45.600	45.000
Std Dev	2.528	2.699

n = 193

Labs Eliminated: 76;79;100;145;159;163;210;216;219;275;
290;291;314;322;390;393;412;413;

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

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

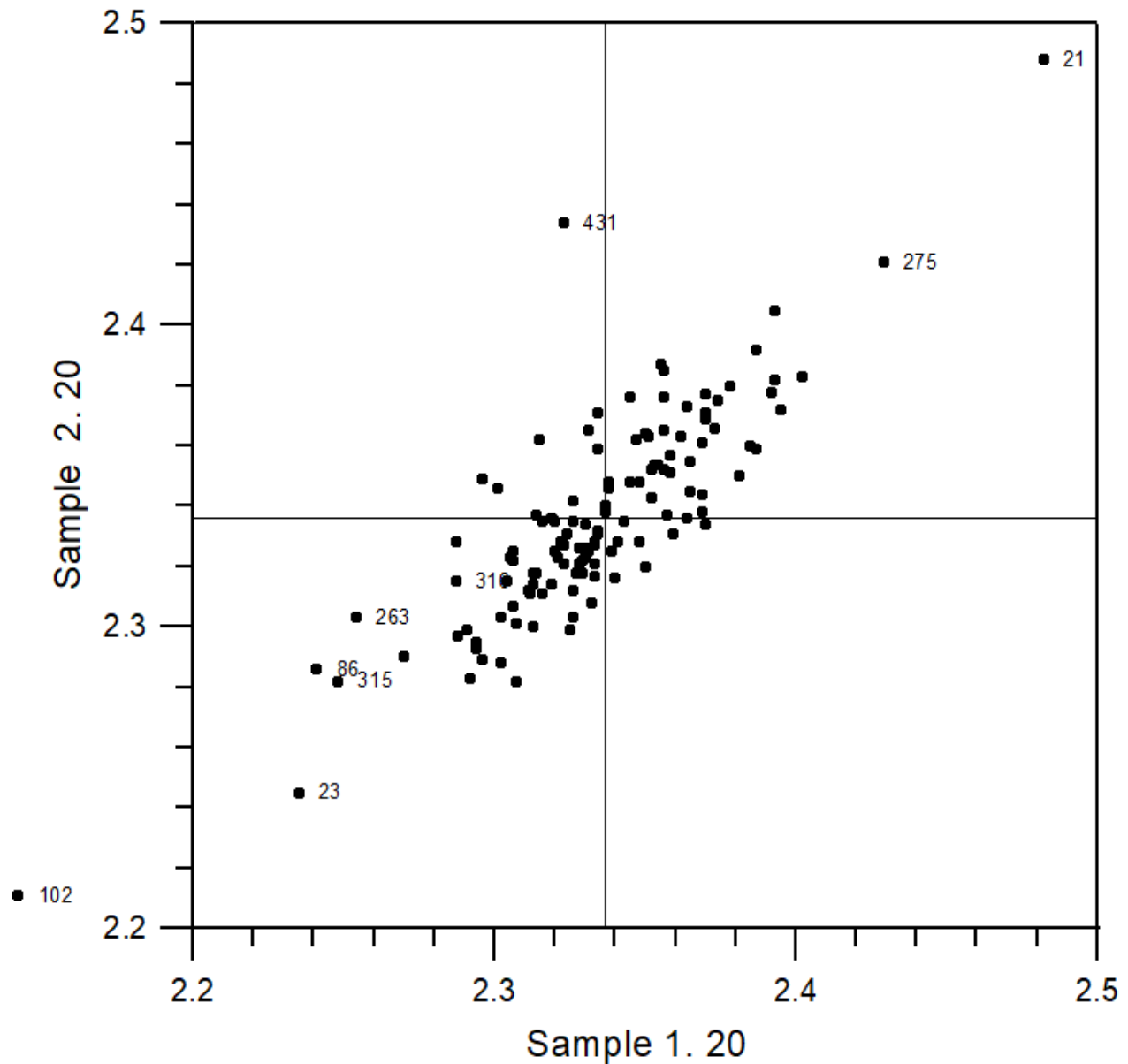
	Mat 1	Mat 2
Mean	2.437	2.439
Median	2.435	2.437
Std Dev	0.029	0.028

n = 122

Labs Eliminated: 21;102;122;275;315;372;421;

Figure 34. Scatter Diagram: Test 31 Max Wet Density

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 32: Maximum Dry Density g/cm³

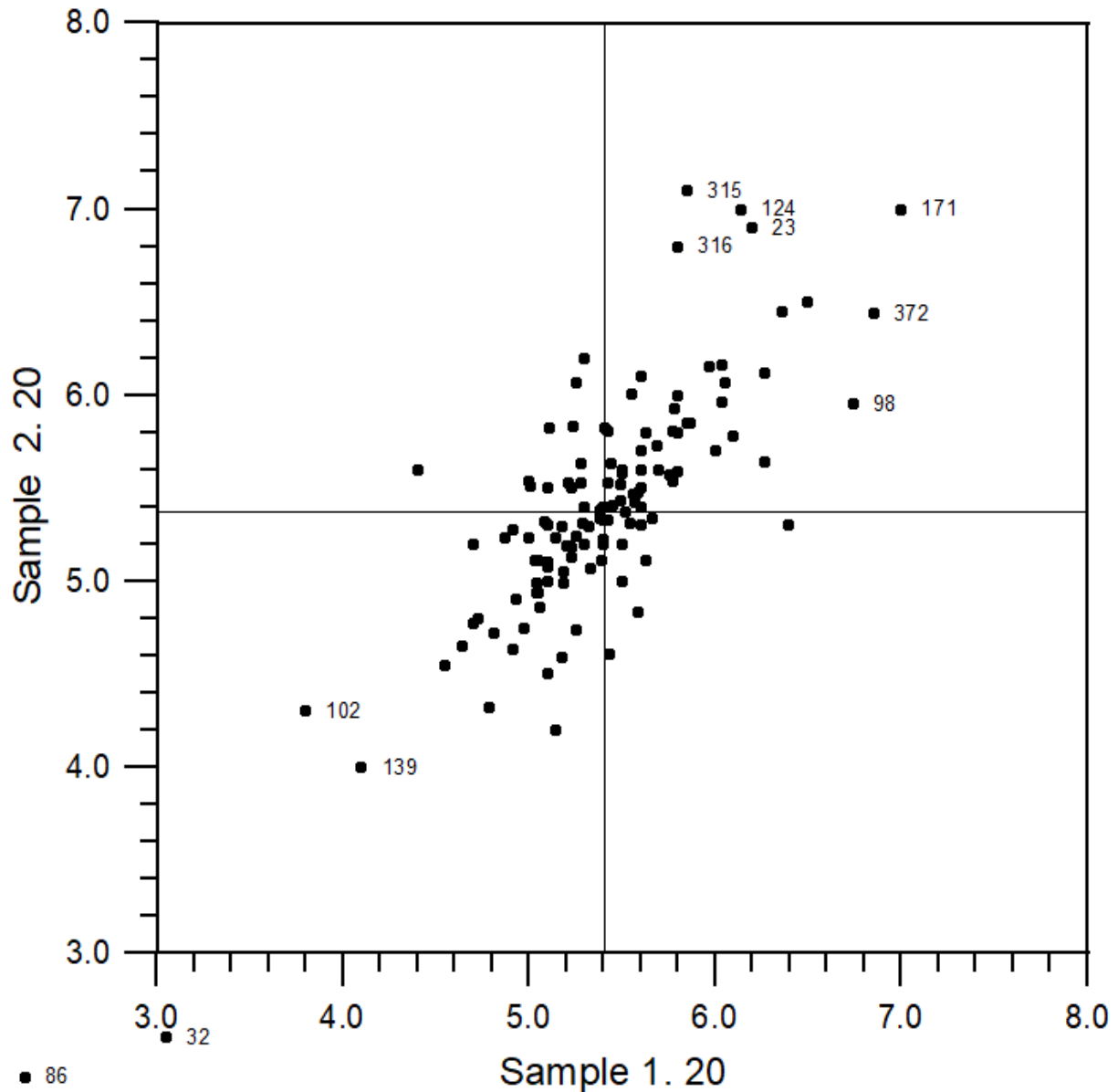
	Mat 1	Mat 2
Mean	2.337	2.336
Median	2.333	2.334
Std Dev	0.027	0.027

n = 120

Labs Eliminated: 21;23;86;102;263;275;315;316;431;

Figure 35. Scatter Diagram: Test 32 Max Dry Density

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



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

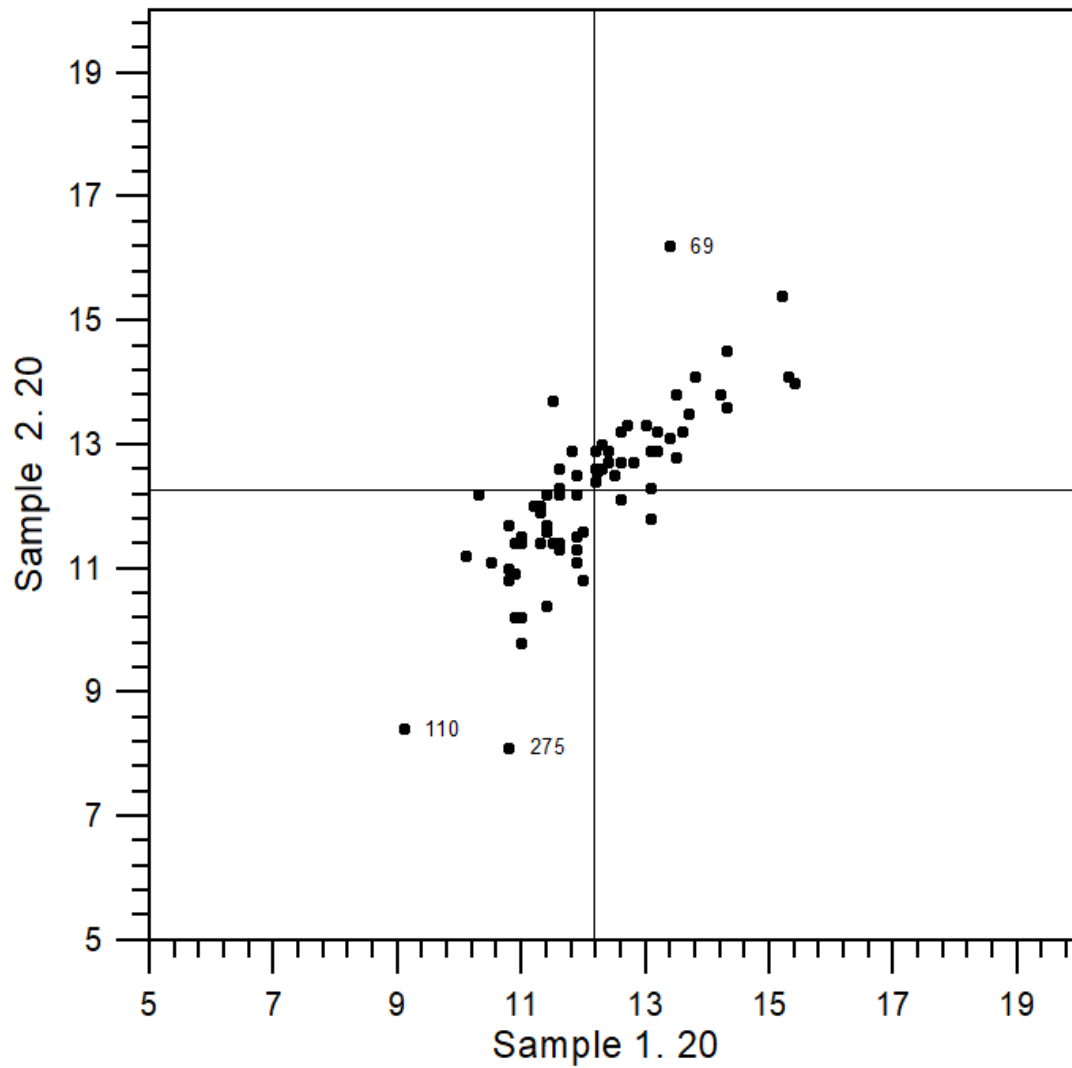
	Mat 1	Mat 2
Mean	5.409	5.376
Median	5.400	5.380
Std Dev	0.408	0.453

n = 118

Labs Eliminated: 23;32;86;98;102;124;139;171;315;316;372;

Figure 36. Scatter Diagram: Test 33 Optimum Moisture %

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

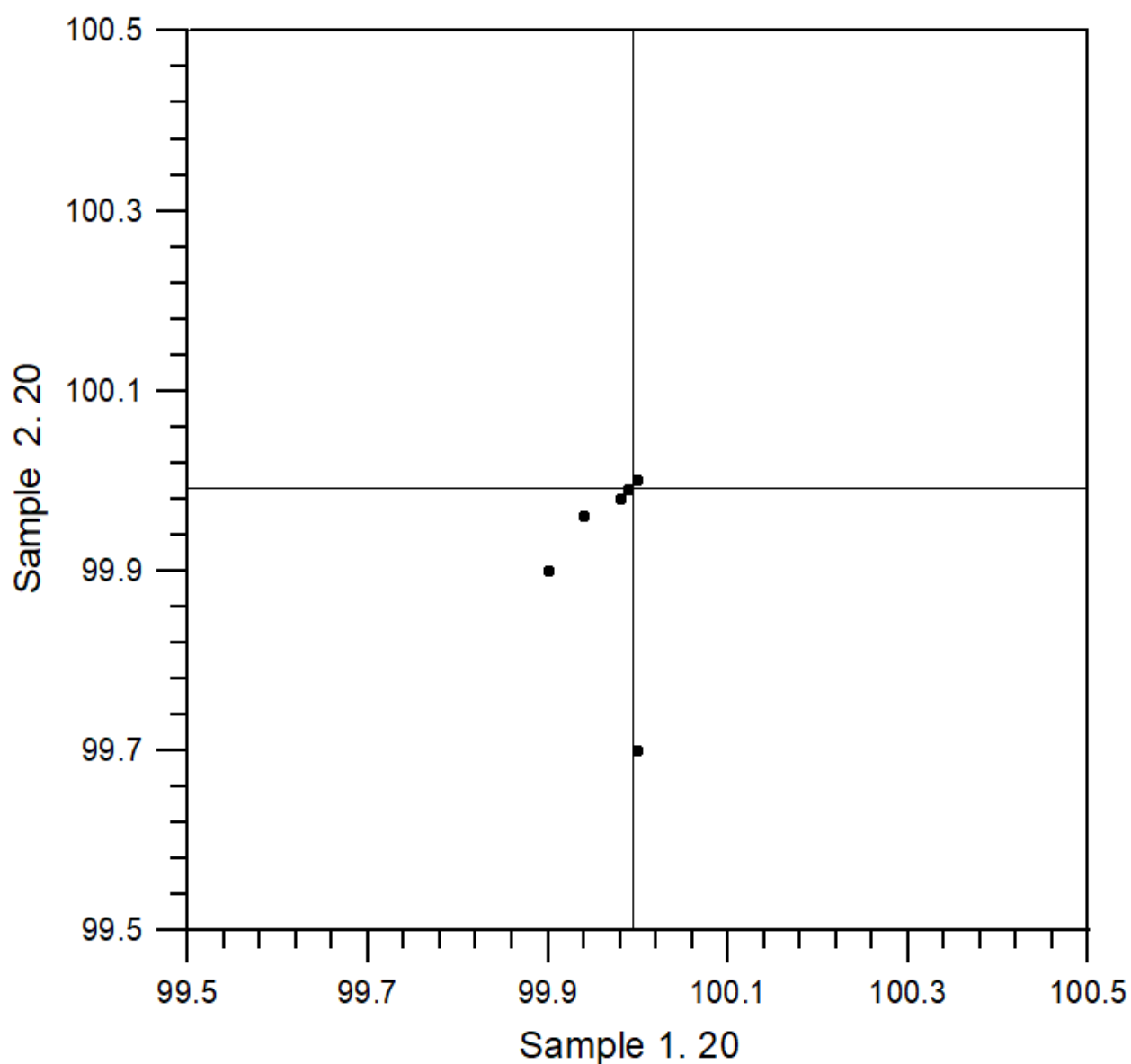
	Mat 1	Mat 2
Mean	12.171	12.275
Median	11.900	12.300
Std Dev	1.264	1.059

n = 75

Labs Eliminated: 69; 110; 275;

