LabSmart

PROFICIENCY TESTING
PROGRAM REPORT

Concrete
2023 (118)

Accredited for Compliance with
ISO/IEC 17043

NATA

Report

This report is available on the LabSmart Services website. The issue of this proficiency report was authorised by Jeffrey Mulholland, General Manager, LabSmart Services, in March 2023.

Contact Details
Email: jeffm@labsmartservices.com.au
Mobile: 0439 208 406

Program Coordinator

The program coordinator for this program was Jeffrey Mulholland, with assistance from Shantelle Popple, LabSmart Services.

Contact Details
Email: jeffm@labsmartservices.com.au
Mobile: 0439 208 406

Please note that any technical questions regarding this program are to be directed to the program coordinator.

Z-scores Summary

A z-scores summary for this program was issued on November 29, 2023. This technical report supersedes the z-scores summary.

Accredited Proficiency Testing Provider

LabSmart Services is accredited by NATA to ISO/IEC 17043, Conformity assessment – General requirements for proficiency testing. Accreditation number 20650. The accreditation provides additional assurance to participants of the quality and importance we place on our proficiency testing programs.

LabSmart Services

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Amendment History

Reports may be downloaded from the LabSmart Services website.

Version 1 – Issued 7 March 2024

Contents

1. Program Aim

The proficiency testing program was conducted in October 2023 with 38 participants from around Australia. The program involved the performance of:

- AS 1012.9 – 2014, Determination of the compressive strength of concrete specimens
- AS 1012.12.1 – 1998 (R2014), Determination of mass per unit volume.

The program provides confidence to the construction materials testing industry regarding the competency of participants (and the industry) to perform these tests. Each participant's performance is statistically assessed and used as a measure of competency relative to all those who participated. Other measures of performance are also used.

This report has been prepared using robust statistics. Information regarding the conduct and design of the program can be found in section 5.

Technical comment (section 3) is provided to assist participants to improve the overall performance of these tests. In addition, test data has been reviewed for consistency, and additional feedback regarding aspects of the test are provided.

A Z-score summary was issued on the 29th of November 2023 to facilitate early feedback on performance.

2. Performance

2.1 Identified Outliers

There were 4 outliers across 3 participants identified across all the tests performed.

Participant's test results are tabulated in section 4, along with the robust statistics and a z-score. The z-score indicates how far away a participant is from the program's median value. A z-score between –1 and 1 indicates a strong consensus concerning all other participants and represents a very good outcome. The z-score graph gives a quick visual indication of how a result compares to others in the program.

Outliers are where a z-score value is greater than 3 or less than -3. It is recommended that participants with outliers investigate their performance of the test. Participants with outliers are detailed in Table 1.

Those participants with z-scores greater than 2 or less than -2 should review their testing methodology. Only those approaching a z-score of 3 (i.e. outside ± 2.75) have been specifically identified in Table 1 as feedback.

More detail on the robust statistics used can be found in section 5.

Technical comment and feedback in section 3 is provided to assist participants to investigate or review their results, as well as for those seeking to improve their testing performance.

Overall, a satisfactory level of testing was achieved by most participants.

Table 1: Statistical Outliers

Test	Investigate (Outliers)		Review (outside ± 2.75)	
	Sample		*Sample*	
	A	B	A	B
Compressive strength	S9	S9	-	-
Mass per unit volume	T6, Q5	-	R7	-

Some other participants whose results may not have shown as a statistical outlier may still need to investigate the result obtained if it is found to be a 'non-statistical' outlier. See Table 2 below and section 3 for further detail.

Table 2: Results requiring further investigation or review (non-statistical)

Test	Review (Non-statistical Outliers)	
	Sample	
	A	B
Compressive strength	M6	-
Mass per unit volume	P3 & Q5	N8

2.2 Program Summary

All 38 participants that joined the program, returned results on time to be included in the final report.

The overall performance of all the participants was very good. The spread of results (variation) was within industry expectations. However, greater care in completing proficiency testing log sheets and better checking by supervisors needs to be undertaken.

The majority of the participants had results (for compressive strength and mass per unit volume) within 1 s.d, which was a good outcome. Participants with a z-score below -2 or above +2 are strongly recommended to review their performance.

Overall, the results are within industry expectations and demonstrated that all participants were competent in performing these tests.

Table 3: Summary of test results statistics.

Statistic	Sample A		Sample B	
	Compressive Strength (MPa)	**Mass per unit volume** (kg/m^3)	**Compressive Strength** (MPa)	**Mass per unit volume** (kg/m^3)
No of participants	38	33	38	33
Median	48.8	2280	32.1	2204
N-IQR	2.58	16.31	2.08	14.83
CV (%)	5.3	0.7	6.5	0.7
Range *	9.4	69	6.5	51

*excludes outlier results.

3. Technical Comment

General

A summary of submitted results for all participants may be found in section 6. The reporting requirements under the Australian Standard are focused on the final calculations for 'compressive strength' and 'mass per unit volume'. Outlier assessment was undertaken based on these results; the robust statistical analysis can be found in section 4 of this report.

Missing Information

Most participants provided all the information requested on the results log sheet. Thank you to all participants, as this makes it far easier to provide informative feedback.

Outcome

The coefficient of variation (CV) shown in Table 4 is one way to broadly evaluate that the participant performance is consistent from one program to another. Based on this, participants did very well on 'Mass per Unit Volume' and were found to be acceptable for 'Compressive Strength'. However, it should be noted that the actual fluctuation in CV values may be attributed to a range of factors. Therefore, further conclusions should not be inferred from the fluctuations observed. See section 5.9 for further details.

Table 4: Summary of CV for current and past programs

Coefficient of Variation (%)			
Program	**Sample**	**Mass per Unit Volume**	**Compressive Strength**
2023(118)	A	0.7	5.3
	B	0.7	6.5
2023(115)	A	0.8	7.8
	B	0.8	3.5
2022 (111)	A	0.7	3.2
	B	0.6	3.7
2022 (108)	A	0.6	5.5
	B	0.7	4.0
2021(102)	A	0.8	2.4
	B	0.6	2.0
2020(95)	A	1.0	6.1
	B	0.6	3.9
2019(88)	A	0.5	3.7
	B	0.6	3.9
2018(80)	A1	1.3	2.8
	B1	1.2	4.9
	A2	0.9	5.0
	B2	1.0	4.0

3.1. Compressive Strength

Nominated Test Date

At times it is not possible to test a sample on its nominated test date, and this can be the result of a range of factors (for example, staff/equipment availability). In this instance, there were 2 participants that did not test on the nominated date of November 1st (see Table 5).

Table 5: Variation in test date

Participant	**K4**		**B6**	
Sample	**A**	**B**	**A**	**B**
Difference in days	+2	+2	+8	+8
Result (MPa)	52.0	35.0	47.5	29.9
Median (MPa)	48.8	32.1	48.8	32.1
Z-score	**1.26**	**1.40**	**-0.49**	**-1.06**

Participant **K4** & **B6** who didn't test on the nominated test date (1/11/2023) tested 2 days and 8 days respectively after all other participants; analysis of the data showed that it did not significantly affect the final outcome.

Incomplete crushing

It was noted during past programs that some cap failures can caused the compression machine to register that maximum load had been reached. Further crushing may yield a higher strength. Some participants may have found this, while some may not have been aware that this can occur.

Calculation of compressive strength (Non-Statistical Outliers)

From the reported diameter and maximum force, the 'Compressive Strength' results can be determined. This was done for each participant and the calculated result compared to the reported compressive strength. Most participants obtained good agreement. It is a reporting requirement to round the compressive strength to the closest 0.5MPa; therefore, participants showing a difference greater than 0.3 MPa can be found in Table 6. For these participants, it may be worthwhile reviewing these results.