Figure 37. Scatter Diagram: Test 34 MDA, FA

**2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM**



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

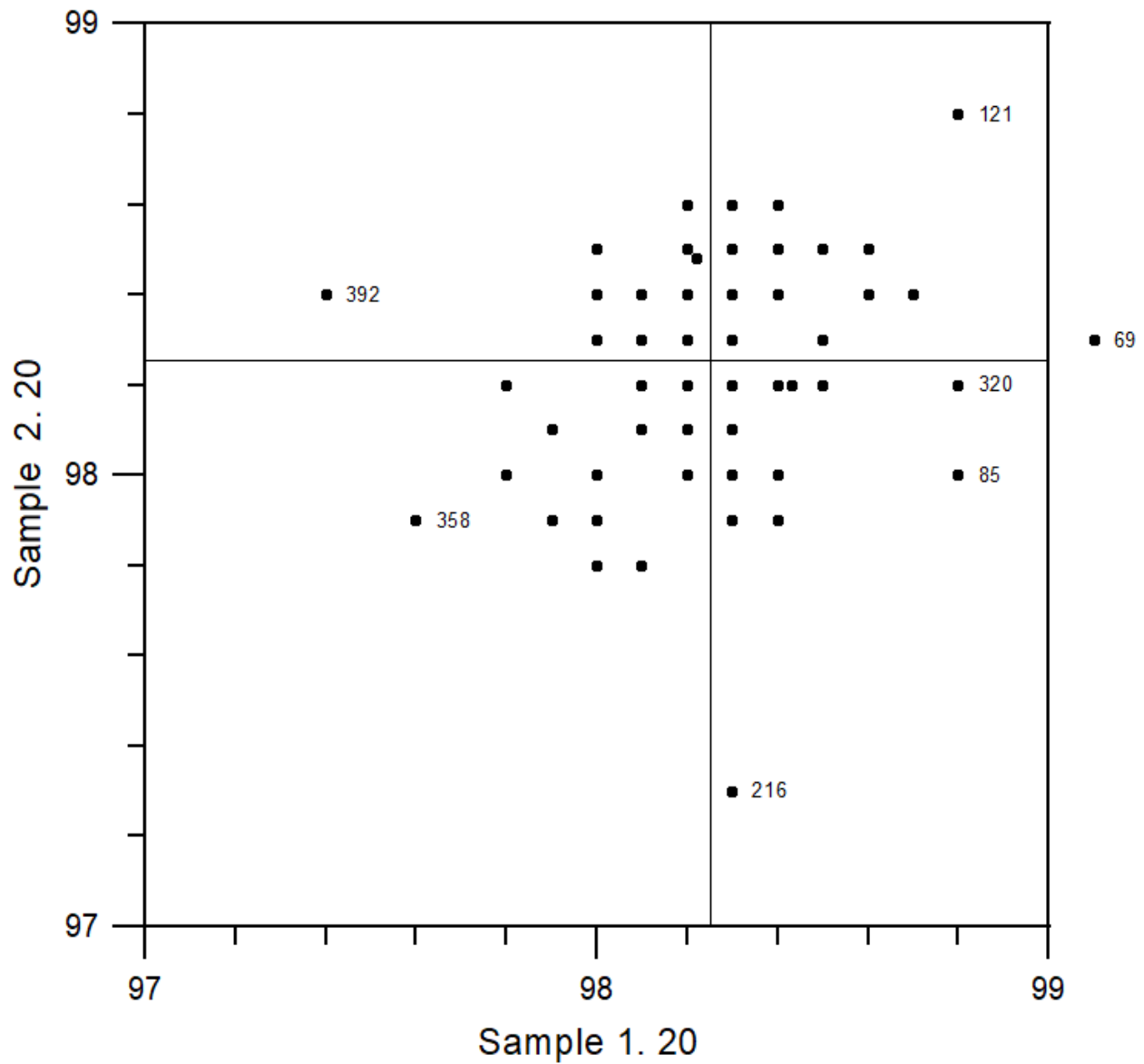
	Mat 1	Mat 2
Mean	99.995	99.992
Median	100.000	100.000
Std Dev	0.021	0.037

n = 94

Labs Eliminated: None

Figure 38. Scatter Diagram: Test 40 P 2.0 mm

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



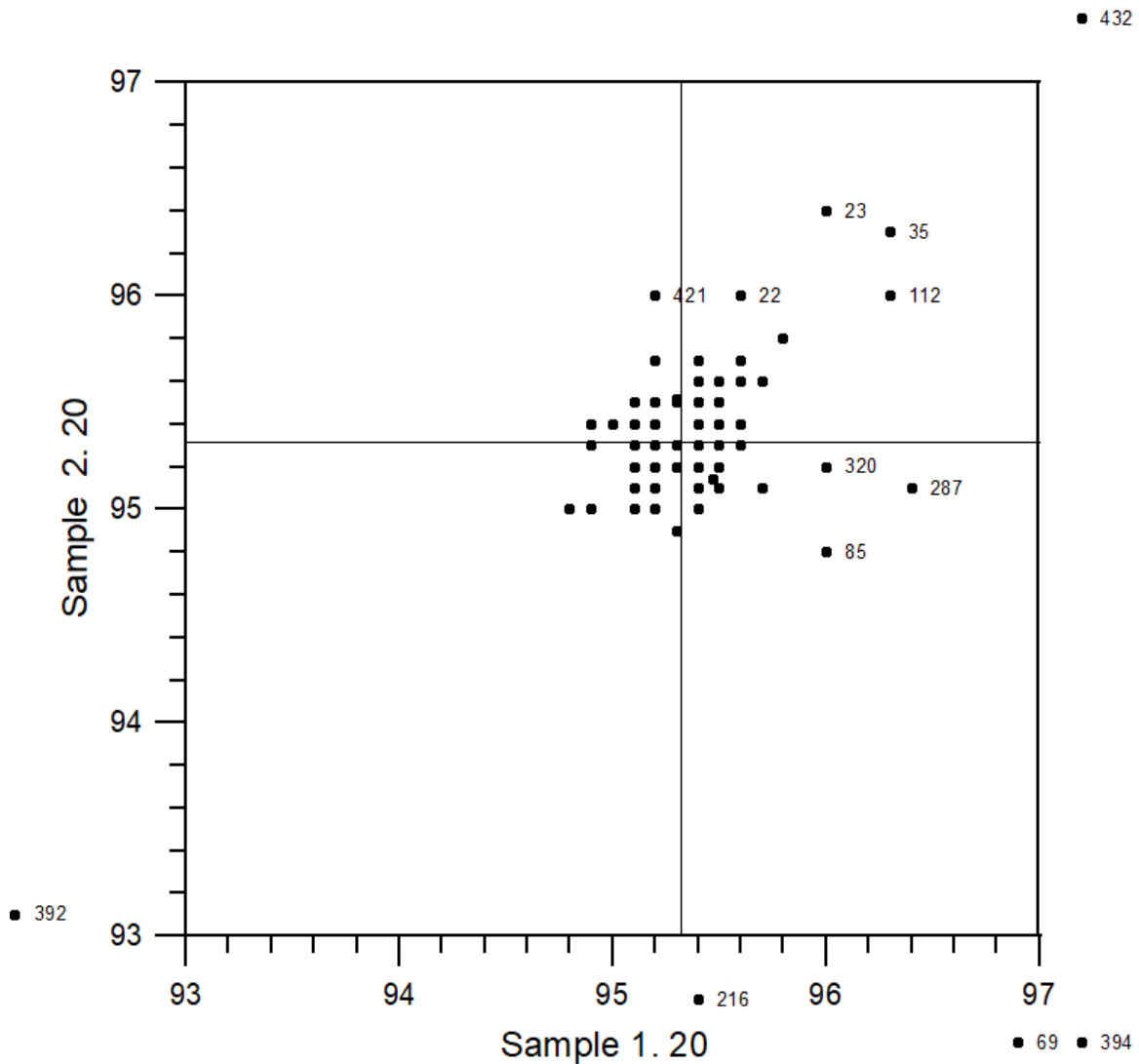
Test 41: Percent Passing the 425 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	98.251	98.254
Median	98.300	98.250
Std Dev	0.169	0.202
n = 87		

Labs Eliminated: 69;85;121;216;320;358;392;

Figure 39. Scatter Diagram: Test 41 P 425 µm

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



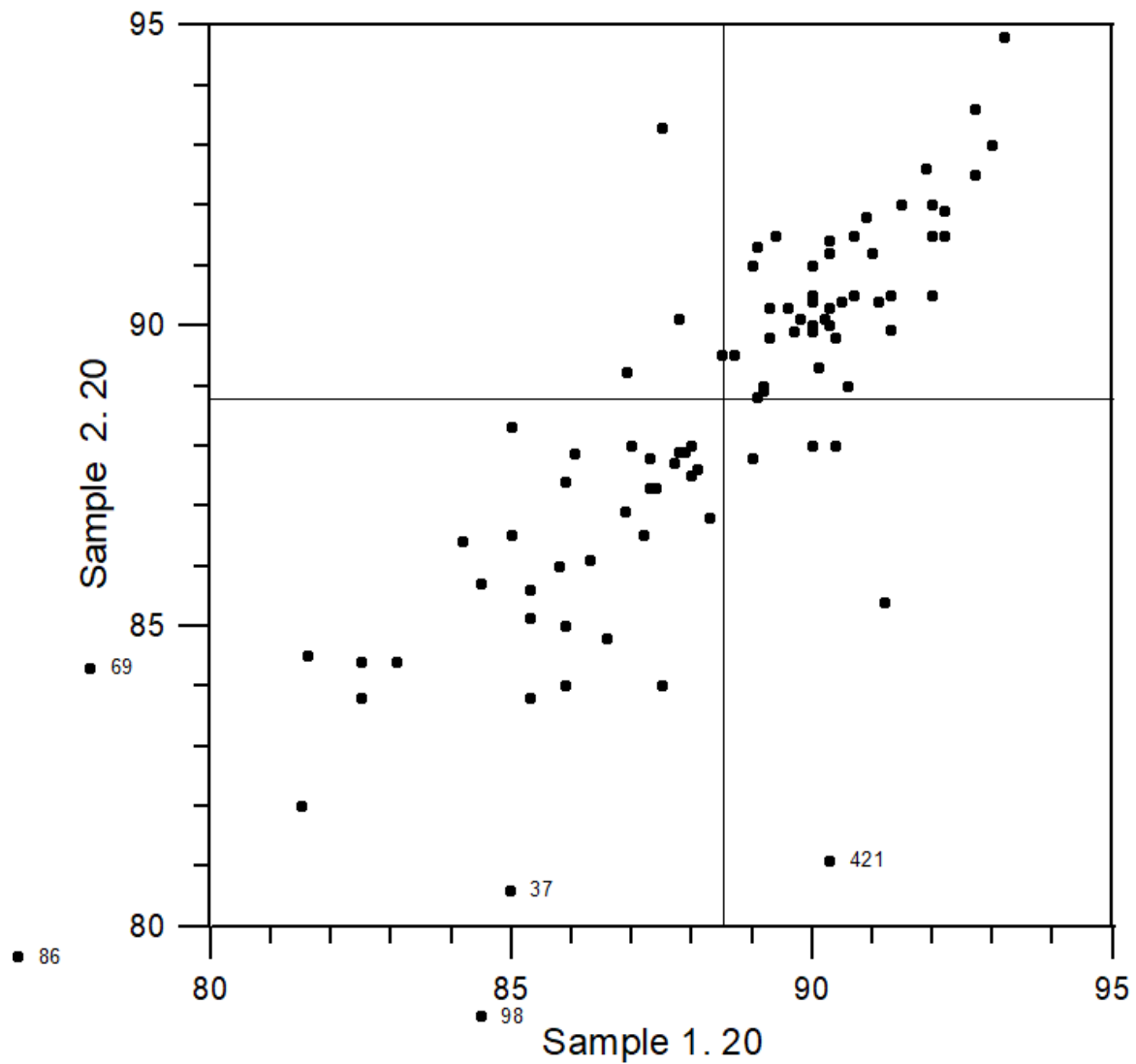
Test 42: Percent Passing the 75 μ m Sieve (Soil)

	Mat 1	Mat 2
Mean	95.319	95.314
Median	95.400	95.300
Std Dev	0.209	0.206
n =	81	

Labs Eliminated: 22;23;35;69;85;112;216;287;
320;392;394;421;432;

Figure 40. Scatter Diagram: Test 42 P 75 μ m

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

	Mat 1	Mat 2
Mean	88.531	88.768
Median	89.000	89.000
Std Dev	2.733	2.639

n = 89

Labs Eliminated: 37;69;86;98;421;

Figure 41. Scatter Diagram: Test 43 P 20 μm

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

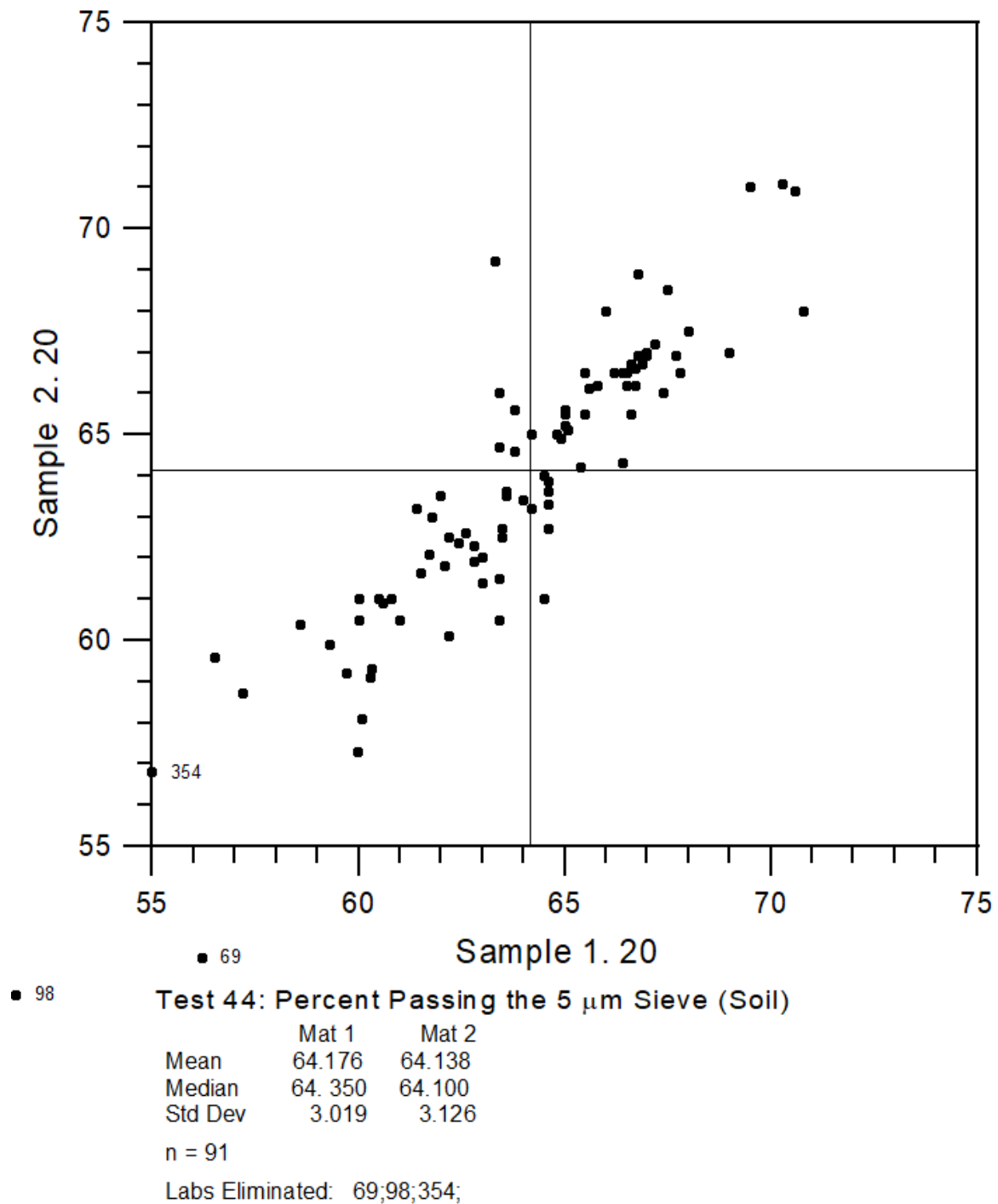
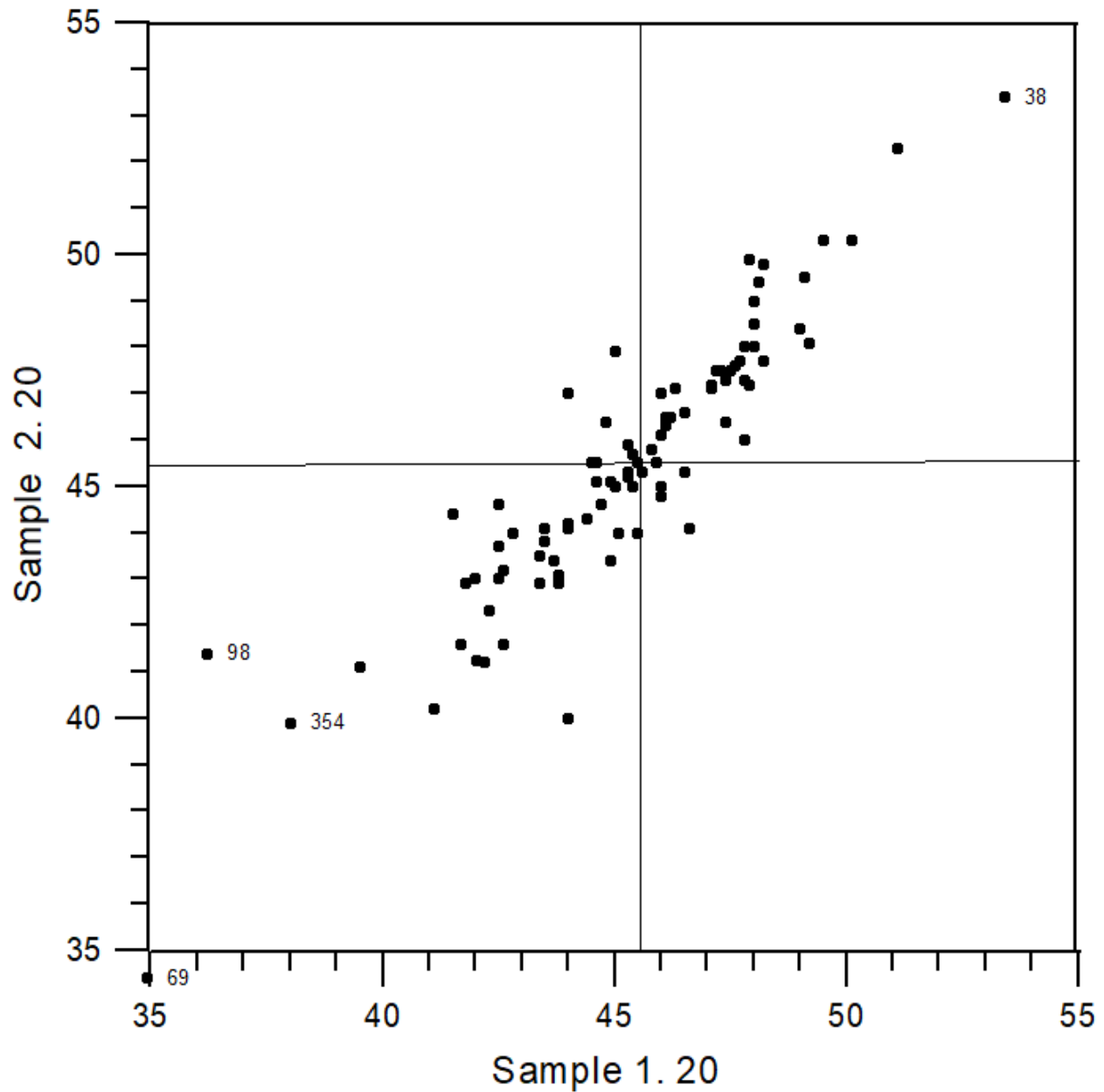


Figure 42. Scatter Diagram: Test 44 P 5 μ m

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



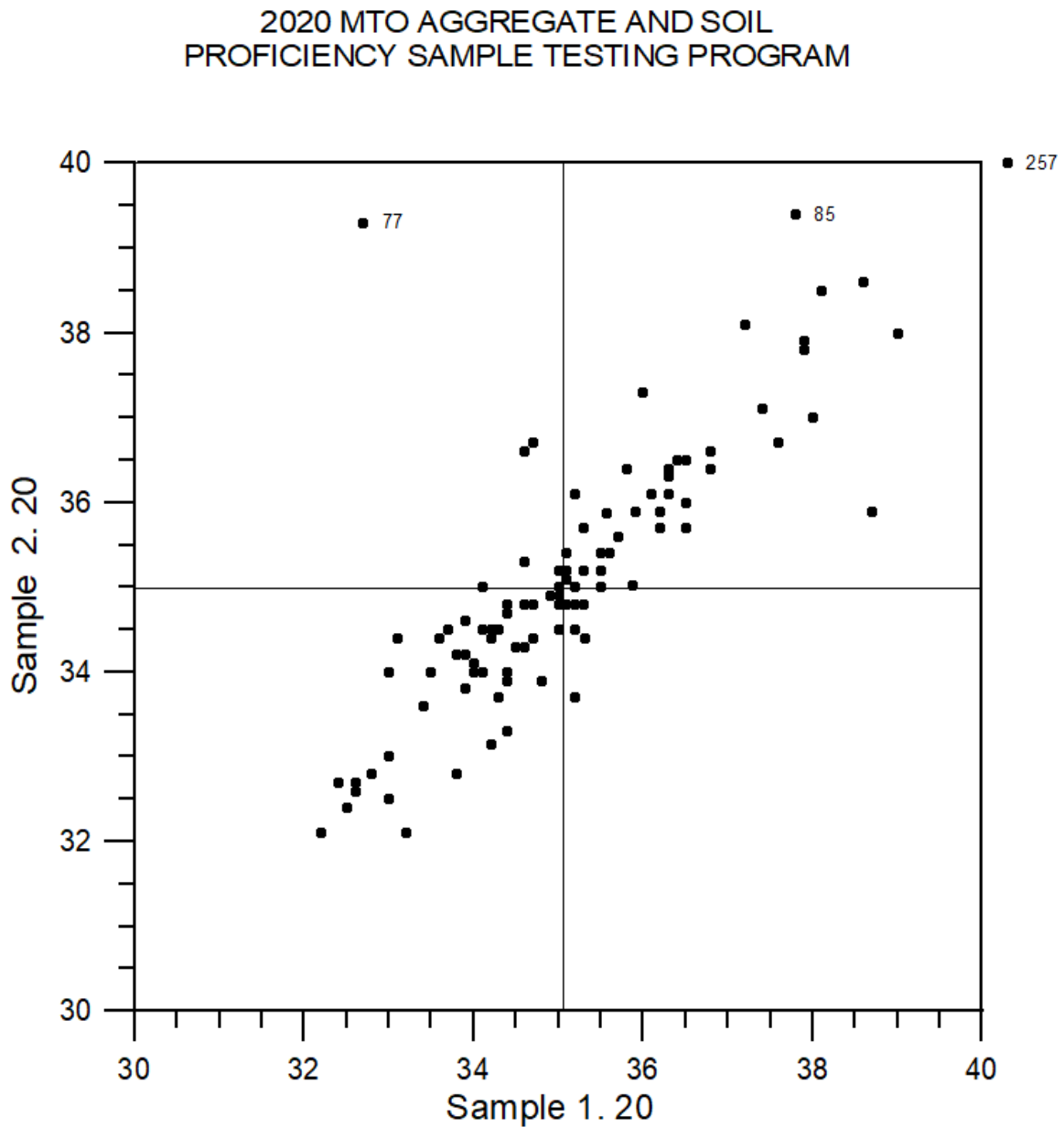
Test 45: Percent Passing the 2 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	45.546	45.562
Median	45.500	45.500
Std Dev	2.29	2.547

n = 90

Labs Eliminated: 38;69;98;354;

Figure 43. Scatter Diagram: Test 45 P 2 μ m



Test 46: Liquid Limit, %

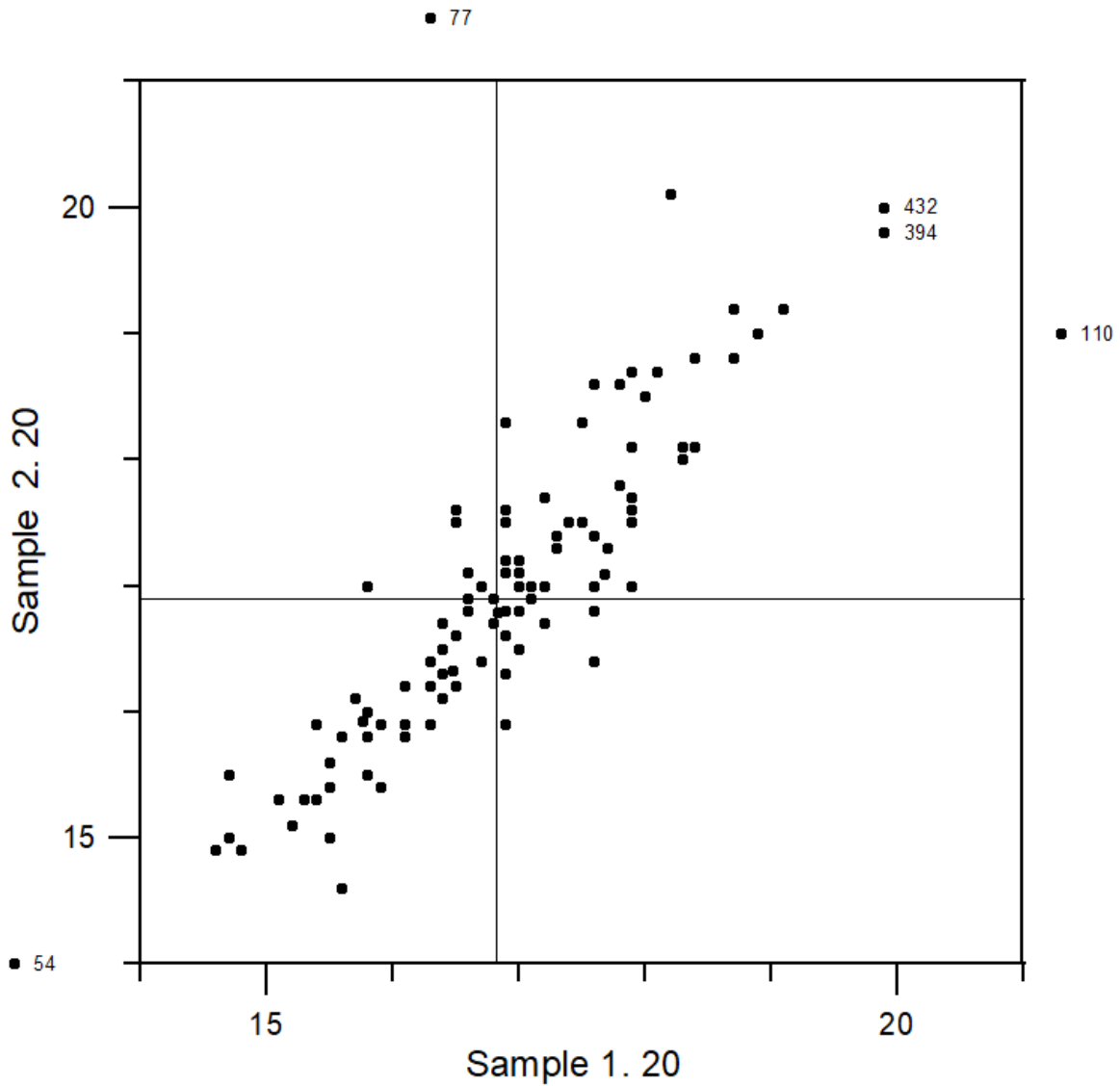
	Mat 1	Mat 2
Mean	35.050	34.989
Median	35.000	34.800
Std Dev	1.490	1.403

n = 105

Labs Eliminated: 77; 85; 257;

Figure 44. Scatter Diagram: Test 46 Liquid Limit %

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 47: Plastic Limit, %

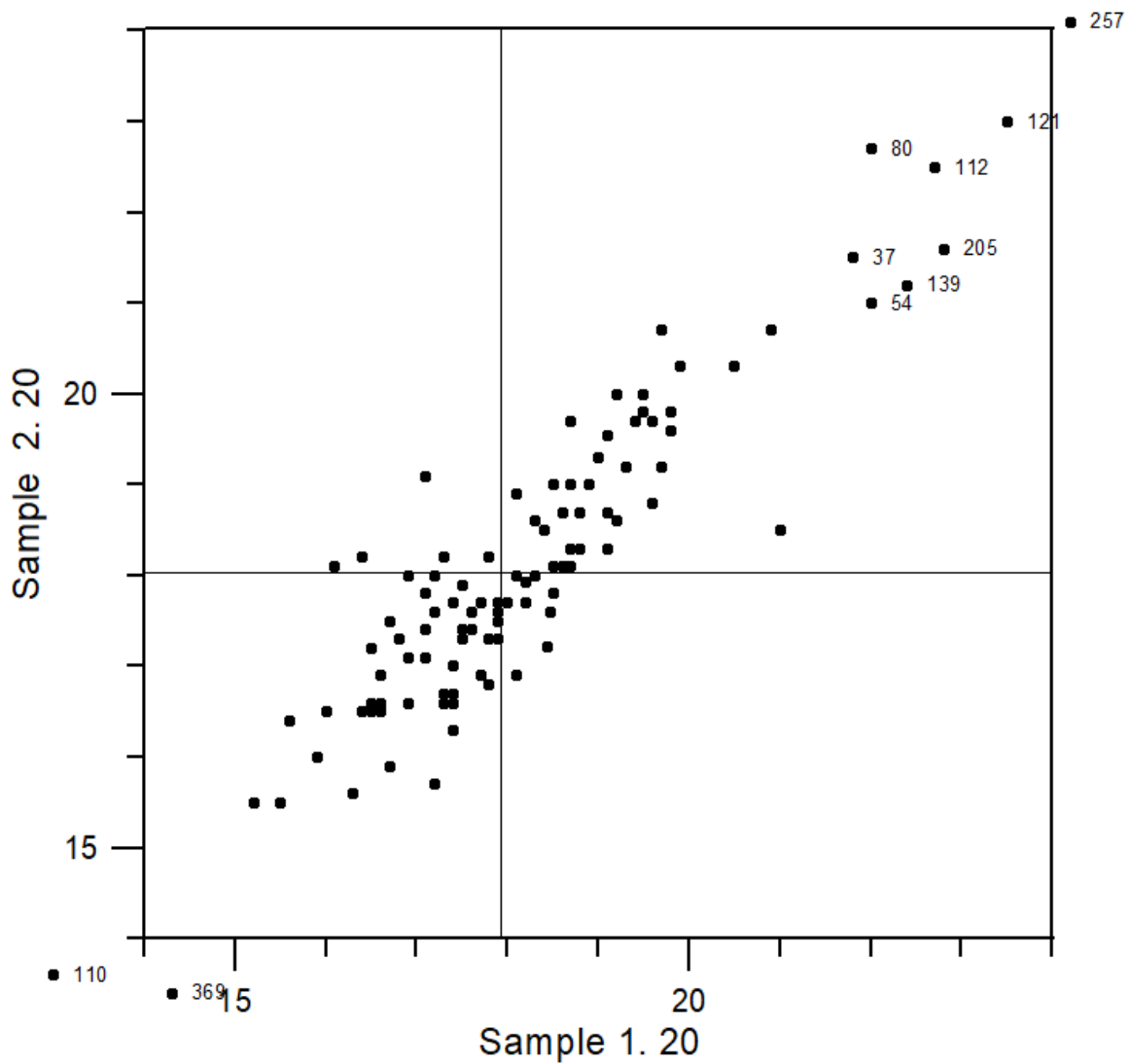
	Mat 1	Mat 2
Mean	16.819	16.898
Median	16.900	16.850
Std Dev	0.983	1.185

n = 103

Labs Eliminated: 54;77;110;394;432;

Figure 45. Scatter Diagram: Test 47 Plastic Limit %

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 48: Plasticity Index, %

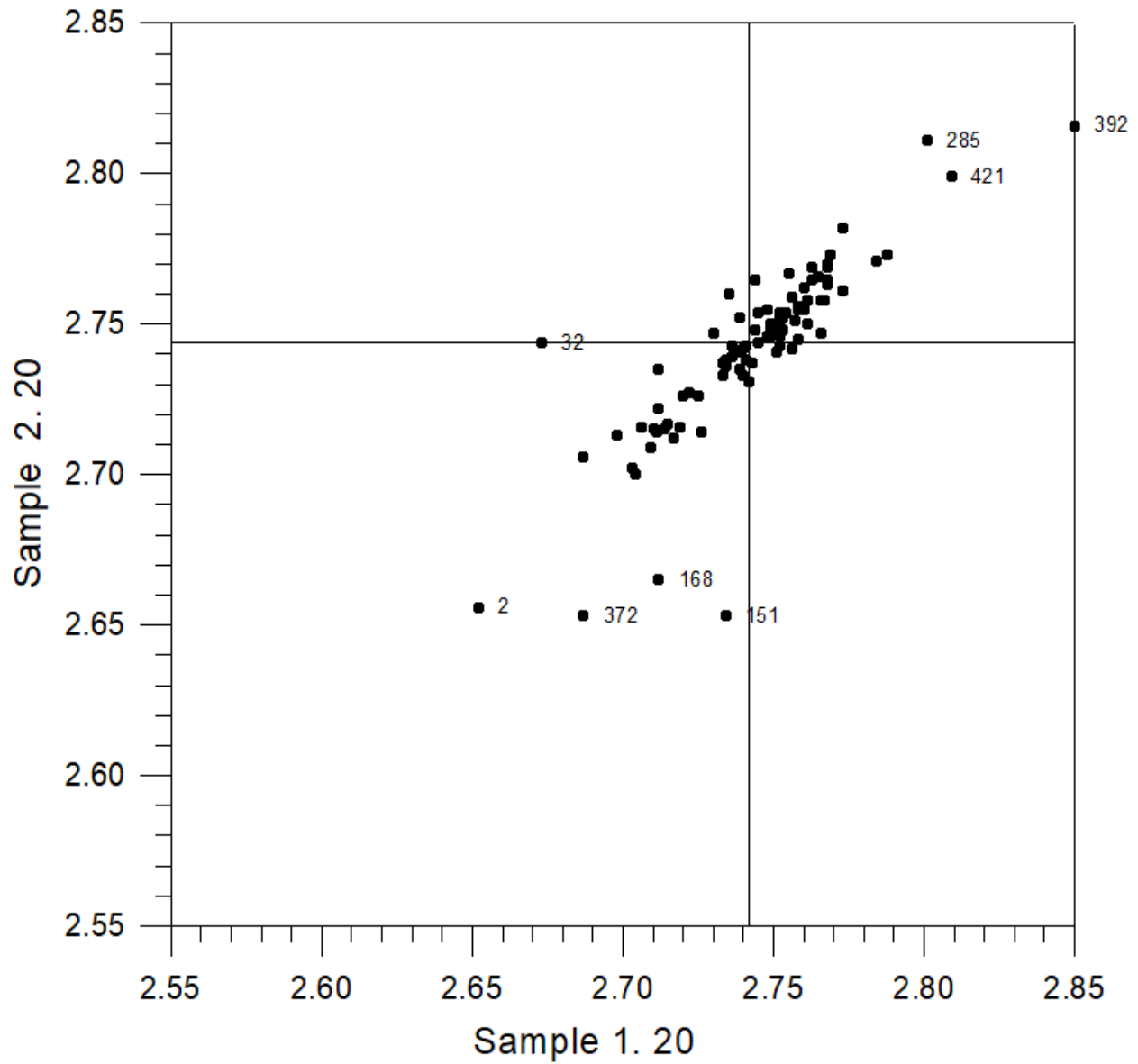
	Mat 1	Mat 2
Mean	17.931	18.027
Median	17.900	17.915
Std Dev	1.20	1.362

n = 98

Labs Eliminated: 37; 54; 80; 110;112;121;139;205;257;369;

Figure 46. Scatter Diagram: Test 48 Plasticity Index %

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 49: Specific Gravity of Soil²³

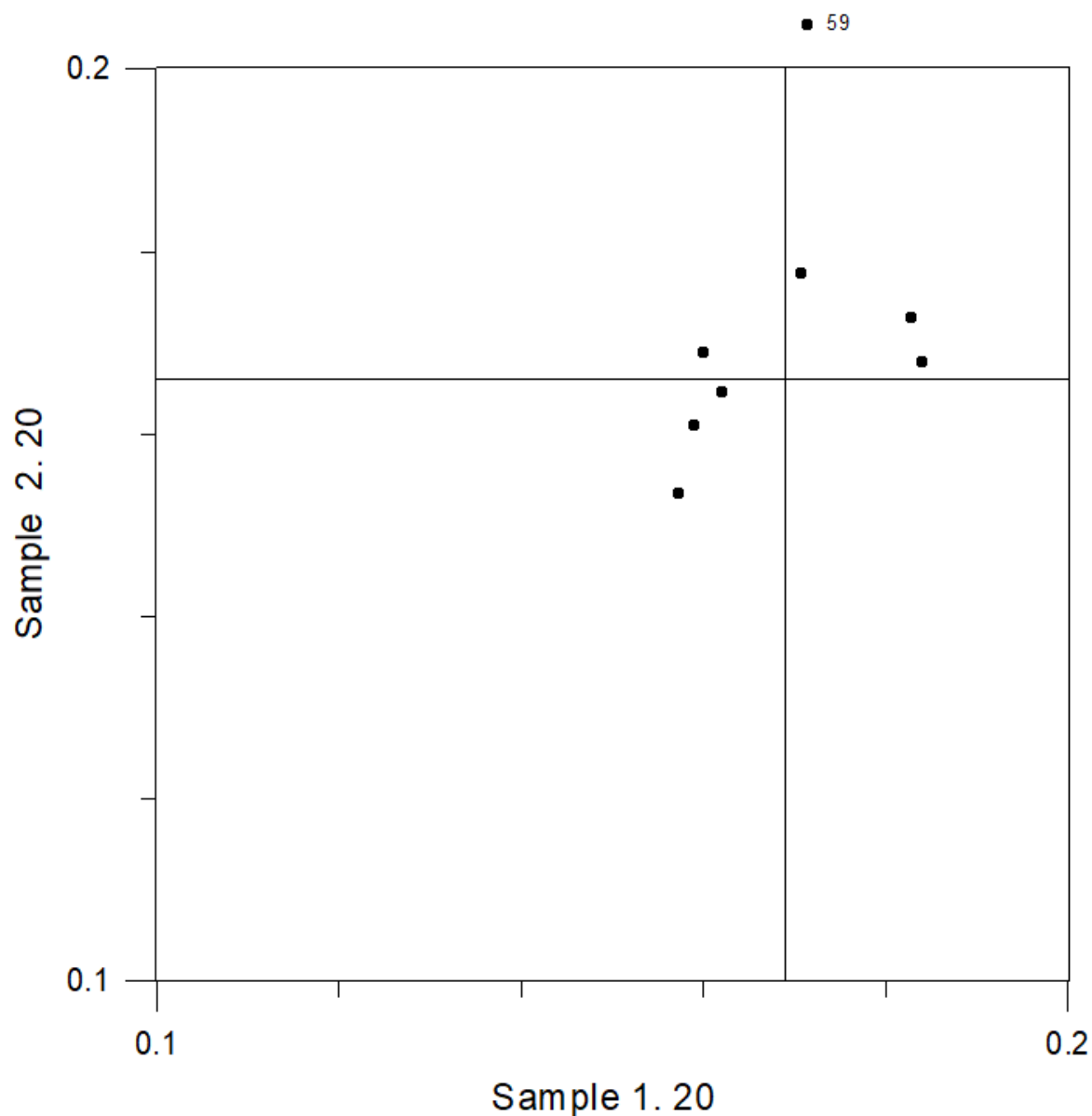
	Mat 1	Mat 2
Mean	2.742	2.744
Median	2.747	2.747
Std Dev	0.022	0.018

n = 84

Labs Eliminated: 2;23;32;151;168;285;372;392;421;