Table 6: Recalculated 'Compressive Strength' results

Code	Compressive Strength		
	Submitted (MPa)	**Recalculated** (MPa)	**Difference** (MPa)
M6 (Sample A)	45.5	49.5	4.0

Statistical Outliers

Overall, a satisfactory level of testing was achieved by all the participants for compressive strength. There were only 2 outliers identified in this program, both were recorded for participant **S9**.

LabSmart assessed the 'results log' sheets for participant **S9**. All information supplied by participant **S9** supported the outcome for their final result; both samples A and B were Sulphur Capped and reported a Shear Failures. In both cases, they tested lower strengths then the rest of the group and show no sign of being mixed up as there was no issue with the Mass Per Unit Volumes and swapping the strengths would not fix both samples. This indicates that there may be an issue with the equipment used, and participant **S9**, should start their investigation there.

Overall, when it comes to outliers for compressive strength, Incomplete crushing (see page 10) may have also been an issue for the participant identified in this program. Additionally, centring the specimens on the platens may have been a factor, but it is hard to check post-testing. Furthermore, checking for transcription errors may be worth considering. However, if no issues can be found with the testing practices, then the outcome would suggest an issue that cannot be checked, e.g. platen centring, grinding etc.

Failure Modes

Out of all the participants who returned results, ~3% reported 'Cap Failure' for Sample A and ~21% for Sample B. In addition, ~11% reported 'shear failure' for Sample A and ~18% for Sample B. All other participants reported results as either a 'Normal' or 'Conical Failure'. Table 7 shows the 'normal/conical' failure statistics vs abnormal (Both 'Cap' and 'Shear') failures.

The median values are very close to the combined results in section 4 regardless of the failure mode. The variation associated with an abnormal failure was not much different from those showing 'normal' failure.

The comparisons drawn above have been observed in previous programs as well. There is no substantial evidence to suggest that 'Shear failure' or 'Cap' values should be discounted or excluded from the data set.

The effect the mode of failure has on the compressive strength result is difficult to determine except in instances where unrealistic results are obtained. Equipment configuration, air voids, variability in compaction and aggregate distribution are only some of the factors that affect the mode of failure. Possible causes of abnormal failures might include capping and crushing practices, the stability of the load frame (i.e. alignment, squareness and rigidity), as well as the correct working/alignment of platens.

Table 7: Normal/Conical and Shear/Cap failure statistics for sample A & B

Compression Statistic MPa	**Sample A**	**Sample B**
	Normal - Conical failure results only.	
Median (MPa)	48.8	32.0
NIQR	2.67	1.56
Number of Participants	33	21
Compression Statistic MPa	**Sample A**	**Sample B**
	Abnormal - Cap or shear failure results only.	
Median (MPa)	48.5	32.2
NIQR	2.52	2.45
Number of Participants	5	17

Capping Methods

Out of the 38 participants who returned the results, 25 participants (~66%) used rubber caps, with 9 participants (~24%) using grounded ends, and there were 4 participants (~11%) using Sulphur capping.

In this program, it was not possible to determine if there was any statistical variation due to the capping method employed due to the small numbers in some groupings. Previous proficiency programs have not encountered any adverse correlation between reported 'compressive strength' and the capping method.

For this program, 'rubber caps', 'Sulphur capping' and 'end-cut' were considered to yield equivalent results and were analysed as a group.

3.2. Mass per unit volume

Calculation of mass per unit volume

The 'Mass per unit volume' result can be determined from the reported height, diameter, and weight. For this program, All participants 'Mass per unit volume' results were recalculated based on the intermediate data supplied. This was done for each result and compared to the reported 'Mass per unit volume'. Generally, good agreement was obtained.

The test method requires the 'Mass per unit volume' result to be rounded to the nearest 20 kg/m^3. However, Participants were requested to report to the nearest 1 kg/m^3. Some participants reported results that may have been rounded to the nearest 20 kg/m^3. This reduces the quality of feedback that can be given to participants. For this report, we focused on results that differed by greater than or equal to 10 kg/m^3 (Table 8). These are considered non-statistical outliers.

Table 8: Recalculated 'Mass per unit volume' results

Participant	Submitted (kg/m^3)	Recalculated (kg/m^3)	Difference (kg/m^3)
P3 (Sample A)	2301	2289	-12
Q5 (Sample A)	2356	2292	-64
N8 (Sample B)	2220	2209	-11

It is essential that the calculation process is correct and accurate. Instructions on the calculation can be found in Section 8 of AS 1012.12.1. It states that the 'mass per unit volume' is the mass divided by the cylinder volume. The volume of a cylinder is given by $V=\pi r^2 h$ where 'h' is the cylinder height, and 'r' is the average radius (i.e. Half the average diameter).

Unrounded values for diameter and height should be used when calculating the volume. The value of pi used can also affect the result. Those using Excel can use the pi() function. Those with calculators that do not have a pi function should use 333/106. The use of 22/7 does not have enough accuracy for this test.

Uncalculated Mass Per Unit Volumes (Review)

Participants **R4, W6, W7, E2 & Y2** did not provide their final calculated Mass Per Unit Volumes. They were calculated by the program coordinator based on the data submitted and were found to be satisfactory except for **W6** for Sample B (see Table 9). These participants need to investigate why these were left off and then calculate the missing results. Participants should check that the results calculated by the program coordinator are in agreement with participants own calculations.

*Table 9: Calculation of **R4, W6, W7, E2** & **Y2***

Participant	Sample A		Sample B	
	Calculated Result	Approximated Z-Score	Calculated Result	Approximated Z-Score
R4	2313	**2.02**	2202	**-0.13**
W6	2294	**0.86**	2143	**-4.11**
W7	2303	**1.41**	2201	**-0.20**
E2	2266	**-0.86**	2202	**-0.13**
Y2	2301	**1.29**	2205	**0.07**

Statistical Outliers

Overall, a satisfactory level of testing was achieved by the majority of participants for mass per unit volume. There were 2 outliers for this program, both associated with sample A (**T6, Q5)**. LabSmart assessed the 'results log' sheets for both outliers for Mass Per Unit Volume. The following comments relate to these participants.

All information supplied by participant **T6** supported their final result. Given the agreement between the participant final result and LabSmart Recalculations, this would indicate an issue with either the measurement of the sample and/or an issue with the sample itself. Participant **T6** would benefit from reviewing its procedures associated with the measuring of its samples and the capability/condition of its equipment.

Participant **Q5** was identified as an outlier for Sample A for Mass Per Unit Volume. Inconsistencies were also found during the comparison of the supplied data and the recalculated data (See section titled **Calculation of mass per unit volume**). This participant needs to review the procedures and equipment used to ensure that their laboratory practices are still satisfactory.

Reporting of cylinder weights

Some participant's cylinder weights were reported in grams instead of kilograms. Converted values are shown in section 6 of the report. Participants need to ensure they follow proficiency program instructions. Conversions were undertaken as these values were used to verify the participant's reported MPUV results.