Figure 47. Scatter Diagram: Test 49 SG of Soils

2020 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 122: Concrete Prism (M1) at 38° C- Expansion at 52 Weeks

	Mat 1	Mat 2
Mean	0.169	0.166
Median	0.171	0.166
Std Dev	0.010	0.007

n = 8

Labs Eliminated: 59;

Figure 48. Scatter Diagram: Test 122 Concrete Prism Test (M1) at 38°C – Expansion at 52 Weeks

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

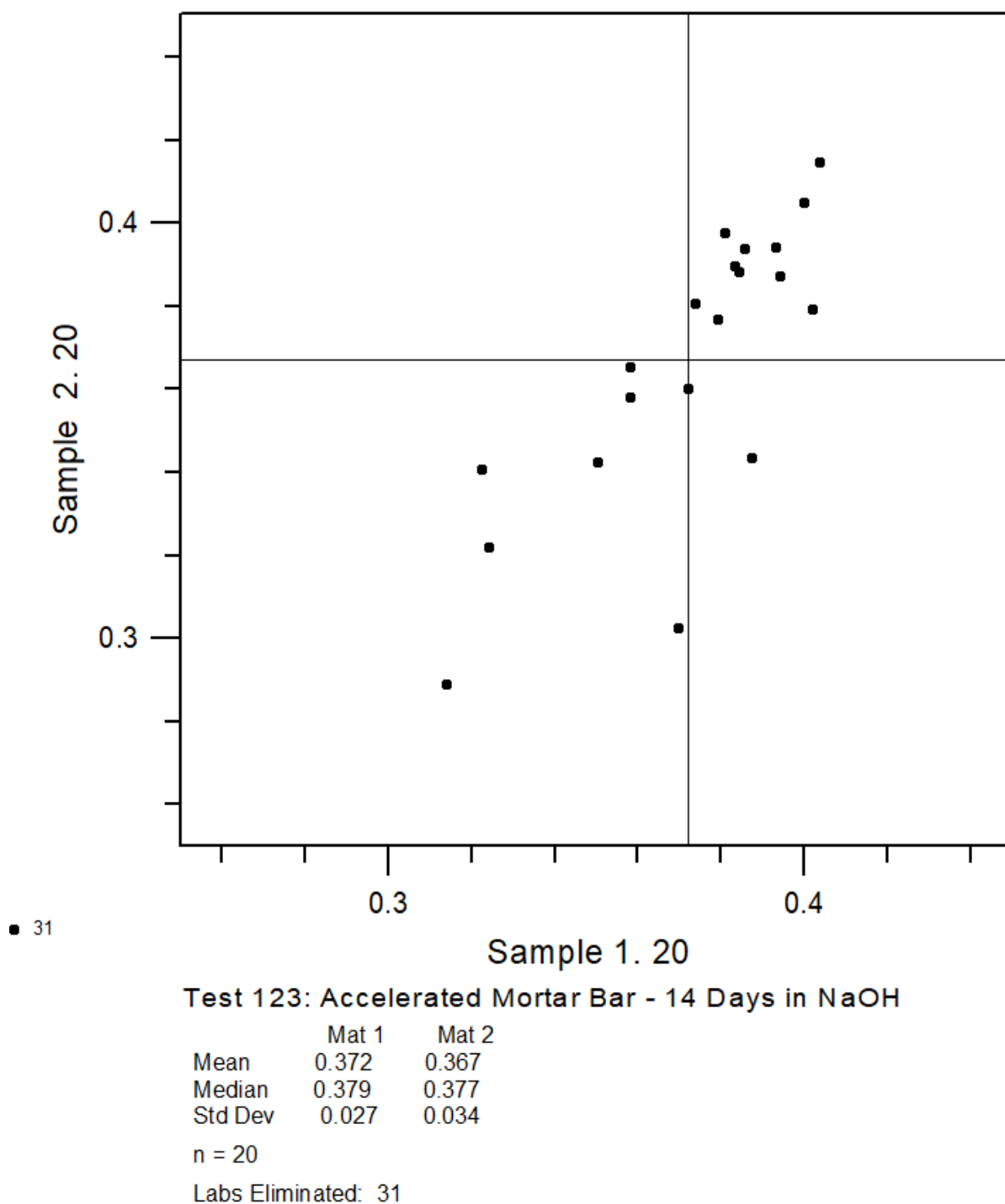
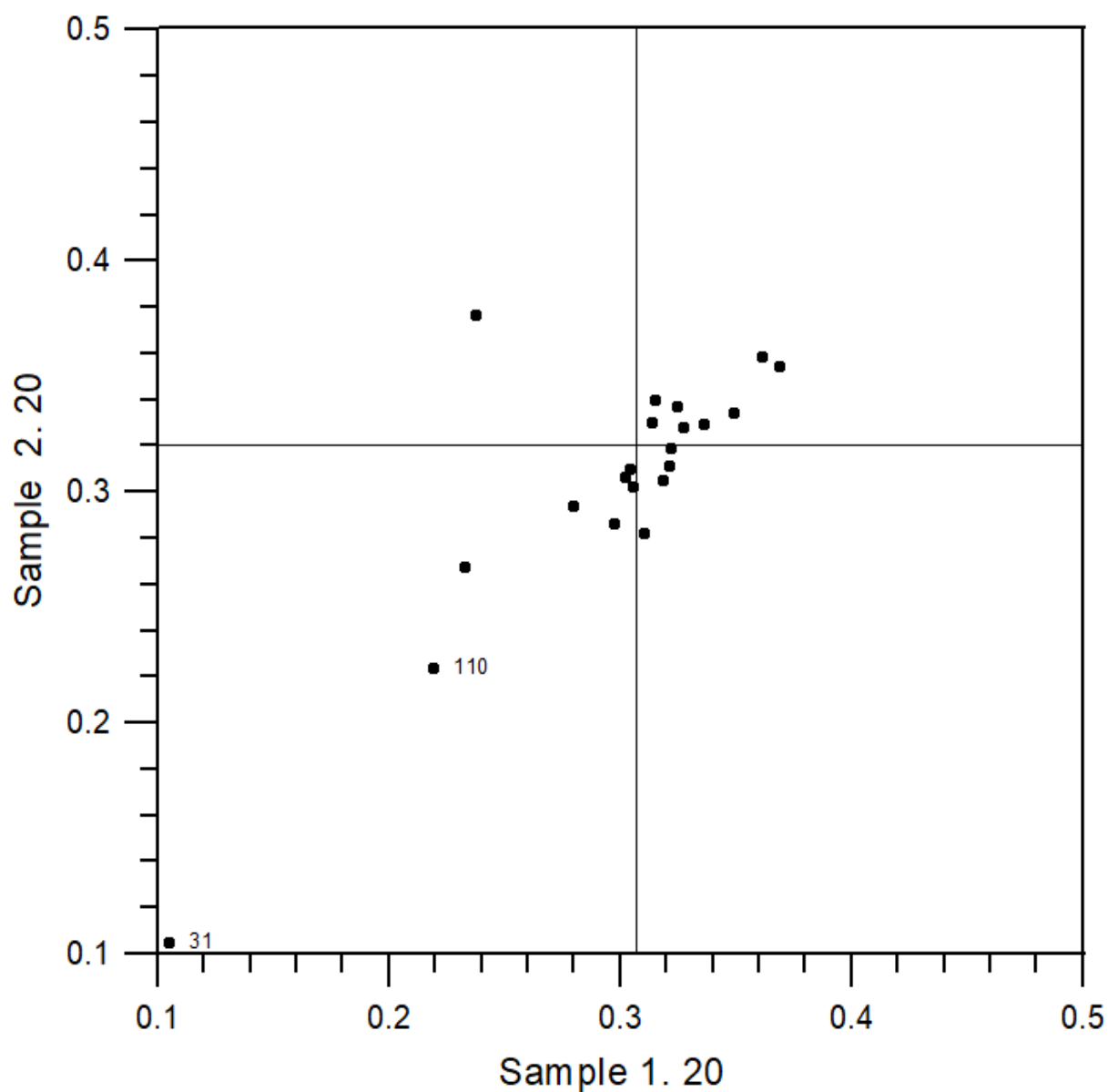


Figure 49. Scatter Diagram: Test 123 AMB (M1).

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 124: Accelerated Mortar Bar - 14 Days in NaOH

	Mat 1	Mat 2
Mean	0.307	0.320
Median	0.318	0.319
Std Dev	0.040	0.028

n = 19

Labs Eliminated: 31;110;

Figure 50. Scatter Diagram: Test 124 AMB (M2).

A scatter plot showing the relationship between Sample 1.20 (X-axis) and Sample 2.20 (Y-axis). The X-axis ranges from 0.0 to 0.2, and the Y-axis ranges from 0.0 to 0.2. A vertical line is drawn at X = 0.11. Data points are plotted as black squares. Most points are clustered near the top right, with a few points at lower values. Two points are labeled: 376 and 59.

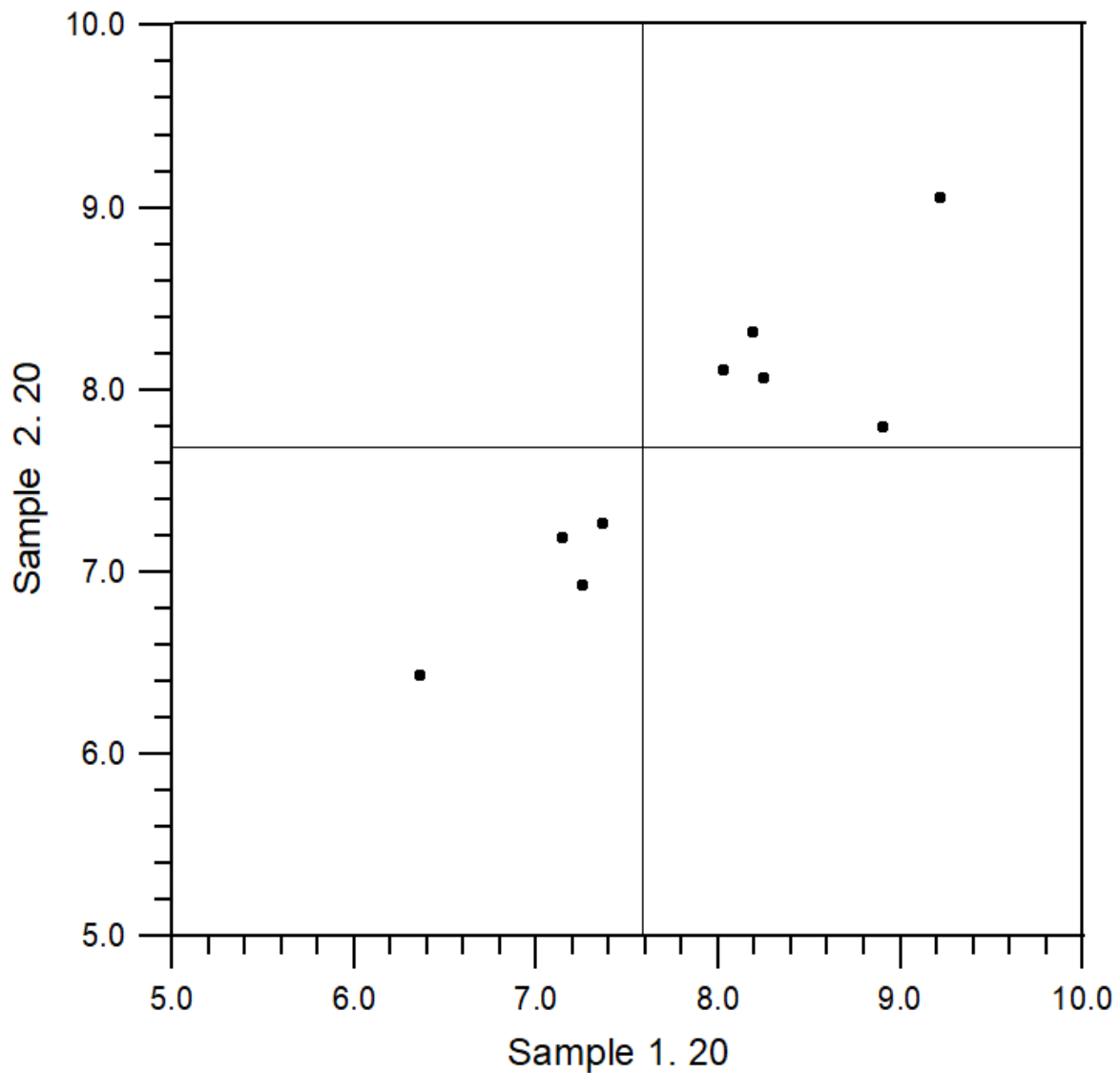
Sample 1.20	Sample 2.20	Label
0.04	0.02	376
0.08	0.08	59
0.09	0.07	
0.10	0.09	
0.11	0.11	
0.11	0.12	
0.11	0.13	
0.12	0.11	
0.12	0.12	
0.12	0.13	

	Mat 1	Mat 2
Mean	0.109	0.101
Median	0.110	0.107
Std Dev	0.007	0.016

Labs Eliminated: 59; 376;

G-45

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

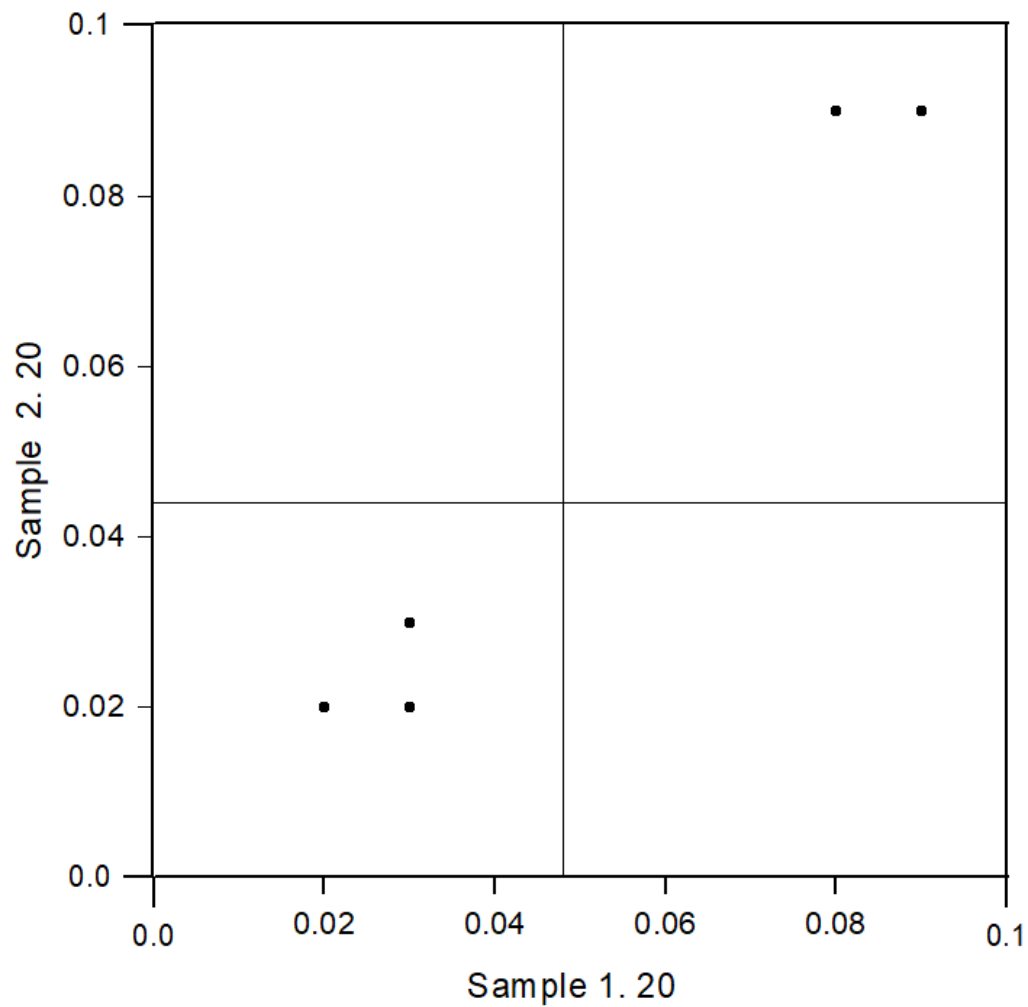
	Mat 1	Mat 2
Mean	7.586	7.687
Median	8.030	7.800
Std Dev	0.909	0.806

n = 9

Labs Eliminated: None

Figure 52. Scatter Diagram: Test 126 % of SiO_2 .