4. Statistics: Z-score & Graph

Sample A - Compressive Strength : Z - Scores

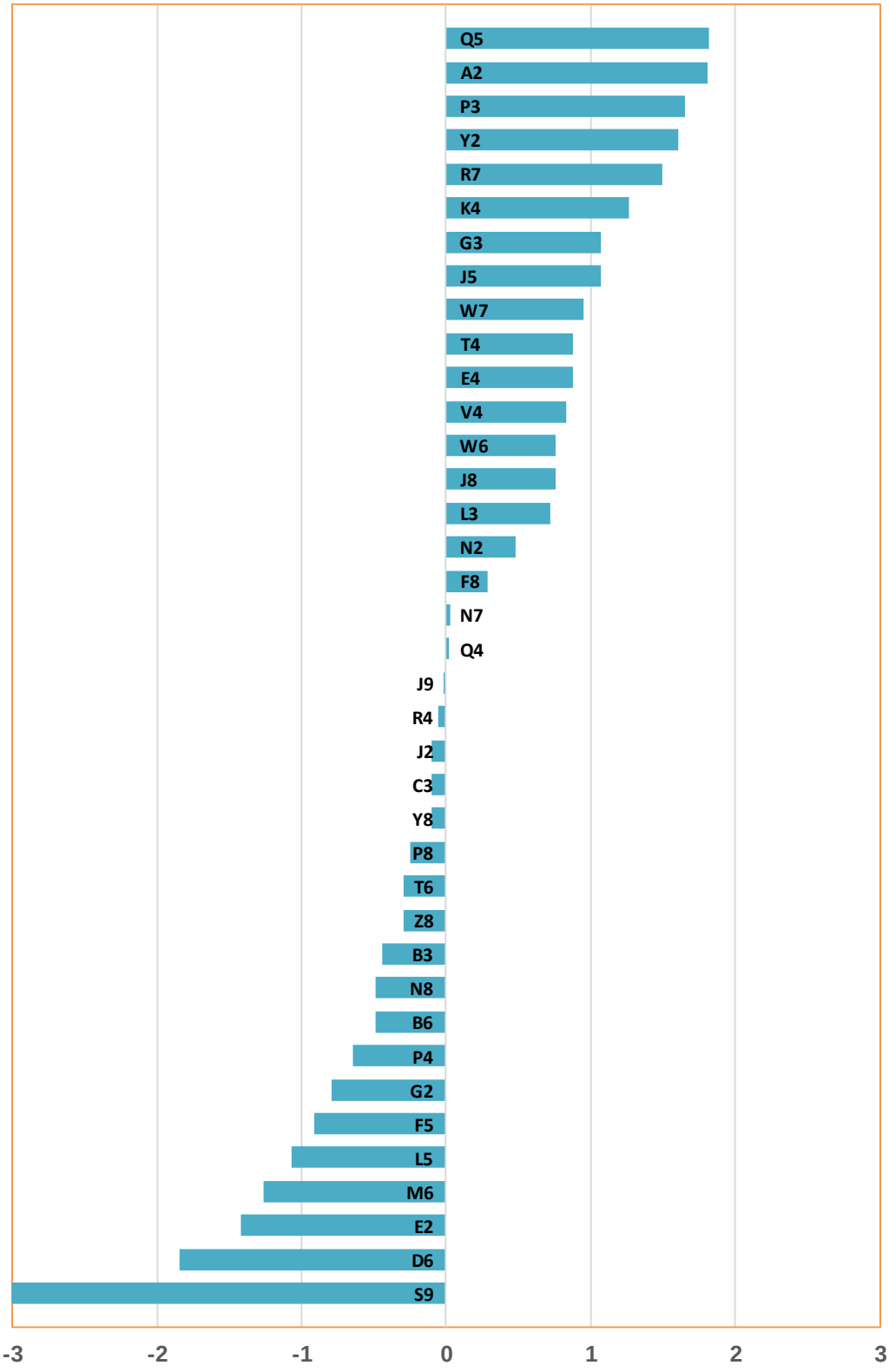
Code	Test Result MPa	Z Score
L5	46.0	-1.07
N7	48.82	0.03
P8	48.1	-0.25
J9	48.7	-0.02
P4	47.1	-0.64
J2	48.5	-0.10
B3	47.6	-0.45
R4	48.6	-0.06
G3	51.5	1.07
D6	44.0	-1.84
T4	51.0	0.87
S9	36.5	**-4.76 #**
F8	49.5	0.29
N8	47.5	-0.49
K4	52.0	1.26
Q4	48.8	0.02
N2	50.0	0.49
G2	46.7	-0.80
L3	50.6	0.72
F5	46.4	-0.91
W6	50.7	0.76
W7	51.2	0.95
E2	45.1	-1.42
V4	50.9	0.83
B6	47.5	-0.49
C3	48.5	-0.10
Y2	52.9	1.61
M6	45.5	-1.26

Code	Test Result MPa	Z Score
J5	51.5	1.07
E4	51.0	0.87
T6	48.0	-0.29
Y8	48.5	-0.10
Z8	48.0	-0.29
P3	53.0	1.65
A2	53.4	1.81
J8	50.7	0.76
Q5	53.44	1.82
R7	52.6	1.49

Statistic	*Value*	
Number of results	**38**	
Median	**48.8**	
Median MU	**0.52**	
First Quartile	**47.5**	
Third Quartile	**51.0**	
IQR	**3.48**	
Normalised IQR	**2.58**	
CV (%)	**5.3**	
Minimum	**44.0**	(36.5)
Maximum	**53.4**	(53.4)
Range	**9.4**	(16.9)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in green have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Compressive Strength: Z - Score Graph



Sample A - MPUV: Z - Scores

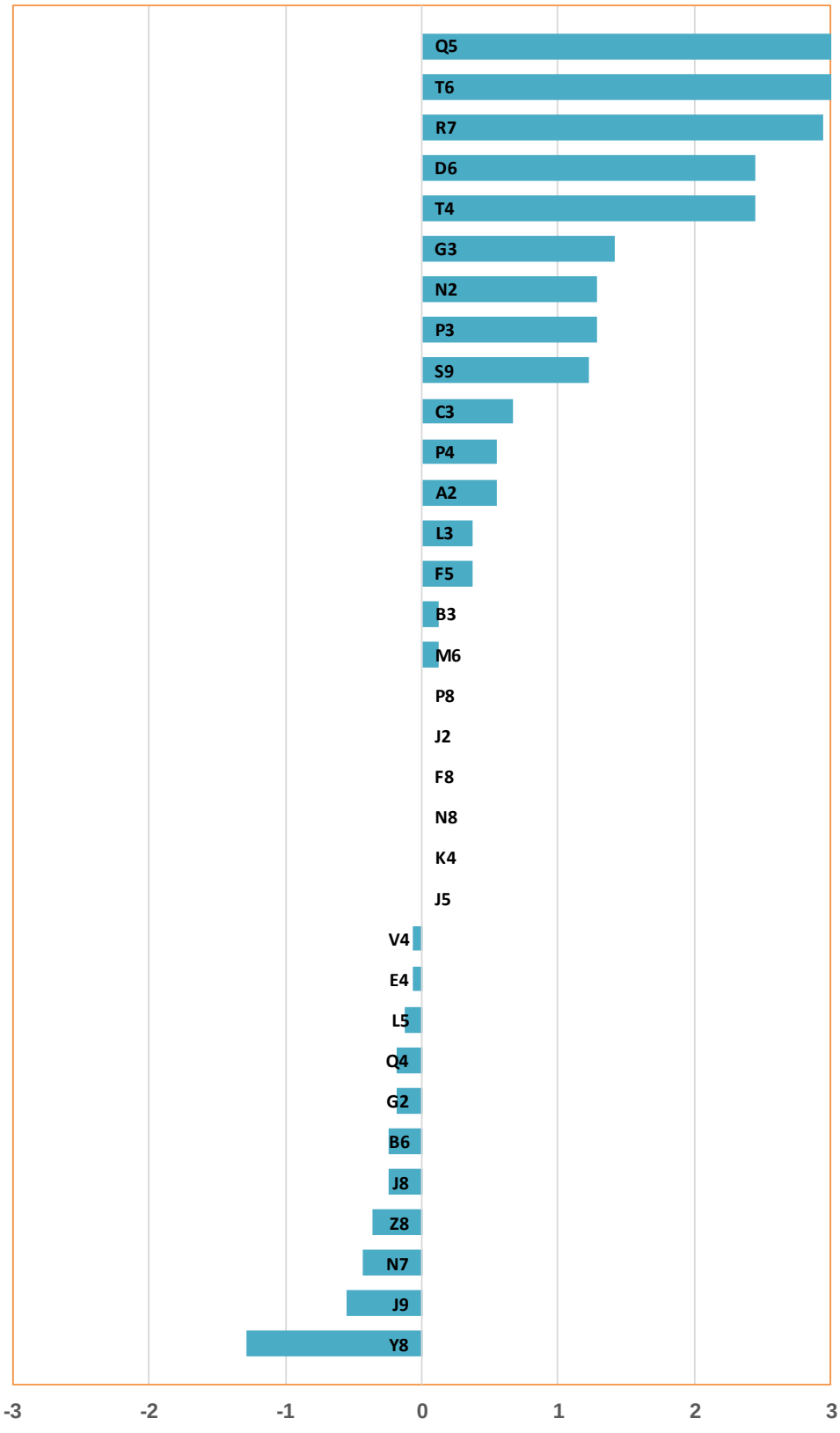
Code	Test Result kg/m³	Z Score
L5	2278	-0.12
N7	2273	-0.43
P8	2280	0.00
J9	2271	-0.55
P4	2289	0.55
J2	2280	0.00
B3	2282	0.12
R4	NR	
G3	2303	1.41
D6	2320	2.45
T4	2320	2.45
S9	2300	1.23
F8	2280	0.00
N8	2280	0.00
K4	2280	0.00
Q4	2277	-0.18
N2	2301	1.29
G2	2277	-0.18
L3	2286	0.37
F5	2286	0.37
W6	NR	
W7	NR	
E2	NR	
V4	2279	-0.06
B6	2276	-0.25
C3	2291	0.67
Y2	NR	
M6	2282	0.12

Code	Test Result kg/m³	Z Score
J5	2280	0.00
E4	2279	-0.06
T6	2335	**3.37** #
Y8	2259	-1.29
Z8	2274	-0.37
P3	2301	1.29
A2	2289	0.55
J8	2276	-0.25
Q5	2356	**4.66** #
R7	2328	2.94

Statistic	*Value*	
Number of results	**33**	
Median	**2280**	
Median MU	**3.55**	
First Quartile	**2278**	
Third Quartile	**2300**	
IQR	**22.00**	
Normalised IQR	**16.31**	
CV (%)	**0.7**	
Minimum	**2259**	(2259)
Maximum	**2328**	(2356)
Range	**69**	(97)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in green have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers. Results in Orange have had the units of measurement changed e.g to Kg/m³

Sample A - MPUV: Z - Score Graph



Sample B - Compressive Strength: Z - Scores

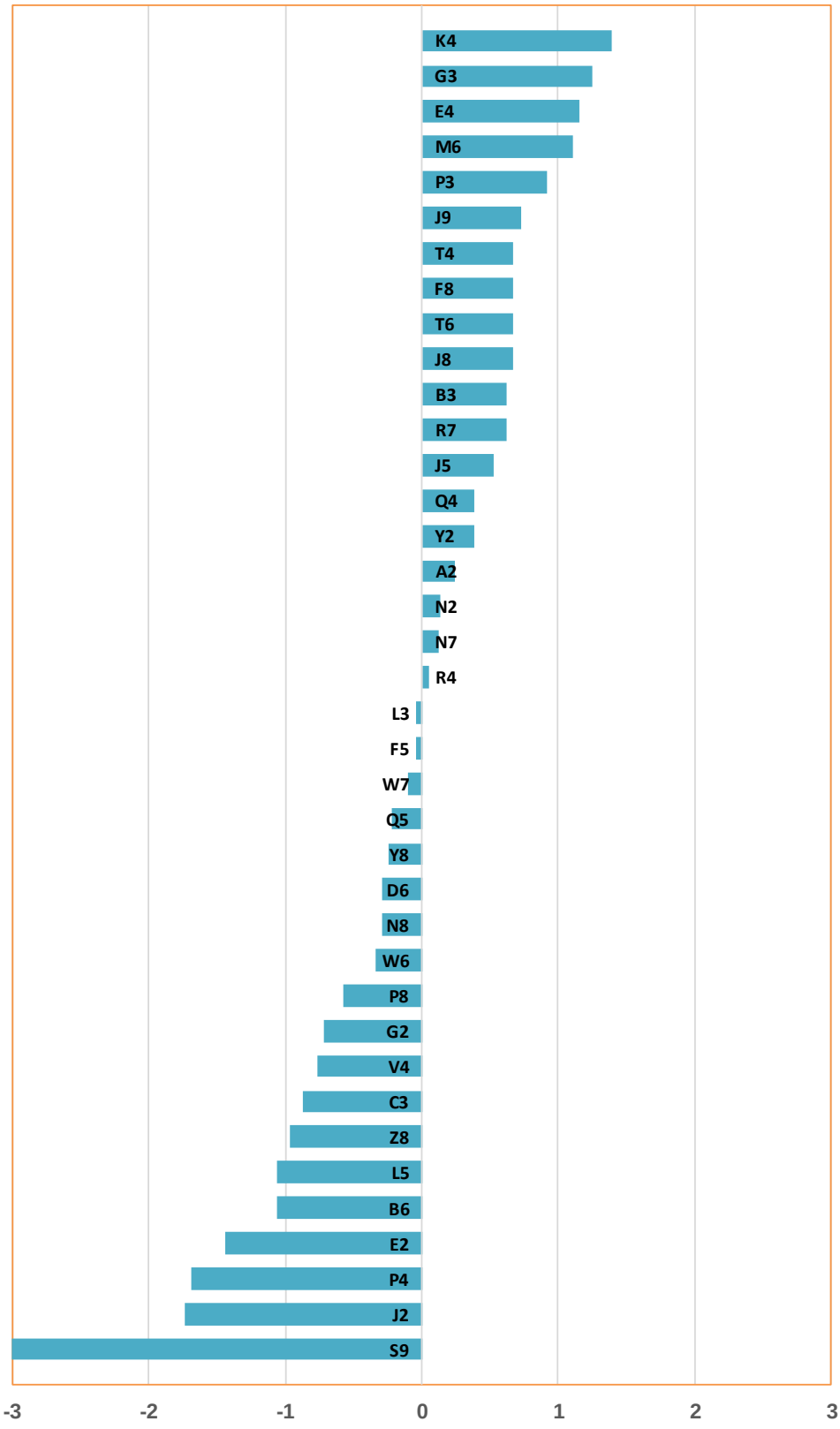
Code	Test Result MPa	Z Score
L5	29.9	-1.06
N7	32.35	0.12
P8	30.9	-0.58
J9	33.6	0.72
P4	28.6	-1.69
J2	28.5	-1.73
B3	33.4	0.63
R4	32.2	0.05
G3	34.7	1.25
D6	31.5	-0.29
T4	33.5	0.67
S9	23.5	**-4.14 #**
F8	33.5	0.67
N8	31.5	-0.29
K4	35.0	1.40
Q4	32.9	0.39
N2	32.4	0.14
G2	30.6	-0.72
L3	32.0	-0.05
F5	32.0	-0.05
W6	31.4	-0.34
W7	31.9	-0.10
E2	29.1	-1.45
V4	30.5	-0.77
B6	29.9	-1.06
C3	30.3	-0.87
Y2	32.9	0.39
M6	34.4	1.11

Code	Test Result MPa	Z Score
J5	33.2	0.53
E4	34.5	1.16
T6	33.5	0.67
Y8	31.6	-0.24
Z8	30.1	-0.96
P3	34.0	0.92
A2	32.6	0.24
J8	33.5	0.67
Q5	31.65	-0.22
R7	33.4	0.63

Statistic	*Value*	
Number of results	**38**	
Median	**32.1**	
Median MU	**0.42**	
First Quartile	**30.7**	
Third Quartile	**33.5**	
IQR	**2.80**	
Normalised IQR	**2.08**	
CV (%)	**6.5**	
Minimum	**28.5**	(23.5)
Maximum	**35.0**	(35.0)
Range	**6.5**	(11.5)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in green have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample B - Compressive Strength: Z - Score Graph