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 127: Weight % of TiO_2 - Chemical Composition of Rocks

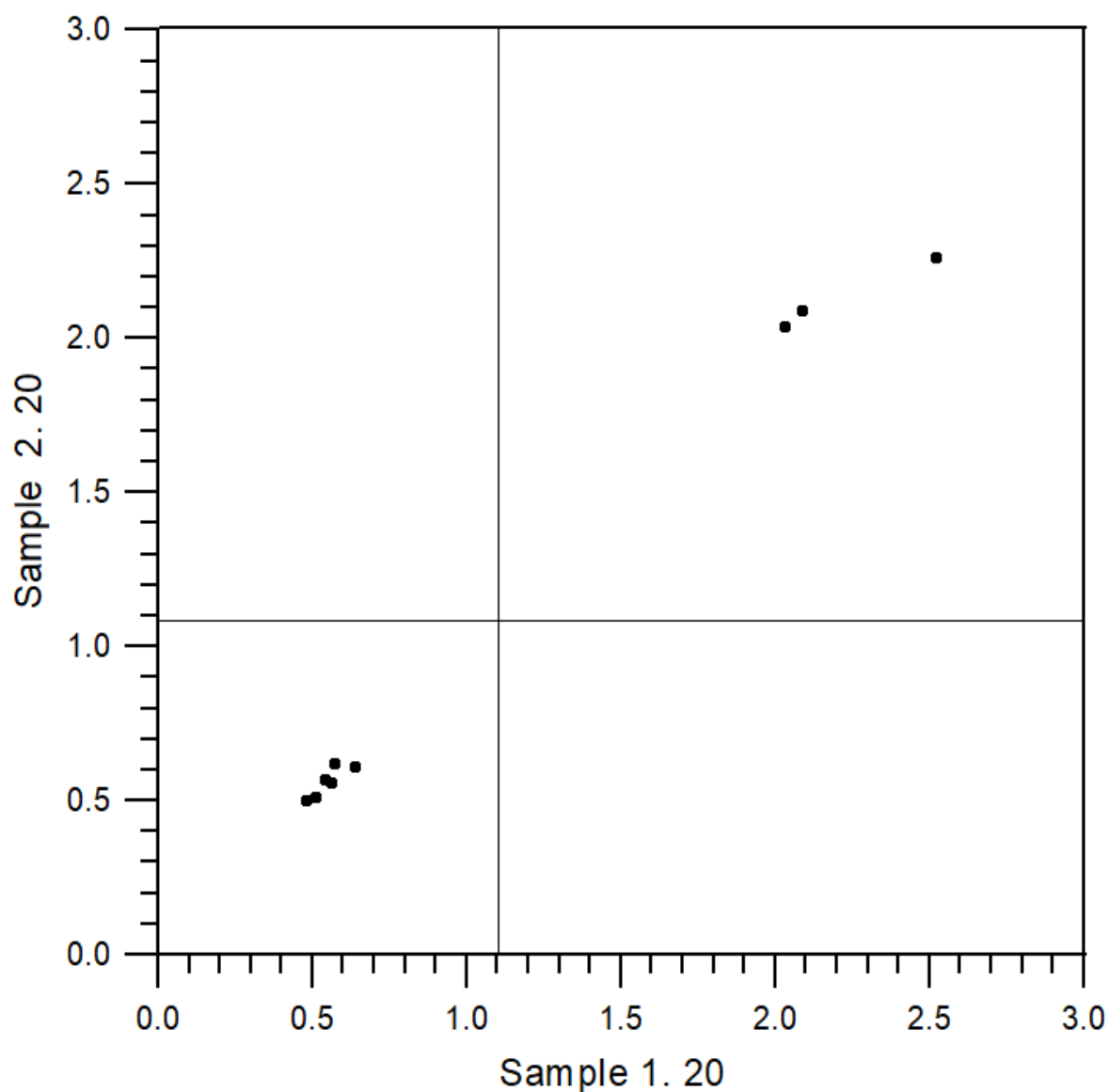
	Mat 1	Mat 2
Mean	0.048	0.044
Median	0.030	0.034
Std Dev	0.038	0.034

n = 9

Labs Eliminated: None

Figure 53. Scatter Diagram: Test 127 % of TiO_2 .

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

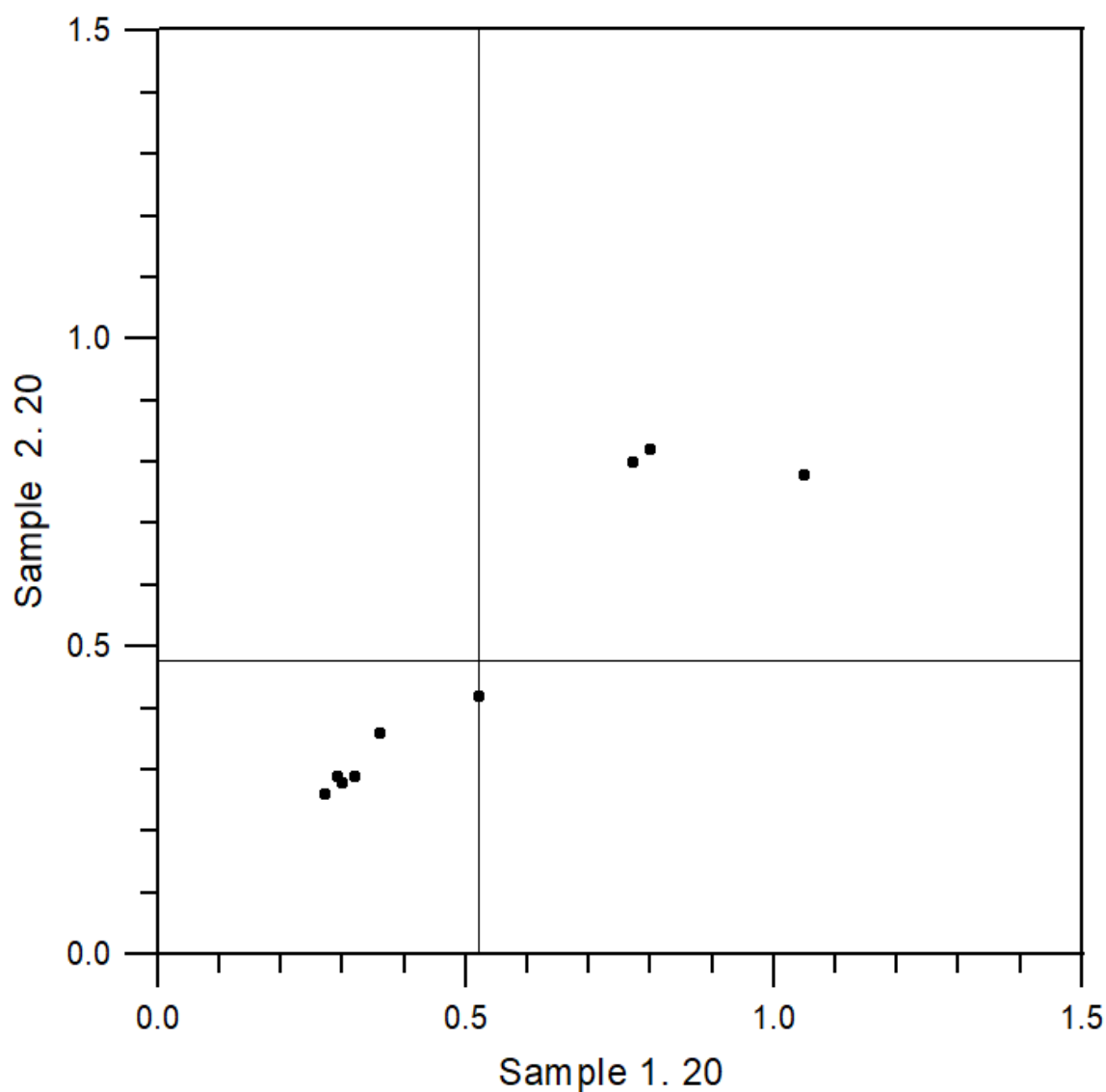
	Mat 1	Mat 2
Mean	1.104	1.084
Median	0.570	0.610
Std Dev	0.843	0.787

n = 9

Labs Eliminated: None

Figure 54. Scatter Diagram: Test 128 % of Al_2O_3 .

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

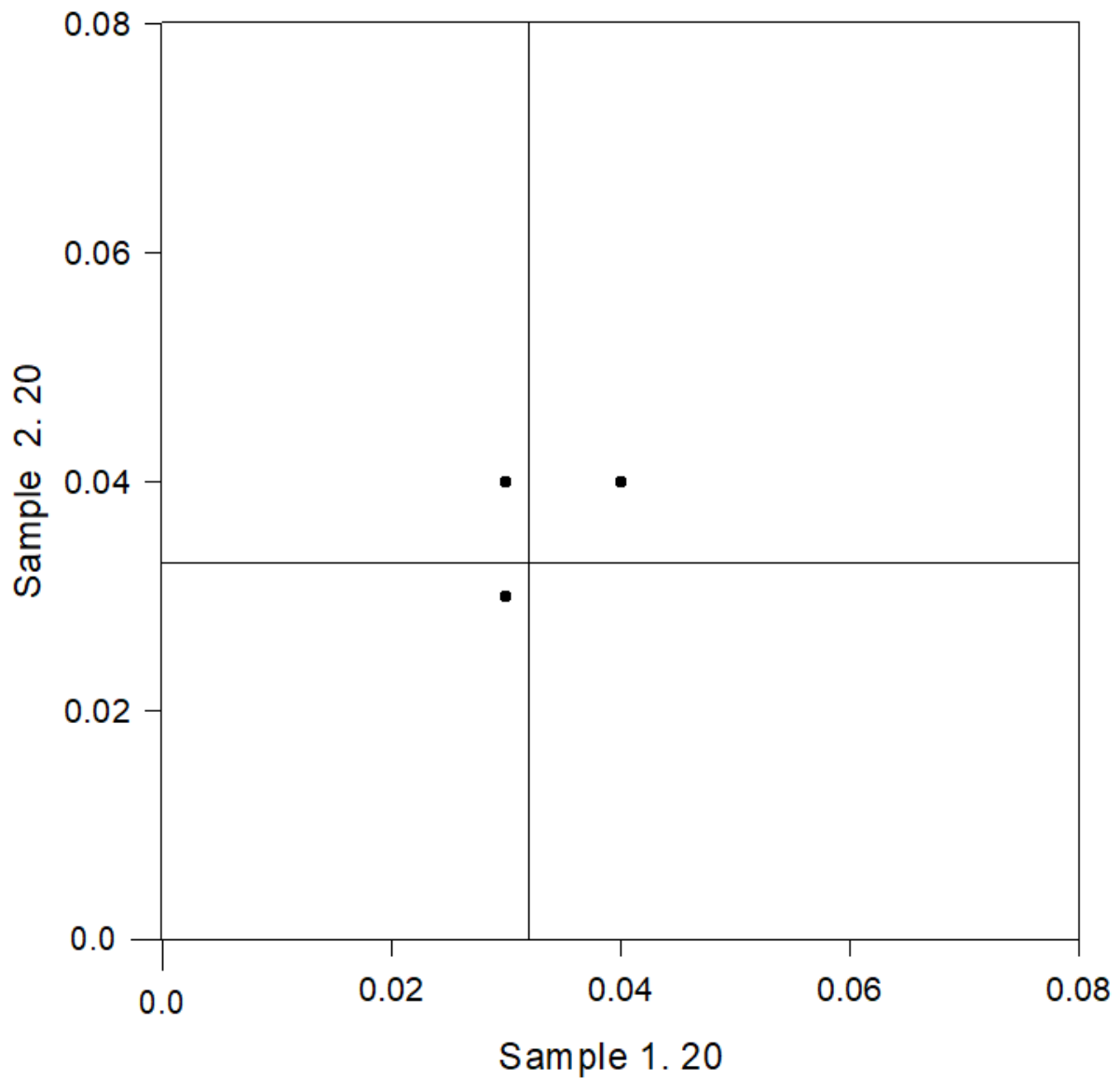
	Mat 1	Mat 2
Mean	0.520	0.478
Median	0.360	0.360
Std Dev	0.285	0.247

n = 9

Labs Eliminated: None

Figure 55. Scatter Diagram: Test 129 % of Fe_2O_3 .

**2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM**



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

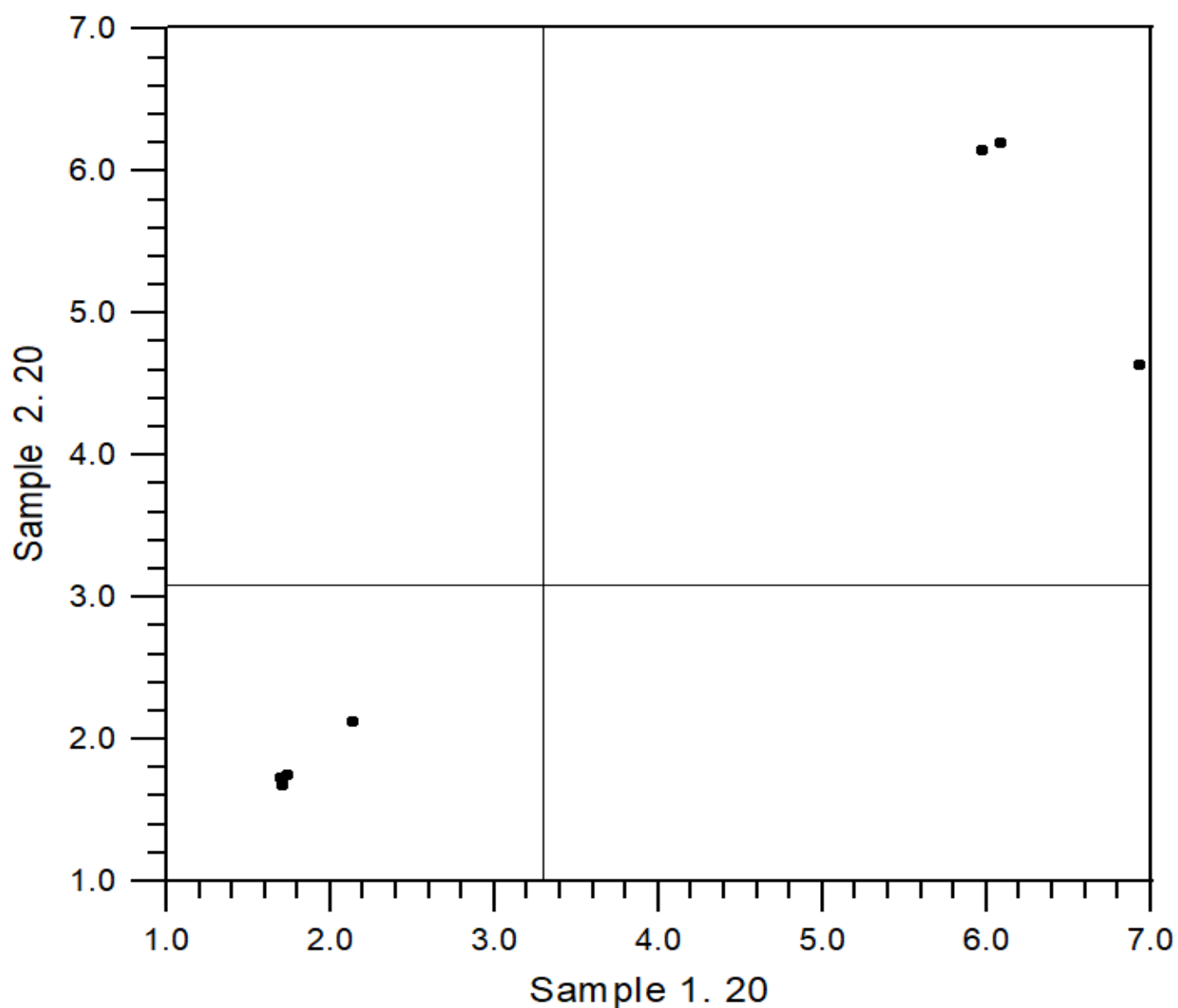
	Mat 1	Mat 2
Mean	0.032	0.033
Median	0.030	0.030
Std Dev	0.004	0.005

n = 9

Labs Eliminated: None

Figure 56. Scatter Diagram: Test 130 % of MnO.

**2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM**



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

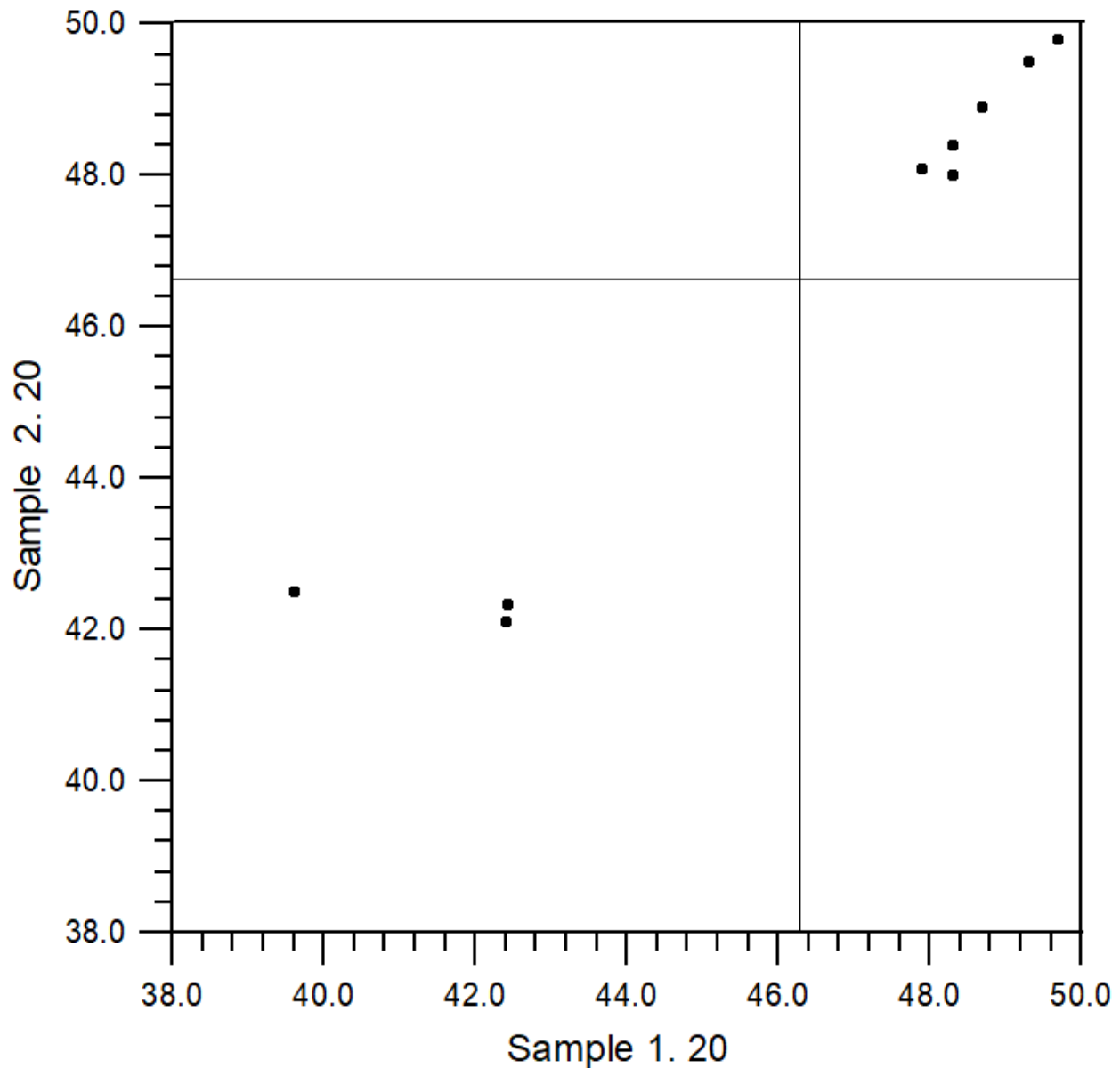
	Mat 1	Mat 2
Mean	3.299	3.082
Median	1.740	1.750
Std Dev	2.290	1.990

n = 9

Labs Eliminated: None

Figure 57. Scatter Diagram: Test 131 % of MgO.