Sample B - MPUV: Z - Scores

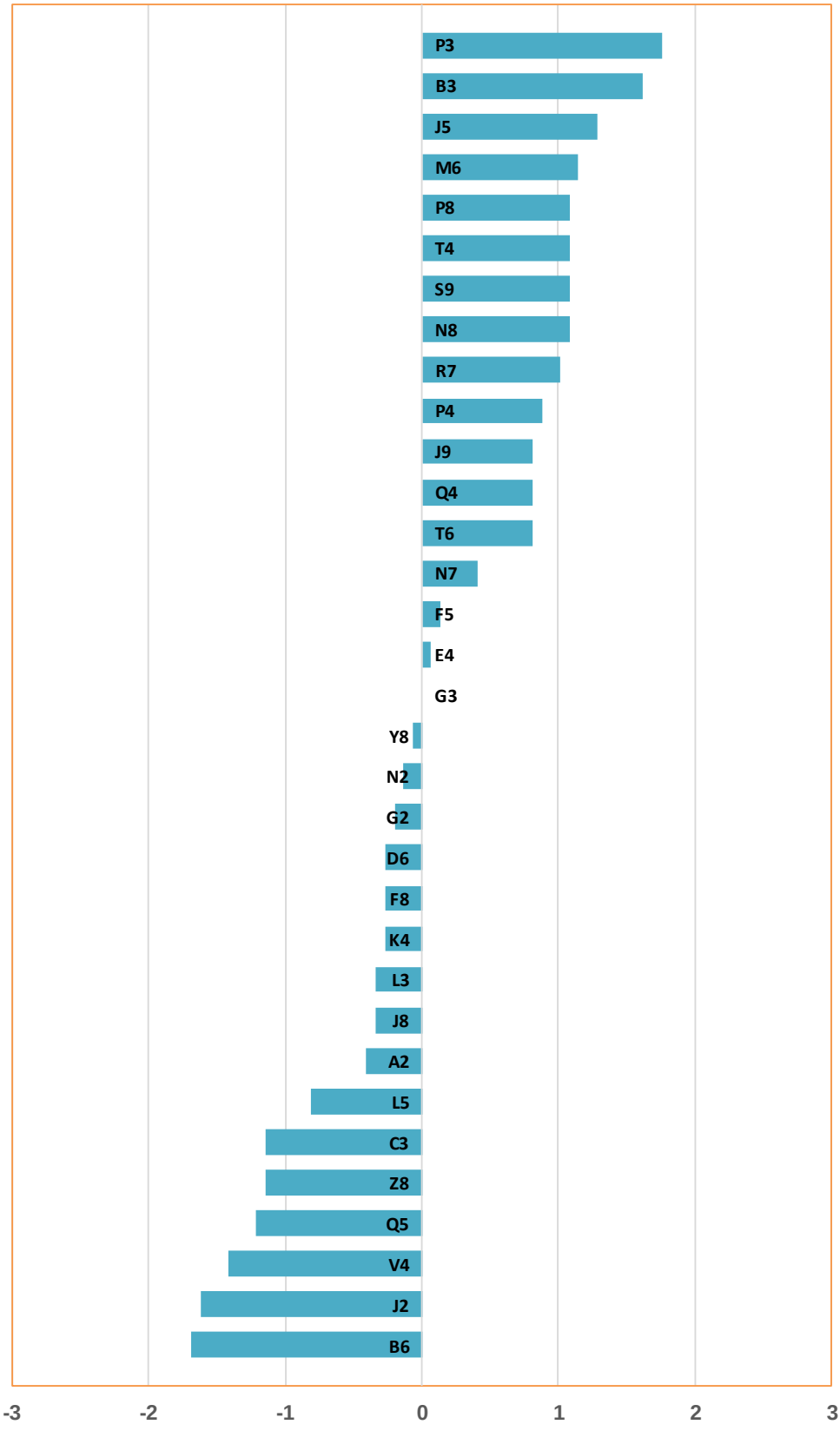
Code	Test Result kg/m³	Z Score
L5	2192	-0.81
N7	2210	0.40
P8	2220	1.08
J9	2216	0.81
P4	2217	0.88
J2	2180	-1.62
B3	2228	1.62
R4	NR	
G3	2204	0.00
D6	2200	-0.27
T4	2220	1.08
S9	2220	1.08
F8	2200	-0.27
N8	2220	1.08
K4	2200	-0.27
Q4	2216	0.81
N2	2202	-0.13
G2	2201	-0.20
L3	2199	-0.34
F5	2206	0.13
W6	NR	
W7	NR	
E2	NR	
V4	2183	-1.42
B6	2179	-1.69
C3	2187	-1.15
Y2	NR	
M6	2221	1.15

Code	Test Result kg/m³	Z Score
J5	2223	1.28
E4	2205	0.07
T6	2216	0.81
Y8	2203	-0.07
Z8	2187	-1.15
P3	2230	1.75
A2	2198	-0.40
J8	2199	-0.34
Q5	2186	-1.21
R7	2219	1.01

Statistic	*Value*	
Number of results	33	
Median	2204	
Median MU	3.23	
First Quartile	2199	
Third Quartile	2219	
IQR	20.00	
Normalised IQR	14.83	
CV (%)	0.7	
Minimum	2179	()
Maximum	2230	()
Range	51	()

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in green have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers. Results in Orange have had the units of measurement changed e.g to Kg/m³

Sample B - MPUV: Z - Score Graph



5. Program Information

5.1. Z-Score Summary

The proficiency program was conducted in October 2023. A 'Z-score Summary' was issued on November 29th, 2023. The summary is intended as an early indicator of participant performance; all results were accepted as they were submitted except for, where needed, adjusting units of measurement (e.g., grams to Kilograms).

A summary was emailed to participants and available on the LabSmart Services Website. The proficiency testing program report supersedes the z-score summary. Further information can be found in section 5.9, 'Statistics'.

5.2. Program Design

5.2.1 Design

This program is held one to two times a year. Participants are required to test two concrete cylinders. The cylinders may be matched (same strength) or unmatched in strength (different strengths). The compressive strength also changes from program to program.

The test requires a minimum skill level. Adherence to the test method is essential for consistent test results. Participant results are checked where possible.

It is expected that the level of experience/skill needed to perform these tests will present a reasonable assessment of the overall competency of the tester and industry performance.

The program was designed to provide technical feedback regarding performance as well as possible improvements. Other considerations involving the design of the program are detailed below.

5.2.2 Selection of material used in the program

Materials used in the preparation of concrete cylinders are selected to ensure that the desired characteristics, such as finish, compressive strength, etc., are obtained.

The concrete cylinders used for this program are made specifically for the program under controlled conditions to ensure uniformity in the strength of the cylinders provided.

5.2.3 Role of Proficiency Testing

The determination of outliers is an important task of this proficiency program. A secondary function is to provide feedback to help those with outliers identify possible areas to investigate and assist all participants in improving.

In addition to the statistics, proficiency programs often obtain other information not normally available in a final report. It allows for a better understanding of the testing and can provide information that can lead to improvements in the testing process or test method.

Proficiency testing enables participants to measure competency against others. It is also a measure of staff performance and the equipment used. Apart from 'measurement uncertainty,' it is the most useful tool a laboratory has in better understanding a test's performance.

5.2.4 Participant assessment

Each participant's assessment is based on a z-score related to the program consensus value (median); this is used to determine any statistical outliers. Compliance with proficiency program requirements, including the correct calculation of results and adherence to program and test method requirements, may also be used as part of the assessment process. Participants may also be asked to investigate any discrepancies detected with the paperwork submitted. See section 5.10 for further details.

5.2.5 Confidentiality

All information, including test results, is treated confidentially. The proficiency testing report does not identify companies or individuals. Each participant is issued a unique identifying code during enrolment that is used in the report to ensure confidentiality of performance.

5.2.6 Reporting of results – Significant figures

The number of decimal places (significant figures) reported for a test affects the statistical analysis and, therefore, the interpretation of the results. A balance must be struck between what is desirable from a statistical viewpoint and how the results are used in practice.

Too few decimal places (e.g., due to rounding) can increase the observed spread of results. Increasing the number of decimal places (with respect to normal reporting) can distort the observed spread of results compared to that encountered in actual practice. Large numbers of similar, rounded results can also cause a distortion in the analysis.

For example, rounding to 0.5 % means that any number between 10.75 and 11.25 will be 11.0%. If the largest value is 10.75 in a set of results, it is pushed out to 11.0 through rounding. Rounded results are beneficial from “an end-user” perspective but are not as useful when considering laboratory performance. The test method acknowledges that additional decimal places may be used for statistical purposes.

For this program, it was decided that the benefits of using additional decimal places would not significantly improve the aim of the proficiency testing program.

Participant's results were analysed as received regardless of whether there were ‘more or less’ significant figures than the number indicated by the test method.

5.2.7 Additional information requested.

This program requested additional information, as detailed in section 6, that may not usually be reported. However, the additional information is consistent with the test's performance and the records the test method requires laboratories to maintain. The additional information is used to interpret participants' performance and assist with providing technical comments, including feedback on outliers and possible participant improvement.

5.2.8 Data checks

As often observed, 'operator errors' can occur in the result calculation process. Every participant's results were recalculated. Both strength and unit mass results were recalculated based on the data provided. Such checks, however, are only as accurate as the raw data supplied by each participant. These checks help ensure that the data is comparable. Any inconsistencies identified during this process are identified as possible feedback for participant improvement. In some cases, inconsistencies identified may need to be investigated by participants.

5.3 Sample Preparation

Two batches of concrete were prepared using two different mix designs. For each mix, 80 cylinders were cast, each individually numbered. After casting, the cylinders were cured in water baths.

After curing, each cylinder was removed from the tank, wrapped in paper, and double-sealed in two plastic bags. One batch was marked as 'Sample A' and the other 'Sample B'. After removing homogeneity samples (at evenly distributed intervals), samples were drawn at random from each batch to make a pair. Each pair of cylinders was assigned a unique participant code.

5.4 Packaging and Instructions

Each pair of cylinders was placed into a sturdy box with bubble wrap. The boxed samples weighed approximately 6 kg. Participants were instructed to test according to the nominated test method and report to the accuracy indicated on the 'Results log' sheet. See 'Appendix A' for a copy of the instructions issued to participants and 'Appendix B' for the log sheet used. A set of instructions and Result log sheets were placed in the box prior to sealing and dispatch.

5.5 Quarantine

Quarantine requirements were assessed and met for all participants. No steps were taken that would have affected individual participants.

5.6 Sample Dispatch

Samples were dispatched to participants on October 19, 2023, using Pack and Send. LabSmart Services tracks dispatched samples from dispatch to delivery for each participant.

5.7 Homogeneity Testing

Samples for homogeneity testing were treated in the same manner as those used for all participants. The homogeneity samples were tested by a NATA-accredited laboratory, which was issued the same instructions as the participants to approximate the same conditions.

Testing was undertaken prior to releasing samples to participants. This allows for early assessments; however, due to how concrete cures, homogeneity data will be different from participant results. The homogeneity data was reviewed and found to be satisfactory. A summary of the homogeneity data is provided in Table 10.

Table 10: Homogeneity Results

	Sample A			Sample B	
	Compressive Strength MPa	**Mass per Unit Volume** kg/m^3		**Compressive Strength** MPa	**Mass per Unit Volume** kg/m^3
H1	48.7	2291	**H11**	33	2215
H2	50.1	2289	**H12**	30.9	2198
H3	50.5	2306	**H13**	30.3	2198
H4	50.2	2267	**H14**	31.9	2200
H5	50.2	2267	**H15**	32.4	2207
H6	50.8	2298	**H16**	31.9	2193
H7	51.1	2285	**H17**	31.9	2196
H8	51.7	2295	**H18**	33.2	2201
H9	52.5	2289	**H19**	33.3	2214
H10	53	2281	**H20**	31.1	2204
Average	50.9	2287	**Average**	32.0	2203
Standard Deviation	1.3	12.5	**Standard Deviation**	1.0	7.4
Range	4.3	39	**Range**	3.0	22
Coefficient of Variation (%)	2.5	0.55	**Coefficient of Variation (%)**	3.2	0.34

5.8 Participation

Out of the 38 participants who entered the program, everyone returned their results in time for inclusion in the report. The nominated date for results to be returned was November 3rd, 2023.

5.9 Statistics

Z-scores were calculated for each test and used to assess the variability of each participant relative to the consensus median. A corresponding z-score graph was produced for each test.

Using median and quartiles reduces the effect that outliers have on the statistics and other influences. Therefore, z-scores provide a more realistic or robust method of assessment.

Some results were reported by participants to more decimal places than requested as part of the proficiency program and by others to fewer decimal places. In all instances, test results have been used as submitted by participants.

A z-score is one way of measuring the degree of consensus with respect to the grouped test results. The z-scores used in this report approximate standard deviations. For each test, a z-score graph is included. Use the graph to visually check how you compare statistically to other participants.

The following bar (Figure 1) is shown at the bottom of each graph. This helps to quickly visualise where each participant's result falls.

Figure 1: Z-score interpretation bar

For example:

- A **strong consensus** (i.e. agreement) means that your test result is close, i.e. within 1 standard deviation of the median.
- A **weak consensus** means that your test result is satisfactory and is within 2 standard deviations of the median.

If you have obtained a test result that is outside 2 standard deviations, then it may be worth **reviewing** your testing processes to ensure that all aspects are satisfactory. Only those obtaining a z-score approaching 3 (I.e. outside the 2.75 range) have been highlighted in the report for review.

If you have obtained a test result that is outside 3 standard deviations, then you will need to investigate your testing processes to ensure that all aspects are satisfactory.

Further details on the statistics used in this proficiency program can be obtained from LabSmart Services or by downloading the 'Participant Guide' from the LabSmart Services website.

5.9.1 Z-score Summary

A "Z-Scores Summary" is issued soon after most results are received. It gives participants early feedback as to any program outliers. The summary is usually available on the LabSmart Services website up until the final report is issued. The final report supersedes the z-score summary.

The final report contains detailed technical feedback regarding test performance and revised z-scores. The program coordinator may include late results or corrections. This may change some of the z-scores slightly in some instances, but generally, the performance outcome remains the same. If there is any impact, it will be discussed in section 5.1 of the report.

5.9.2 Comparing statistics from one program to another.

Statistics generated from one proficiency program are not usually comparable to those from another proficiency testing program. Only very general comparisons may be possible. This is due to the range of variables that differ from one proficiency program to another.

These variables include:

- Type of material selected.
- The number of participants
- Experience of participants
- Test methodology variations.
- Equipment used.
- Test methods used.
- Experience of supervisors
- Range of organizations involved.
- Program design and the statistics employed.

The program outcome represents a 'snapshot' of the industry's competency and, hence, provides an overview. The more participants involved in a proficiency program at a given time, the more representative the overview.

5.9.3 Measurement uncertainty

The statistics detailed in this program do not replace the need for laboratories to separately calculate measurement uncertainties associated with each test when required by the client or NATA. The proficiency program does give information useful for calculating the MU and 'benchmarking' the MU calculated.

5.9.4 Metrological traceability

The assigned median value used in this proficiency testing program is derived from participant performance and is not metrologically traceable.

5.10 Non-statistical Matters

One of the issues proficiency testing providers faces is what to do with an incorrect result even if its z-score is satisfactory. In many cases, they cannot be detected but still can have a significant impact on the statistics calculated. This can cause biased (or unfair) outcomes for other participants.

To limit the effect erroneous results have on a program, additional information is requested to allow the main results to be recalculated. In some cases, results shown to be erroneous may be rejected for inclusion in the program. If the result does not add any statistical bias, it is left in the program.

The result, however, is incorrect even though it may have a satisfactory z-score. To highlight that the participant needs to investigate erroneous results, it is considered a 'non-statistical' matter.

This may also be applied to non-compliance to program requirements, e.g. incorrect reporting of results, etc., or incorrect partial calculations/data.

Non-statistical matters were not used as part of the assessment process for this program.