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

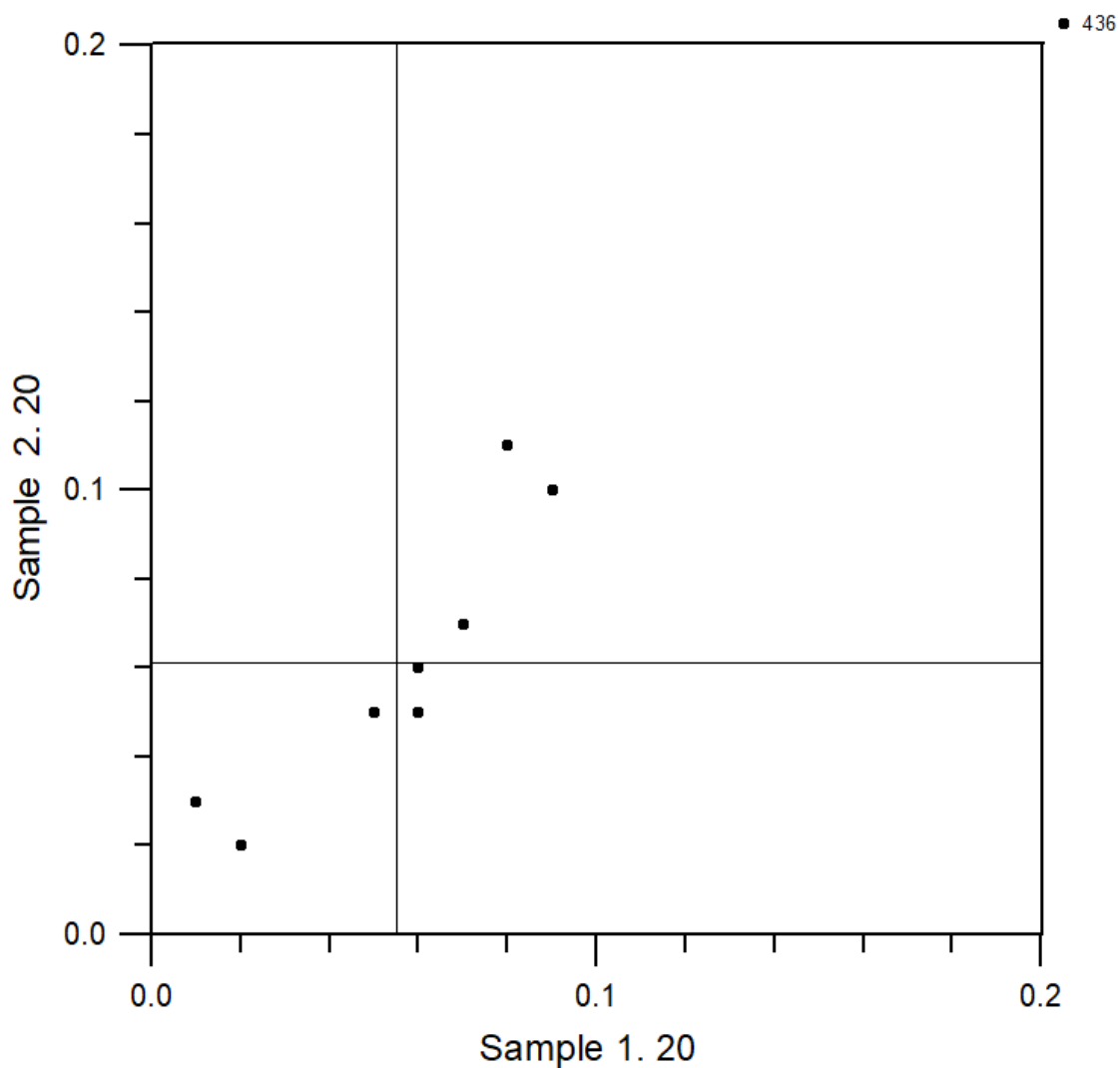
	Mat 1	Mat 2
Mean	46.291	46.627
Median	48.300	48.100
Std Dev	3.742	3.290

n = 9

Labs Eliminated: None

Figure 58. Scatter Diagram: Test 132 % of CaO.

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

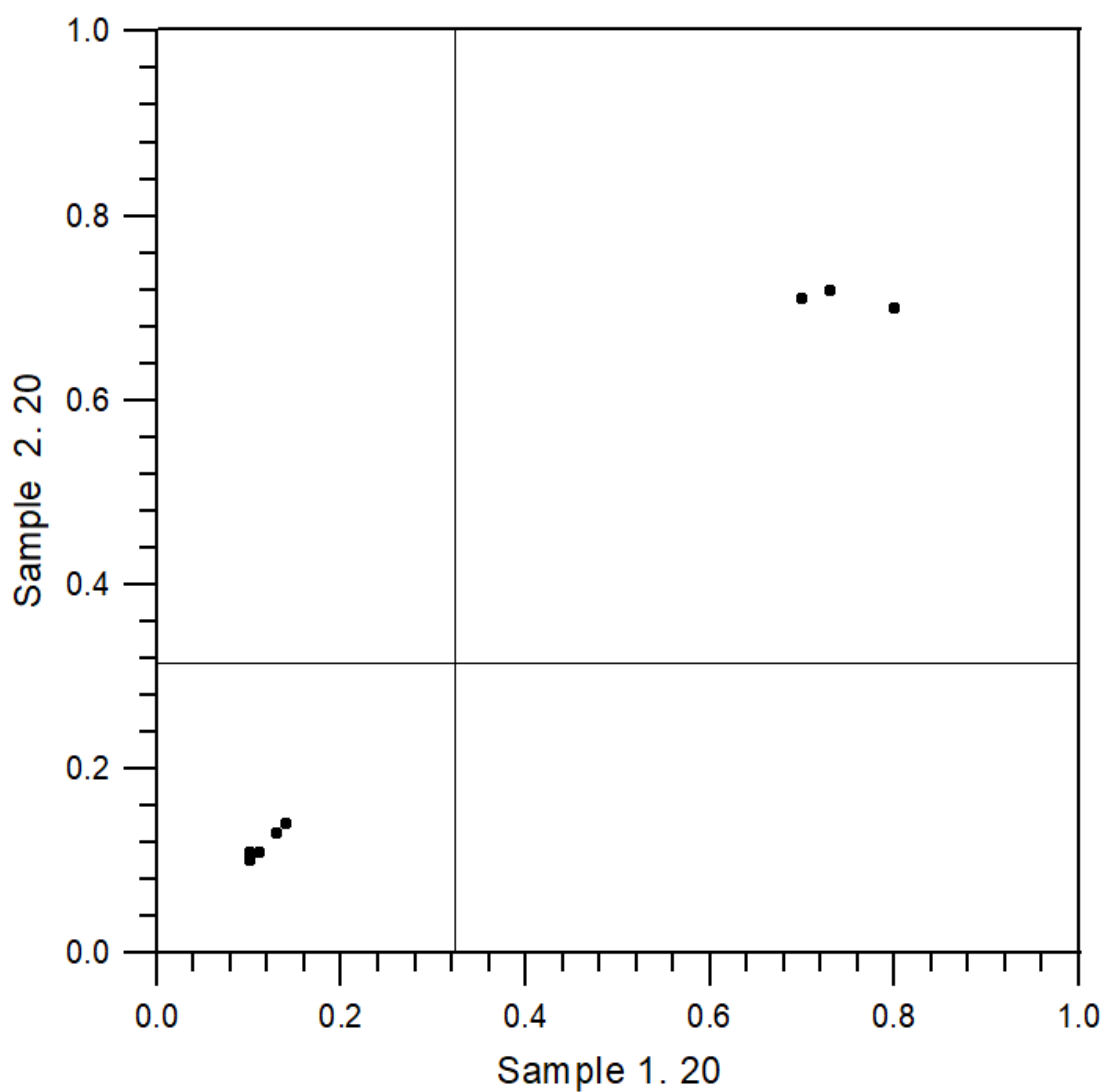
	Mat 1	Mat 2
Mean	0.055	0.061
Median	0.060	0.055
Std Dev	0.028	0.031

n = 8

Labs Eliminated: 436;

Figure 59. Scatter Diagram: Test 133 % of Na_2O .

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

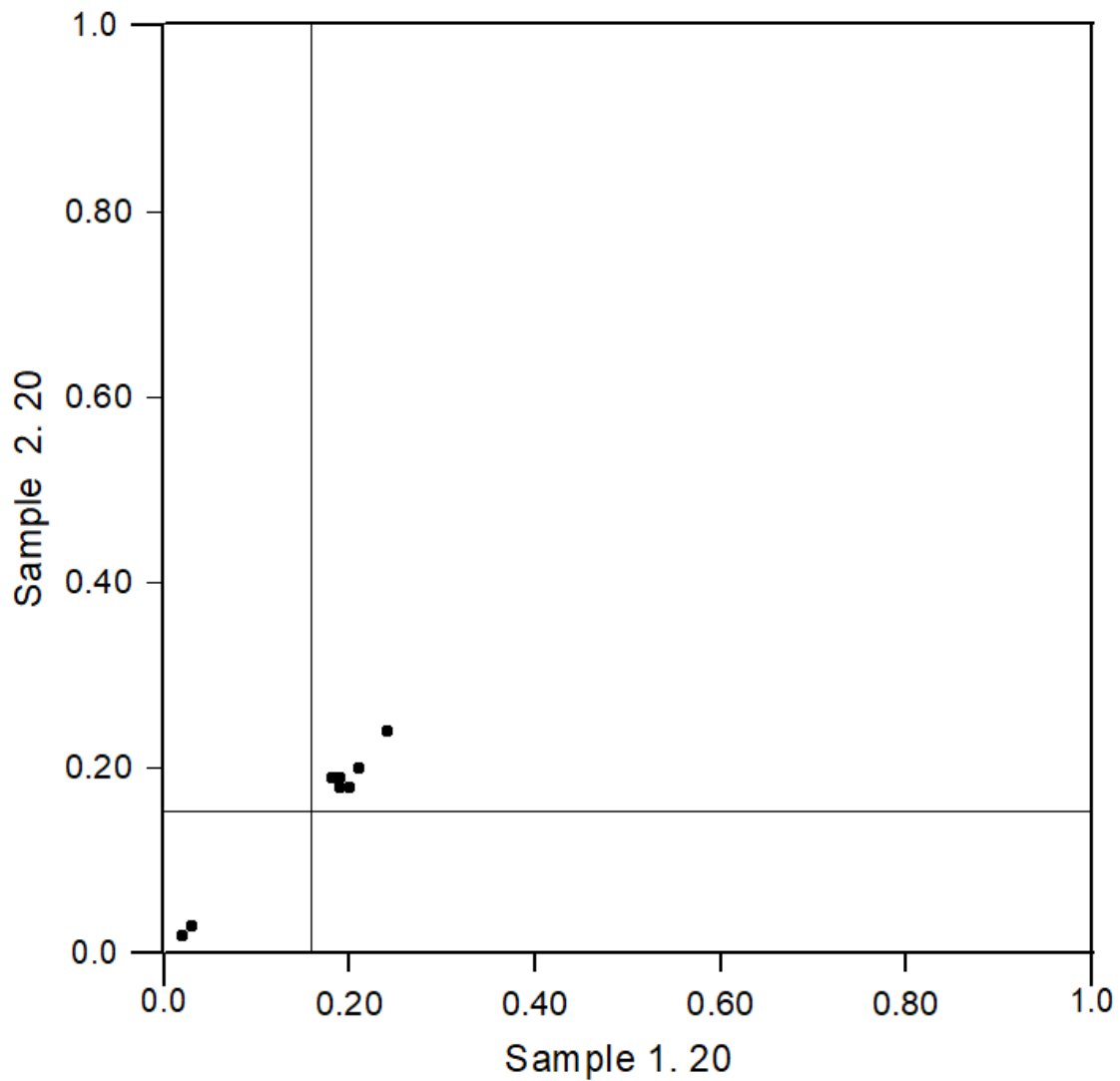
	Mat 1	Mat 2
Mean	0.324	0.314
Median	0.130	0.130
Std Dev	0.315	0.297

n = 9

Labs Eliminated: None

Figure 60.Scatter Diagram: Test 134 % of K_2O .

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

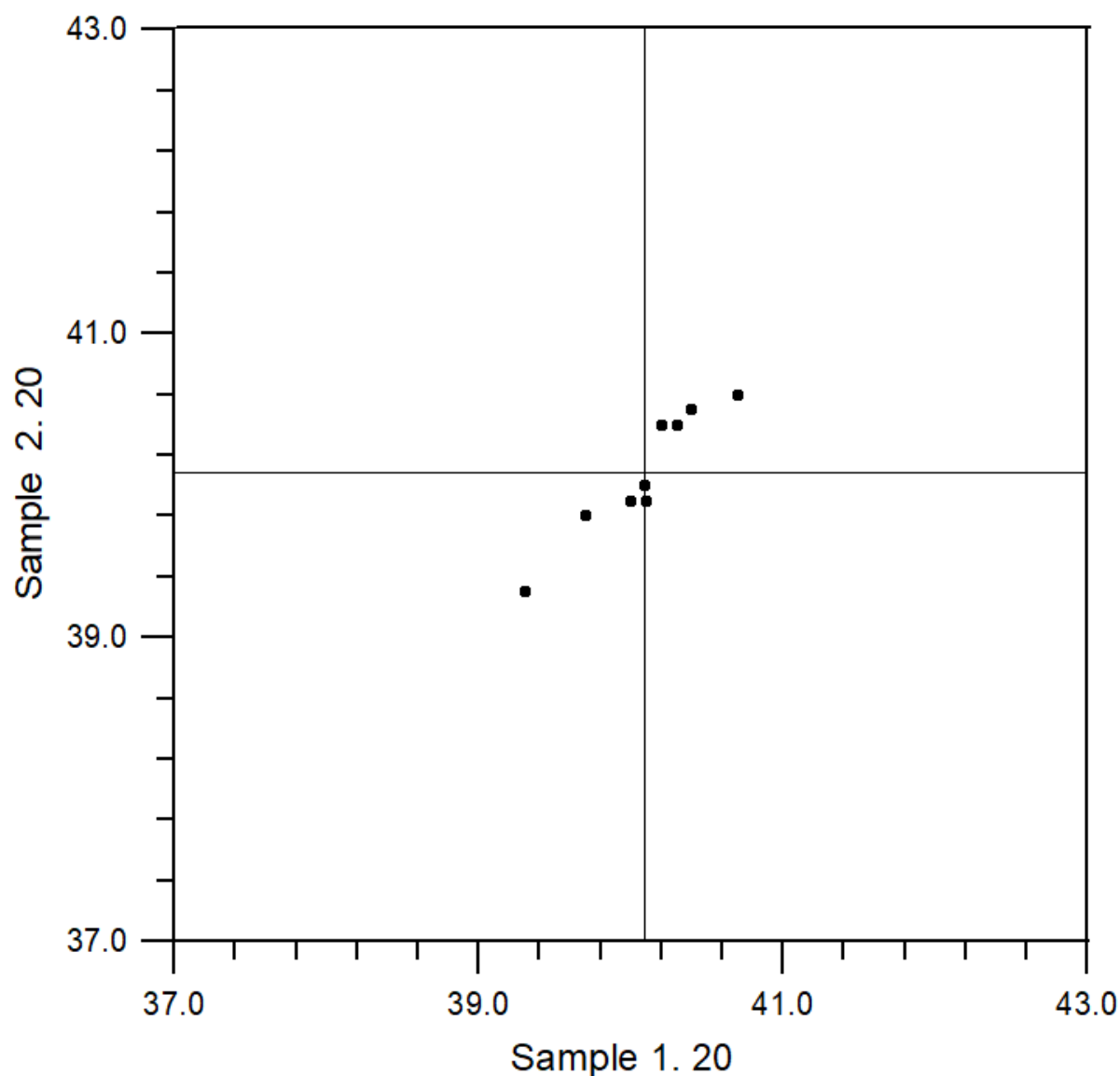
	Mat 1	Mat 2
Mean	0.158	0.154
Median	0.190	0.185
Std Dev	0.084	0.082

n = 8

Labs Eliminated: 436

Figure 61. Scatter Diagram: Test 135 % of P_2O_5 .

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



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

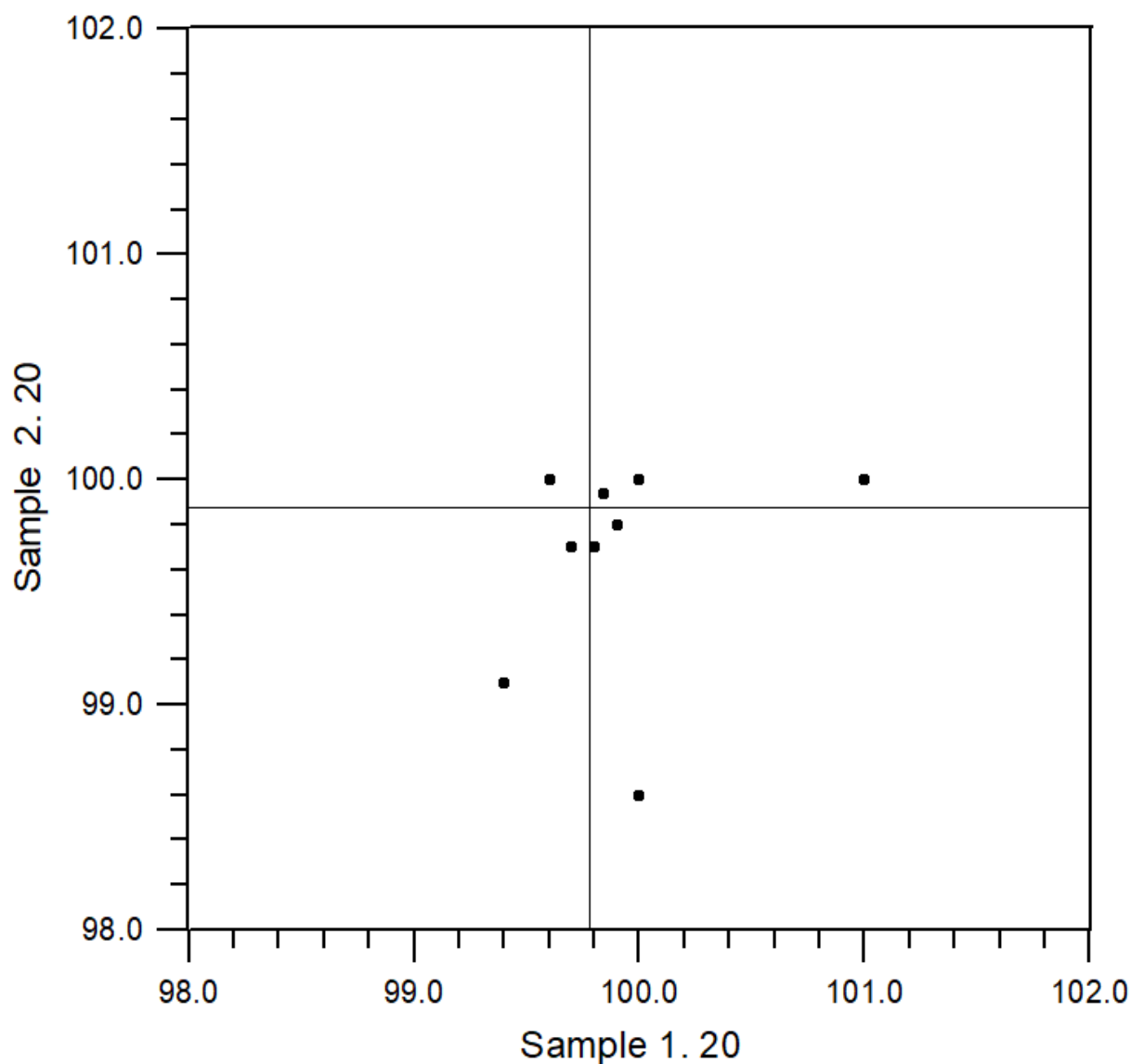
	Mat 1	Mat 2
Mean	40.088	40.089
Median	40.100	40.000
Std Dev	0.404	0.420

n = 9

Labs Eliminated: None

Figure 62. Scatter Diagram: Test 136 % of Loss on Ignition.