6. Summary of Participants Results

Summary of Participant Results Sample A

Code	Damage	Surface	Conditioning	Capping	Height mm	Diameter mm		Weight kg	Mass per unit volume kg/m^3	Maximum Force kN	Compressive Strength MPa	Failure	Date Tested
L5	nil	Wet	Tropical	Rubber	200	100.0	100.0	3.579	2278	361	46.0	Normal	1/11/2023
N7	NA	0	Tropical	Rubber	201	100.0	100.2	3.595	2273	383.45	48.82	Normal	1/11/2023
P8	nil	SS Wet	Tropical	Rubber	200	99.8	99.8	3.581	2280	376	48.1	Normal	1/11/2023
J9	0	SS Wet	Tropical	Rubber	200	100.0	100.0	3.567	2271	382	48.7	Conical F	1/11/2023
P4	nil	Wet	Tropical	Rubber	199	99.8	100.0	3.571	2289	369	47.1	Normal	1/11/2023
J2	---	SS Wet	Tropical	Rubber	200	100.4	100.4	3.598	2280	383.7	48.5	Shear F	1/11/2023
B3	nil	SS Dry	Tropical	Rubber	199	100.0	100.0	3.567	2282	374	47.6	Conical F	1/11/2023
R4	coarse top	Wet	Tropical	Rubber	199	99.8	100.1	3.612	0	382	48.6	Conical F	1/11/2023
G3	no damage	Wet	Temperate	End Grind	197	100.2	100.2	3.578	2303	406	51.5	Normal	1/11/2023
D6	---	Wet	Temperate	Sulphur	200	99.8	99.8	3.616	2320	346	44.0	Normal	1/11/2023
T4	---	Wet	Temperate	Sulphur	198	100.0	100.0	3.606	2320	399	51.0	Normal	1/11/2023
S9	---	Wet	Temperate	Sulphur	199	100.0	100.0	3.592	2300	285	36.5	Shear F	1/11/2023
F8	nil	SS Wet	Tropical	End Grind	195	100.1	100.5	3.503	2280	392	49.5	Shear F	1/11/2023
N8	nil	SS Wet	Tropical	End Grind	195	100.1	100.2	3.515	2280	372.8	47.5	Conical F	1/11/2023
K4	nil	SS Wet	Tropical	End Grind	198	100	100.2	3.551	2280	410.0	52.0	Normal	3/11/2023
Q4	nil	SS Wet	Tropical	End Grind	197	99.8	100.0	3.516	2277	382	48.8	Conical F	1/11/2023
N2	nil	SS Wet	Temperate	Rubber	198	99.8	99.8	3.564	2301	391.2	49.999	Conical F	1/11/2023
G2	no	Wet	Tropical	Rubber	198	100.8	100.4	3.580	2277	371	46.7	Normal	1/11/2023
L3	Nil	SS Wet	Tropical	Rubber	198	100.0	100.0	3.551	2286	397	50.6	Normal	1/11/2023
F5	---	SS Wet	Tropical	End Grind	197	100.4	100.2	3.559	2286	367	46.4	Normal	1/11/2023
W6	na	SS Wet	Tropical	Rubber	199	100.0	100.0	3.586	0	398.2	50.7	Normal	NR
W7	ok small bubbles	Wet	Temperate	Rubber	200	99.8	100.8	3.640	0	404.581	51.2	Normal	1/11/2023
E2	0	Wet	Temperate	Rubber	198.95	100.30	100.29	3.562	0	356.378	45.1	Cap Failure	1/11/2023
V4	none	SS Wet	Tropical	Sulphur	199	99.8	100.2	3.562	2279	400	50.9	Conical F	1/11/2023
B6	0	Wet	Temperate	Rubber	199	100.4	100.4	3.585	2276	376	47.5	Normal	9/11/2023
C3	na	SS Dry	Tropical	Rubber	200	100.2	100.4	3.619	2291	383.5	48.5	Normal	1/11/2023
Y2	nil	SS Wet	Tropical	Rubber	198	100.0	100.0	3.578	0	415	52.9	Normal	1/11/2023
M6	0	SS Wet	Temperate	Rubber	199	99.8	100.2	3.567	2282	389	45.5	Conical F	1/11/2023
J5	0	SS Wet	Temperate	Rubber	198	99.8	100.0	3.530	2280	403	51.5	Conical F	1/11/2023
E4	0	SS Wet	Temperate	Rubber	198	99.8	100.4	3.545	2279	403	51.0	Conical F	1/11/2023
T6	none	SS Wet	Temperate	Rubber	202	100.6	100.0	3.726	2335	379	48.0	Conical F	1/11/2023
Y8	nill	Wet	Temperate	Rubber	200	100.0	100.0	3.548	2259	381	48.5	Shear F	1/11/2023
Z8	0	SS Wet	Temperate	Rubber	199	99.8	100.2	3.554	2274	377	48.0	Normal	1/11/2023
P3	none	SS Wet	Temperate	End Grind	197	100.0	100.0	3.542	2301	417	53.0	Normal	1/11/2023
A2	none	Wet	Temperate	End Grind	197	100.2	100.0	3.549	2289	419	53.4	Normal	1/11/2023
J8	none	SS Wet	Temperate	End Grind	197	100.0	100.0	3.529	2276	399	50.7	Normal	1/11/2023
Q5	nil	Wet	Temperate	Rubber	198	100.6	100.1	3.589	2356	423.1	53.44	Normal	1/11/2023
R7	no damage	Wet	Temperate	Rubber	198	99.8	99.8	3.606	2328	412	52.6	Conical F	1/11/2023