2020 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM



Test 137: % Total -Chemical Composition of Rocks

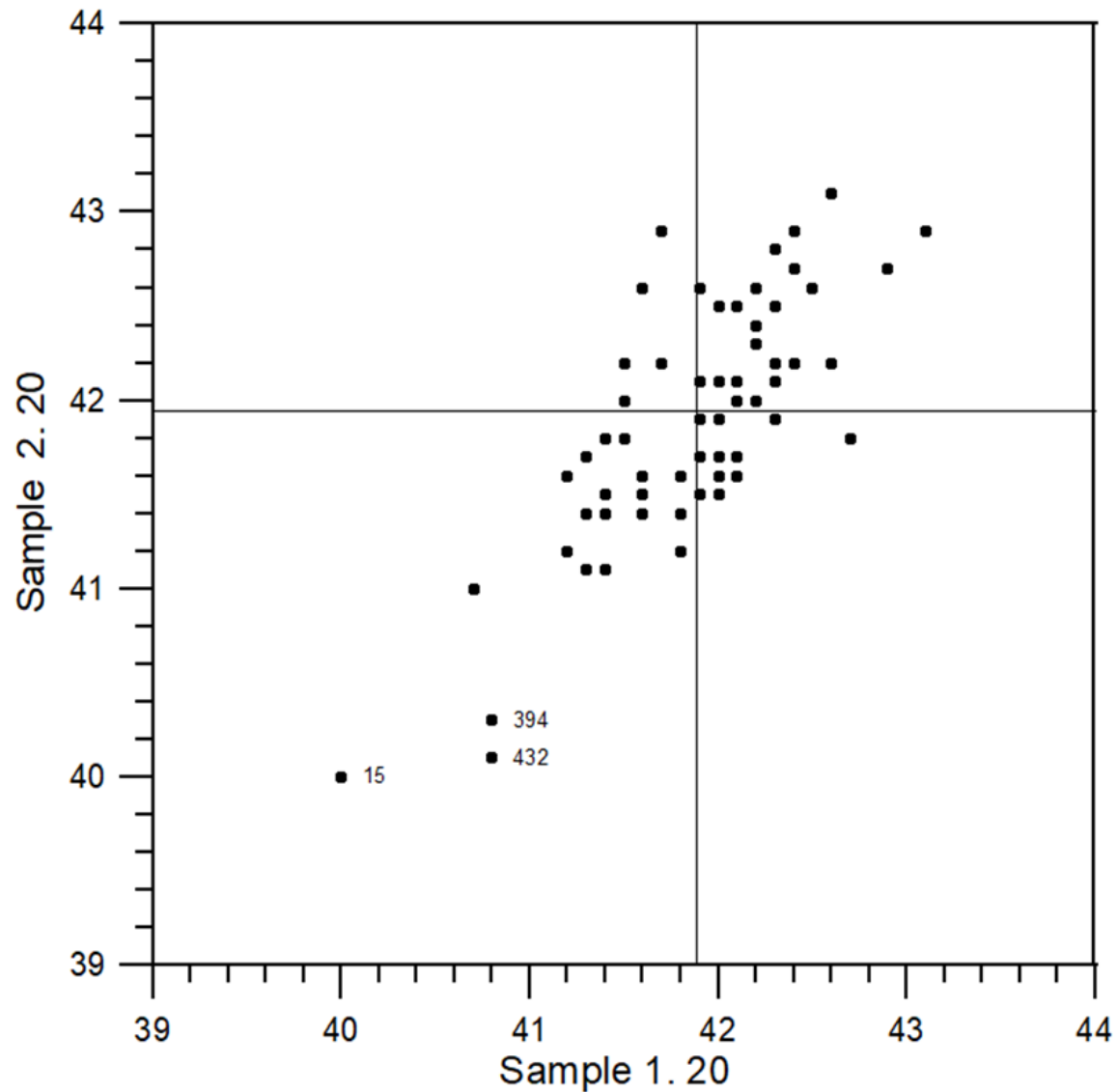
	Mat 1	Mat 2
Mean	99.78	99.877
Median	99.840	99.877
Std Dev	0.206	0.140

n = 9

Labs Eliminated: None

Figure 63. Scatter Diagram: Test 137 % of Total.

Appendix H. Scatter Diagrams – Superpave



Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	41.881	41.948
Median	41.900	41.800
Std Dev	0.488	0.533

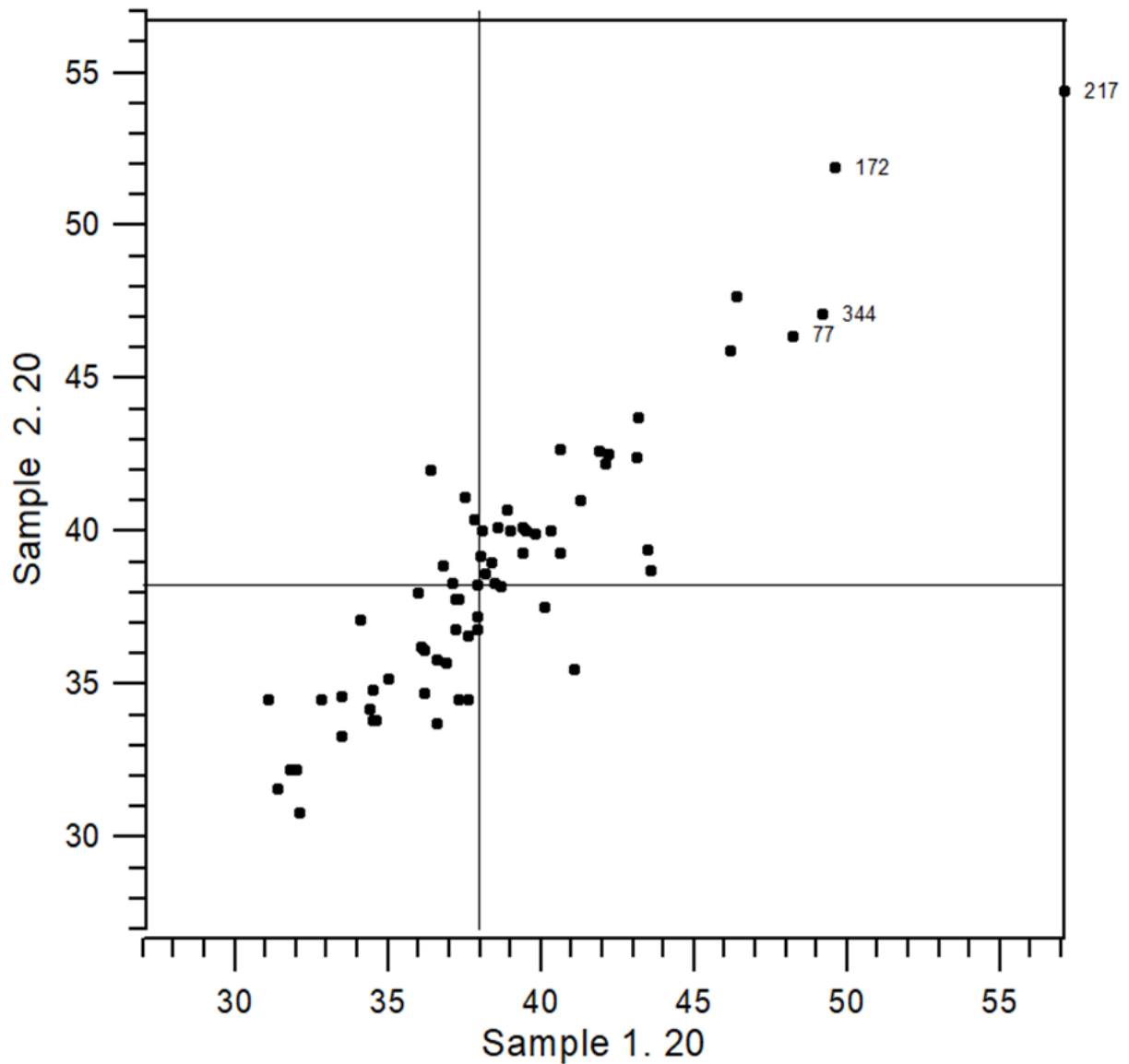
n = 64

Labs Eliminated: 15, 33, 394, 432

• 33

Figure 64. Scatter Diagram: Test 95 UC Void

2020 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	37.927	38.265
Median	37.900	38.300
Std Dev	3.485	3.804

n = 63

Labs Eliminated: 77;172;217;344;

Figure 65. Scatter Diagram: Test 96 SE Value

2020 MTO SUPERPAVE
 CONSENSUS PROPERTY TESTING PROGRAM

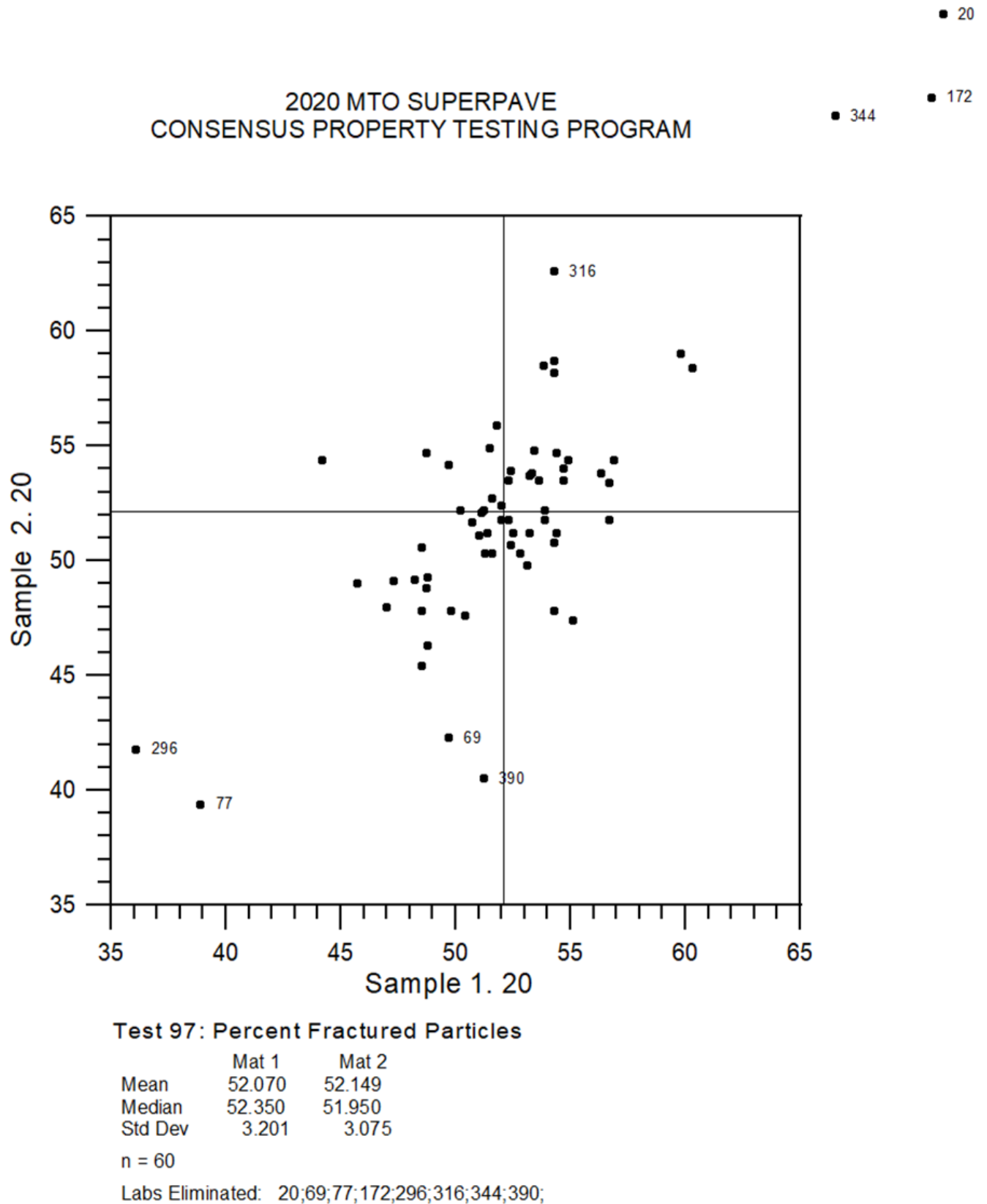
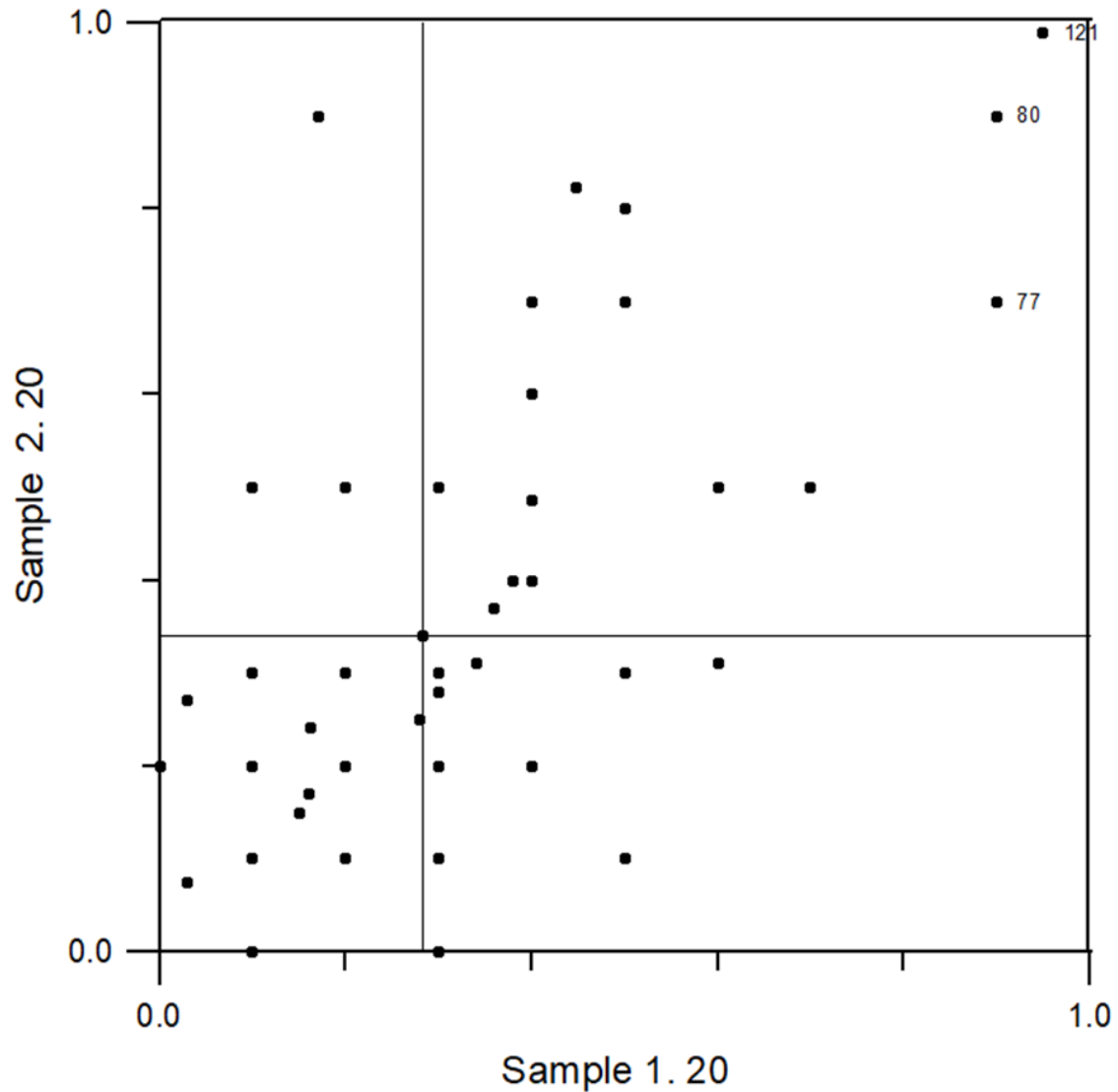


Figure 66. Scatter Diagram: Test 97 % Fractured

■ 253 ■ 183

2020 MTO SUPERPAVE CONSENSUS PROPERTY TESTING PROGRAM



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	0.283	0.340
Median	0.300	0.300
Std Dev	0.162	0.241

n = 63

Labs Eliminated: 77;80;121;183;253;

Figure 67. Scatter Diagram: Test 99 % F & E

Appendix I. Production Laboratory Ratings

Table 6. 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	10	28.4	10	10	9	96
4	8	27.8	10	10	9	93
9	10	24.8	10	10	10	93
12	10	29.7	10	10	10	100
13	10	30.0	10	10	10	100
15	10	28.1	10	10	10	97
18	10	29.7	10	9	9	97
19	10	29.2	10	9	10	97
20	10	23.2	10	7	10	86
21	0	15.0	10	9	10	63
22	10	28.6	10	9	10	97
23	0	13.6	4	10	7	49
25	10	28.6	10	10	10	98
26	10	29.2	10	10	8	96
28	10	28.4	9	10	8	93
29	0	27.8	10	8	10	80
30	10	30.0	1	6	10	81
31	0	29.7	10	9	8	81
32	7	29.7	0	10	3	71
33	10	29.5	10	10	10	99
35	8	25.4	10	10	10	91
37	9	25.6	10	10	10	92
38	10	11.2	10	9	10	72
42	7	29.7	10	10	6	90
43	10	29.5	10	10	10	99
46	10	27.3	10	10	10	96
47	10	30.0	10	9	10	99
52	7	28.6	10	6	10	88
54	10	22.1	10	10	5	82
56	9	24.0	10	10	10	90
58	10	27.8	10	8	9	93
59	10	27.3	10	10	10	96
60	10	28.6	0	9	0	68
61	10	29.2	10	6	10	93
65	10	24.8	10	10	7	88
68	10	30.0	10	10	10	100
69	9	26.2	10	9	9	90
70	10	26.7	10	10	9	94

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
71	4	25.4	10	8	10	82
73	10	23.5	10	9	10	89
74	10	27.5	10	5	6	84
75	10	22.9	10	10	10	90
76	10	30.0	10	1	10	87
77	9	10.1	10	9	6	63
78	7	24.8	9	10	0	73
79	10	29.5	10	3	9	88
80	9	29.2	9	9	8	92
81	10	27.0	10	10	9	94
83	9	25.1	10	6	10	86
85	10	24.8	8	7	10	85
86	9	27.0	10	9	9	91
90	10	28.9	10	10	5	91
93	10	23.5	10	9	7	85
95	10	30.0	10	10	10	100
97	10	28.9	10	8	10	96
98	8	23.5	0	10	10	74
99	10	30.0	10	10	9	99
100	7	28.1	10	1	9	79
101	7	30.0	10	10	10	96
102	9	29.5	10	10	9	96
103	2	27.0	10	9	9	81
107	9	28.6	4	10	10	88
108	10	27.3	3	10	10	86
110	10	30.0	10	10	7	96
112	6	30.0	10	10	7	90
113	10	23.5	10	10	7	86
114	10	23.2	10	7	10	86
115	10	24.8	10	9	10	91
117	7	13.6	10	10	9	71
118	5	20.5	6	7	8	66
120	10	29.2	10	10	10	99
121	9	28.6	9	9	8	91
122	8	26.2	7	9	10	86
124	9	20.2	10	10	10	85
129	10	30.0	10	10	10	100
137	10	25.4	10	10	10	93
138	9	29.7	0	9	5	75
139	7	26.2	10	10	5	83
140	10	25.1	10	8	10	90
141	10	28.6	10	6	9	91

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
144	10	28.1	2	10	9	84
145	9	19.6	10	3	10	73
146	9	27.8	2	6	10	78
147	10	27.3	10	10	3	86
150	9	22.1	10	10	8	84
151	10	25.9	10	6	9	87
154	10	22.9	10	8	7	83
156	9	29.2	1	10	10	85
157	6	28.6	8	10	10	89
158	10	27.8	10	10	9	95
159	10	23.5	10	3	10	81
160	3	27.3	10	9	9	83
161	10	28.6	9	9	10	95
163	10	26.7	10	5	10	88
167	4	28.4	10	9	6	82
168	9	18.5	10	8	8	76
171	10	7.1	10	10	8	64
172	7	27.3	0	8	10	75
174	5	13.9	2	9	7	53
176	0	25.1	10	10	2	67
183	8	27.5	10	10	8	91
187	7	30.0	10	10	10	96
188	10	24.0	10	8	8	86
193	10	25.1	10	10	9	92
194	10	30.0	10	10	10	100
195	10	29.2	10	9	9	96
196	5	28.1	0	10	8	73
198	4	27.3	10	9	10	86
199	10	29.7	10	7	10	95
200	8	30.0	10	10	10	97
205	1	24.0	10	2	10	67
210	9	19.9	10	0	8	67
214	2	24.3	10	10	10	80
215	9	5.7	0	10	8	47
216	10	30.0	10	5	10	93
217	10	30.0	10	9	9	97
219	10	21.8	10	0	2	63
234	10	24.3	10	9	10	90
245	10	22.4	10	10	10	89
249	10	30.0	10	10	10	100
253	10	20.7	8	10	9	82
254	5	26.2	10	8	8	82

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
257	4	29.5	10	10	10	91
258	10	23.2	10	10	9	89
261	10	27.3	10	9	10	95
263	8	28.9	10	10	10	96
264	10	29.2	5	6	6	80
266	9	17.2	10	10	10	80
268	9	25.1	10	3	10	82
269	10	25.9	10	9	8	90
271	10	27.5	10	9	10	95
272	10	28.1	9	9	10	94
274	9	22.1	10	8	10	84
275	4	29.5	10	0	10	76
276	10	29.7	0	9	9	82
277	10	30.0	10	10	10	100
278	10	25.4	10	9	1	79
279	8	28.4	10	10	10	95
280	10	11.2	10	10	8	70
285	8	21.3	10	10	10	85
287	10	30.0	10	10	10	100
288	10	26.2	10	9	10	93
290	9	28.6	10	4	7	84
291	10	24.5	10	2	9	79
293	10	27.0	10	9	10	94
294	10	25.6	10	10	10	94
296	9	28.4	10	10	9	95
297	10	27.5	6	8	10	88
300	10	25.9	2	9	10	81
301	10	22.6	5	9	10	81
303	10	29.5	10	10	10	99
305	3	24.8	10	5	8	73
309	10	21.3	10	10	8	85
310	10	28.6	10	8	9	94
312	10	29.2	10	10	10	99
314	10	25.1	0	1	10	66
315	0	13.6	10	8	9	58
316	10	28.6	10	10	7	94
318	10	28.6	10	10	10	98
320	10	24.5	10	9	10	91
321	10	29.5	10	10	9	98
322	6	28.4	9	0	9	75
324	10	29.7	10	10	10	100
326	9	27.5	10	7	10	91

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
328	10	27.5	10	7	10	92
329	9	24.8	3	10	10	81
331	9	29.2	8	7	10	90
335	4	29.2	7	3	8	73
339	10	30.0	10	10	9	99
340	10	29.2	10	10	9	97
341	9	27.3	6	10	10	89
344	7	28.4	10	8	10	91
353	9	25.6	10	10	10	92
354	10	25.4	10	9	9	91
358	10	24.3	10	10	10	92
360	2	27.3	10	10	9	83
368	9	29.7	10	9	10	97
369	10	18.5	0	9	6	62
372	9	25.4	10	9	9	89
373	8	27.0	10	10	10	93
375	5	21.3	0	10	7	62
378	10	17.5	10	10	10	82
379	10	27.8	10	9	10	95
380	0	27.5	10	10	8	79
381	10	29.2	3	9	8	85
382	9	24.5	7	9	10	85
386	10	29.5	10	9	10	98
387	10	10.9	10	9	7	67
390	6	18.8	8	5	10	68
392	10	23.2	10	10	9	89
393	10	30.0	10	2	9	87
399	10	13.6	10	10	10	77
400	10	22.9	10	8	9	86
402	9	23.2	10	10	2	77
403	10	29.7	10	10	4	91
404	10	29.7	10	10	10	100
405	10	30.0	10	10	10	100
406	10	30.0	10	9	10	99
412	10	23.5	10	0	10	76
413	6	24.5	10	0	9	71
415	10	22.6	10	8	10	87
421	0	29.5	5	10	6	72
422	3	28.4	10	8	10	85
428	10	20.2	10	9	10	85
430	10	30.0	10	10	4	91
431	6	30.0	10	10	7	90

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
432	3	29.5	1	10	10	76
433	10	29.5	10	10	10	99
435	10	1.6	0	7	5	34

Appendix J. Full Services Aggregate Laboratory Ratings

Table 7. Full Service 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	10.0	9	10	10	10.0	10.0	10	99
15	10	28.1	10	10	10	8	10.0	10	10	10	10.0	10.0	7	95
18	10	29.7	10	9	9	10	9.5	9	10	10	10.0	9.3	10	97
19	10	29.2	10	10	9	9	10.0	-	10	9	9.5	9.3	10	96
22	10	28.6	10	10	9	-	10.0	-	10	10	10.0	10.0	5	94
28	10	28.4	9	8	10	-	10.0	-	10	10	9.0	9.0	10	95
31	0	29.7	10	8	9	5	6.0	10	1	0	2.5	9.7	2	62
35	8	25.4	10	10	10	10	10.0	8	10	10	10.0	10.0	10	94
37	9	25.6	10	10	10	10	10.0	10	10	10	9.0	6.7	10	94
38	10	11.2	10	10	9	0	8.0	7	8	10	10.0	9.0	10	75
47	10	30.0	10	10	9	9	10.0	8	8	10	9.0	10.0	10	95
56	9	24.0	10	10	10	10	10.0	10	5	7	10.0	7.3	10	88
59	10	27.3	10	10	10	-	8.5	10	10	9	6.0	9.7	10	93
61	10	29.2	10	10	6	-	9.5	-	9	5	6.0	-	7	85
69	9	26.2	10	9	9	-	1.5	-	8	10	0.0	10.0	5	75
75	10	22.9	10	10	10	-	6.5	10	7	10	10.0	10.0	10	90
76	10	30.0	10	10	1	-	9.5	8	5	10	10.0	-	10	87
78	7	24.8	9	0	10	-	10.0	10	7	0	10.0	9.3	10	77
79	10	29.5	10	9	3	-	7.5	-	9	7	8.0	8.0	10	85
80	9	29.2	9	8	9	10	10.0	9	10	10	9.5	9.0	4	90
81	10	27.0	10	9	10	-	10.0	-	8	10	9.5	10.0	10	95
83	9	25.1	10	10	6	-	9.5	6	8	10	7.0	8.7	10	85
86	9	27.0	10	9	9	-	9.5		10	10	10.0	3.3	9	89
90	10	28.9	10	5	10	-	10.0	10	10	-	9.0	-	10	94

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	23.5	0	10	10	-	10.0		8	7	3.5	6.7	10	74
101	7	30.0	10	10	10	-	10.0	6	6	10	10.0	8.7	10	91
107	9	28.6	4	10	10	-	9.0	10	6	9	10.0		8	87
108	10	27.3	3	10	10	-	10.0	9	10	10	9.0	9.3	10	91
110	10	30.0	10	7	10	-	10.0	10	10	6	8.5	9.7	2	88
112	6	30.0	10	7	10	-	10.0	10	9	10	9.0	9.7	10	93
114	10	23.2	10	10	7	-	9.5	5	10	9	10.0	10.0	10	88
120	10	29.2	10	10	10	-	10.0		9	9	8.0	9.7	9	95
121	9	28.6	9	8	9	-	10.0	9	10	10	10.0	9.3	5	91
124	9	20.2	10	10	10	-	10.0	-	8	6	10.0	6.0	7	82
157	6	28.6	8	10	10	-	5.5	9	8	10	8.5	-	9	87
172	7	27.3	0	10	8	-	6.0	9	9	8	3.5	10.0	7	75
183	8	27.5	10	8	10	-	10.0	10	10	9	7.0	10.0	7	90
188	10	24.0	10	8	8	7	9.5	10	10	10	10.0	9.0	10	90
199	10	29.7	10	10	7	-	10.0		4	10	10.0	9.7	8	91
216	10	30.0	10	10	5	-	10.0	10	10	10	9.5	10.0	10	96
217	10	30.0	10	9	9	-	10.0	10	6		7.5	-	9	92
245	10	22.4	10	10	10	-	9.0		10	9	8.5	8.3	9	89
257	4	29.5	10	10	10	-	10.0	6	9	6	9.5	9.7	10	88
263	8	28.9	10	10	10	-	8.5	10	9	6	9.5	7.3	10	91
285	8	21.3	10	10	10	-	8.5	9	10	10	10.0	9.7	8	89
293	10	27.0	10	10	9	-	5.0	-	10	9	9.0	9.3	10	91
296	9	28.4	10	9	10	-	5.5	-	9	10	5.0	9.0	10	88
309	10	21.3	10	8	10	-	9.5	10	9	9	10.0	-	9	89
316	10	28.6	10	7	10	-	7.5	8	10	6	9.5	4.7	7	85
326	9	27.5	10	10	7	-	7.5	-	10	9	8.5	9.7	9	90
382	9	24.5	7	10	9	-	4.5	-	10	7	9.5	-	10	84
390	6	18.8	8	10	5	-	8.5	-	8	4	8.5	9.3	8	72

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
406	10	30.0	10	10	9	-	7.5	10	8	10	9.5	8.3	3	90
422	3	28.4	10	10	8	-	7.0	10	10	6	9.0	8.3	10	85
433	10	29.5	10	10	10	-	10.0	10	10	10	10.0	9.7	10	99

Appendix K. Soil Laboratory Ratings

Table 8. Soil Laboratory Ratings

Lab Number	LS-702: Hydrometer Analysis	LS-703 & 4: Atterberg Limits	LS-705: Specific Gravity	Rating
2	8.2	10.0	0	61
9	10.0	10.0	10	100
12	9.6	8.3	10	93
13	10.0	8.3	10	94
15	9.8	10.0	10	99
18	9.4	10.0	9	95
19	9.6	9.3	10	96
20	6.8	10.0	10	89
21	9.4	10.0	7	88
22	7.6	10.0	7	82
23	5.2	10.0	3	61
28	9.6	10.0	10	99
29	9.6	9.3	8	90
30	8.6	10.0	6	82
31	6.2	8.0	6	67
32	9.2	9.7	5	80
35	7.4	10.0	10	91
37	7.0	5.0	8	67
38	6.8	9.0	10	86
46	9.6	7.7	9	88
47	8.0	9.7	8	86
52	10.0	8.7	7	86
54	9.0	4.7	7	69
56	6.0	9.3	8	78
58	10.0	10.0	10	100
59	10.0	10.0	10	100
68	9.6	10.0	9	95
69	2.0	7.0	5	47
71	9.8	10.0	10	99
74	9.2	9.7	10	96
78	8.8	7.7	10	88
79	9.0	9.0	7	83
80	8.8	4.3	10	77
81	9.0	8.7	10	92
83	9.2	10.0	10	97
85	6.6	5.7	10	74
86	7.2	9.0	10	87

Lab Number	LS-702: Hydrometer Analysis	LS-703 & 4: Atterberg Limits	LS-705: Specific Gravity	Rating
98	4.8	10.0	10	83
101	9.2	9.0	7	84
102	8.8	9.7	8	88
108	10.0	9.7	10	99
112	4.8	4.0	9	59
114	9.0	8.7	10	92
118	9.6	6.7	6	74
120	9.6	10.0	10	99
121	6.8	3.3	10	67
138	9.8	8.7	9	92
139	9.8	6.0	10	86
144	9.0	9.7	10	96
146	8.4	10.0	8	88
151	9.2	9.3	5	78
156	9.6	7.3	10	90
159	7.0	9.3	4	68
168	8.8	8.7	4	72
172	8.8	10.0	10	96
173	9.6	9.3	10	96
183	10.0	8.0	10	93
188	9.8	10.0	5	83
195	9.8	10.0	10	99
210	9.8	9.0	10	96
216	7.8	10.0	10	93
253	7.4	10.0	10	91
261	10.0	10.0	9	97
266	9.4	8.7	10	94
276	8.2	7.7	10	86
285	10.0	8.3	1	64
287	8.6	9.3	10	93
296	9.2	9.7	8	90
300	9.8	9.7	10	98
312	10.0	7.0	10	90
315	9.0	10.0	10	97
320	7.6	10.0	8	85
322	9.2	9.3	10	95
354	5.2	6.7	7	63
358	7.4	10.0	10	91
360	9.8	8.0	10	93
368	7.8	9.0	9	86
369	9.6	4.0	10	79

Lab Number	LS-702: Hydrometer Analysis	LS-703 & 4: Atterberg Limits	LS-705: Specific Gravity	Rating
372	8.8	8.0	2	63
375	9.8	9.7	10	98
378	8.6	9.3	10	93
381	8.6	10.0	10	95
392	6.4	7.3	0	46
393	9.8	6.7	10	88
399	9.4	9.7	7	87
406	9.0	10.0	10	97
412	8.6	7.7	9	84
421	7.8	10.0	0	59
422	9.0	8.3	6	78
428	9.0	10.0	9	93
432	6.6	6.3	9	73
433	9.8	8.7	10	95

Appendix L. Superpave Laboratory Ratings

Table 9. Superpave Laboratory Ratings

Laboratory No.	T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
13	10	10	10	10	100
15	0	10	8	10	70
18	10	8	10	10	95
20	9	10	0	7	65
22	9	10	10	10	98
25	10	10	10	10	100
26	9	10	10	10	98
28	10	10	10	9	98
31	5	10	10	9	85
33	5	10	10	10	88
35	10	10	9	10	98
37	10	10	10	8	95
38	9	9	10	10	95
43	10	9	7	8	85
47	10	8	10	7	88
56	10	10	10	9	98
58	9	10	9	10	95
59	8	6	9	10	83
61	10	8	9	8	88
69	5	9	5	6	63
71	10	10	10	8	95
75	9	10	9	10	95
77	9	2	0	4	38
79	9	8	10	9	90
80	10	6	7	2	63
81	10	10	9	10	98
83	10	10	10	10	100
86	10	10	8	10	95
101	10	4	10	8	80
108	10	10	8	9	93
112	10	10	10	9	98
114	9	9	9	10	93
115	10	8	10	10	95
118	7	4	10	8	73
120	10	10	9	9	95
121	9	6	7	1	58

Laboratory No.	T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
124	8	10	10	9	93
141	9	6	9	10	85
157	9	10	10	10	98
172	9	0	0	7	40
183	10	8	10	0	70
188	8	10	10	9	93
193	10	8	9	9	90
199	9	10	7	10	90
216	10	10	10	9	98
217	9	0	10	9	70
245	10	8	9	9	90
253	9	10	10	0	73
257	8	10	4	10	80
263	10	10	10	10	100
271	10	10	8	10	95
285	10	10	8	9	93
293	10	10	6	9	88
296	6	8	0	10	60
300	8	10	10	10	95
309	8	9	10	9	90
316	10	10	5	10	88
326	8	9	10	10	93
339	8	10	10	10	95
340	10	9	9	10	95
344	6	2	0	9	43
368	8	10	7	8	83
390	9	10	5	10	85
432	2	7	10	6	63
433	10	10	10	10	100

This page is left intentionally blank.