Note Denotes when units have been changed e.g Grams to Kilograms

Summary of Participants Results - Sample B

Code	Damage	Surface	Conditioning	Capping	Height mm	Diameter mm		Weight kg	Mass per unit volume kg/m3	Maximum Force kN	Compressive Strength MPa	Failure	Date Tested
L5	nil	Wet	Tropical	Rubber	200	99.8	100.0	3.436	2192	234	29.9	Normal	1/11/2023
N7	NA	0	Tropical	Rubber	200	100.0	100.0	3.471	2210	254.12	32.35	Normal	1/11/2023
P8	nil	SS Wet	Tropical	Rubber	200	100.0	100.2	3.503	2220	243	30.9	Normal	1/11/2023
J9		SS Wet	Tropical	Rubber	199	100.0	100.0	3.464	2216	264	33.6	Cap Failure	1/11/2023
P4	nil	Wet	Tropical	Rubber	200	100.0	100.0	3.483	2217	225	28.6	Normal	1/11/2023
J2		SS Wet	Tropical	Rubber	199	100.4	100.4	3.435	2180	224.6	28.5	Cap Failure	1/11/2023
B3	nil	SS Dry	Tropical	Rubber	199	100.0	99.9	3.479	2228	262	33.4	Conical F	1/11/2023
R4	coarse top air voids	Wet	Tropical	Rubber	199	100.5	99.7	3.448		253	32.2	Abnormal SF	1/11/2023
G3	no damage	Wet	Temperate	End Grind	197	100.8	100.6	3.444	2204	276	34.7	Normal	1/11/2023
D6	---	Wet	Temperate	Sulphur	199	99.8	99.8	3.430	2200	248	31.5	Normal	1/11/2023
T4	---	Wet	Temperate	Sulphur	200	100.4	100.4	3.526	2220	266	33.5	Normal	1/11/2023
S9	---	Wet	Temperate	Sulphur	199	100.0	100.0	3.464	2220	183	23.5	Shear F	1/11/2023
F8	nil	SS Wet	Tropical	End Grind	195	99.8	100.3	3.383	2200	262	33.5	Shear F	1/11/2023
N8	nil	SS Wet	Tropical	End Grind	198	101.4	101.9	3.549	2220	255.6	31.5	Conical F	1/11/2023
K4	nil	SS Wet	Tropical	End Grind	197	100.0	100.0	3.406	2200	276.0	35.0	Normal	3/11/2023
Q4	nil	SS Wet	Tropical	End Grind	196	99.8	99.8	3.398	2216	257	32.9	Shear F	1/11/2023
N2	nil	SS Wet	Temperate	Rubber	199	99.6	99.6	3.414	2202	252.3	32.382	Cap Failure	1/11/2023
G2	no	Wet	Tropical	Rubber	200	100.2	100.2	3.467	2201	241	30.6	Normal	1/11/2023
L3	concave top	SS Wet	Tropical	Rubber	199	100.0	99.8	3.430	2199	251	32.0	Normal	1/11/2023
F5	---	SS Wet	Tropical	End Grind	197	100.2	100.2	3.427	2206	252	32.0	Normal	1/11/2023
W6	na	SS Wet	Tropical	Rubber	199	100.0	99.8	3.342		245.8	31.4	Normal	NR
W7	small amount of air bubbl	Wet	Temperate	Rubber	200	99.8	100.2	3.457		250.221	31.9	Normal	1/11/2023
E2	some surface bubbles	Wet	Temperate	Rubber	199.39	100.28	100.17	3.464		229.630	29.1	Cap Failure	1/11/2023
V4	none	SS Wet	Tropical	Sulphur	199	100.0	100.2	3.419	2183	240	30.5	Shear F	1/11/2023
B6		Wet	Temperate	Rubber	201	100.2	100.2	3.454	2179	236	29.9	Shear F	9/11/2023
C3	na	SS Dry	Tropical	Rubber	200	100.2	100.2	3.448	2187	239.3	30.3	Normal	1/11/2023
Y2	nil	SS Wet	Tropical	Rubber	199	100.0	100.2	3.453		259	32.9	Normal	1/11/2023
M6		SS Wet	Temperate	Rubber	199	100.0	100.2	3.484	2221	271	34.4	Cap Failure	1/11/2023
J5		SS Wet	Temperate	Rubber	200	100.2	100.8	3.520	2223	263	33.2	Shear F	1/11/2023
E4		SS Wet	Temperate	Rubber	199	100.1	100.4	3.460	2205	271	34.5	Cap Failure	1/11/2023
T6	none	SS Wet	Temperate	Rubber	201	100.0	100.0	3.498	2216	263	33.5	Conical F	1/11/2023
Y8	nill	Wet	Temperate	Rubber	200	100.0	100.0	3.460	2203	248	31.6	Shear F	1/11/2023
Z8		SS Wet	Temperate	Rubber	200	100.0	100.2	3.442	2187	237	30.1	Cap Failure	1/11/2023
P3	none	SS Wet	Temperate	End Grind	200	100.0	100.0	3.503	2230	267	34.0	Normal	1/11/2023
A2	none	Wet	Temperate	End Grind	197	100.2	100.2	3.414	2198	256	32.6	Normal	1/11/2023
J8	none	SS Wet	Temperate	End Grind	198	100.0	100.0	3.423	2199	264	33.5	Normal	1/11/2023
Q5	nil	Wet	Temperate	Rubber	200	100.7	100.1	3.462	2186	250.6	31.65	Abnormal SF	1/11/2023
R7	no damage	Wet	Temperate	Rubber	199	99.8	99.8	3.454	2219	262	33.4	Cap Failure	1/11/2023

Note Denotes when units have been changed e.g Grams to Kilograms

Appendix A: Instructions for Testers

Concrete Proficiency Program 2023 (118)

INSTRUCTIONS FOR TESTER

1. **Do not open the plastic bags until the 1st of November. Store at room temperature away from fluctuating temperatures and sunlight.**
2. Please read these instructions carefully on receipt of samples.
3. Please check that the package you have received contains the following:
   - Results Log sheet
   - Two nominal 100 mm Ø by 200 mm concrete cylinders sealed in plastic bags marked 'Sample A' and 'Sample B'.
4. Inspect packaging on arrival for damage or leakage. Contact LabSmart Services if the box is wet, or damaged, or if anything is missing (Phone 0439 208 406).
5. It is strongly recommended that participants follow AS 1012, Method 9 when testing the concrete cylinders, but an alternative equivalent method may also be used.
6. On the 1st of November, remove each cylinder from the plastic bag. Remove the paper covering. Inspect each cylinder and record its condition on the proficiency testing results log sheet (AS 1012, clause 4.1 (a) to (h)). If surface bubbles appear excessive, record it on the log sheet but continue with the test. If cylinders show any chipping or damage caused by transport, please contact LabSmart Services before testing.
7. Within 10 minutes of opening the plastic bag, immerse each concrete cylinder into the curing tank. Allow the cylinders to pre-condition for at least three hours prior to capping and testing by full immersion in water at 23 ± 2° C temperate zone or 27 ± 2° C tropical zone.
8. Follow AS 1012, Method 9. Test both cylinders within 15 minutes of each other.
9. Record all information and calculations as per AS 1012, Method 9 on the proficiency testing results log sheet **but to the accuracy shown on the results log sheet.**
10. Ensure to have the Laboratory Supervisor check & approve prior to signing the log sheet.
11. **Please E-mail the "Results Log" to LabSmart Services by 3rd of November 2023**
    E-mail: info@labsmartservices.com.au
12. Please retain the completed "Results Log" as this contains your participation code that will identify your results in the technical report covering the proficiency testing program. It is also recommended that a copy of completed worksheets be kept with the results log in your proficiency file. Results can also be used for technical auditing or training.
13. Have a query? Contact LabSmart Services. Phone 0439 208 406.

Thank you for participating in this proficiency testing program.

Concrete PT Instructions V2023.1 (118).docx

Appendix B: Results Log

LabSmart

Concrete Compression Proficiency Program – 2023 (118)

RESULTS LOG **Laboratory: XXXXX** **Participation Code: xx**

Please TEST cylinders on the 1st of November 2023

Please E-mail info@labsmartservices.com.au with the completed results log by 3rd of November 2023

TEST		Sample A	Sample B
Date samples received			
Describe the condition of the samples	List defects, damage		
	SS Wet or Dry		
Test Method used	AS 1012.9 OR		
Conditioning	Temperate or Tropical		
Capping Method #	Rubber or Sulphur		
Height	Report to 1 mm		
Diameter	Report to 0.2 mm		
Weight	Report to 0.001 kg		
Maximum Force	Report to 1 kN		
Compressive Strength	Report to 0.1 MPa		
Type of cylinder failure v	Normal – CON F Abnormal – SF, CAP F		
Test Method used	AS 1012.12.1 OR		
Tested	Capped or Uncapped		
Weight	Report to 0.001 kg		
Mass per unit volume	Report to 1 kg/m³		
Date Tested			
Tested by:			

COMMENTS: .....

.....

.....

Supervisor Name *(Please Print)*	Signature	Date

In signing the above, I acknowledge that the above results are approved and have been checked. I will also ensure that the results are kept confidential, both internal and external, to the laboratory until the issue of the final technical report covering this program.

Thank you for participating. Please retain this sheet for your records

If cylinder end grinding only is available, please report.
For a description of cylinder failures, please see the next page.

XX Concrete PT Results Log V2023.1 (115).Docx

LabSmart

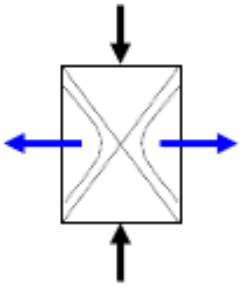
Concrete Compression Proficiency Program – 2023 (118)

Concrete Cylinder Failure Modes

"Normal"

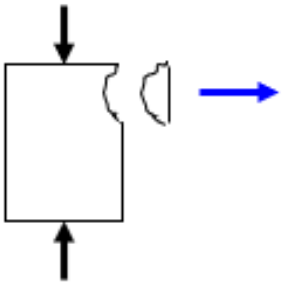
OR

"Conical Failure"



"Shear Failure"

"Cap Failure"



Have a query? Contact LabSmart Services. Phone: 0439 208 406

XX Concrete PT Results Log V2023.1 (115).Docx