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Concrete – 2022 (111)

Proficiency Testing Program Report

Accredited for compliance with ISO/IEC 17043

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.

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Program Coordinator

The program coordinator for this program was Jeffrey Mulholland, LabSmart Services.

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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 in December 2022. 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 24 March 2023

Contents

1. Program Aim

This proficiency testing program was conducted in October/November 2022 with 33 participants from around Australia. The program involved the performance of the following:

- AS 1012.9 – 2014, Determination of the Compressive Strength of concrete specimens
- AS 1012.12.1 – 1998 (R2014), Determination of Mass per Unit Volume.

This 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 in improving 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 5th of December 2022 to facilitate early feedback on performance.

2. Performance

2.1. Identified Outliers

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.

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. However, those participants with z-scores greater than 2 or less than -2 should review their testing methodology. There were no outliers identified across the tests performed.

The z-score graph gives a quick visual indication of how a result compares to others in the program. 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 in investigating or reviewing their results, as well as for those seeking to improve their testing performance.

2.2. Program Summary

Of the 33 participants that joined this program, 31 returned results in time to be included in this report.

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

Most participants had results (for Compressive Strength and Mass per Unit Volume) within 1 s.d, which was a good outcome. Only 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 performed these tests competently.

Table 1: 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	31	31	31	31
Median	36.8	2316	54.8	2318
N-IQR	1.19	17.05	2.00	14.83
CV (%)	3.2	0.7	3.7	0.6
Range*	4.6	61	6.5	50

* 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 'Compressive Strength' and 'Mass per Unit Volume'. An Outlier assessment was undertaken based on these results; the robust statistical analysis can be found in section 4 of this report.

Table 2: Summary of CV for current and past programs

Coefficient of Variation (%)			
Program	**Sample**	**Mass per Unit Volume**	**Compressive Strength**
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
2017(70)	A1	0.6	5.7
	A2	0.4	2.6
	B1	0.7	5.8
	B2	1.0	8.3
2016(63)	A	0.8	4.9
	B	0.6	4.9
2014(56)	A	0.8	3.6
	B	0.5	4.1

Outcome

Overall, participants agreed well on the ‘Mass per Unit Volume’ and the ‘Compressive Strength’. The Coefficient of Variation (CV) shown in Table 2 is one way to broadly evaluate that the participant's performance is consistent from one program to another. Based on this, participants did very well on all tests. 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.

Missing Information

Most participants provided all the information requested on the results log sheet. Thank you to all participants; this makes providing informative feedback far easier.

3.1. Compressive Strength

Nominated Test Date

Sometimes it is impossible to test a sample on its nominated test date, and this can result from a range of factors (for example, staff/equipment availability). In this instance, there was only 1 participant that did not test on the nominated date of November 23rd. (see Table 3).

Table 3: Variation in test date

Participant	**Y4**	
Sample	**A**	**B**
Difference in days	+1	+1
Result (MPa)	38	54.8
Median (MPa)	36.8	54.8
Z-score	**1.01**	**0.00**

Data analysis of participant **Y4** results indicates that their late test date did not significantly affect their final outcome.

Incomplete crushing

It was noted during past programs that some cap failures caused the compression machine to register that the maximum load had been reached. Further crushing yielded 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)

The ‘Compressive Strength’ results can be determined from the reported diameter and maximum force. Where possible, LabSmart recalculated ‘Compressive Strength’ for each participant, and this calculated result was compared to the participant-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 have been highlighted in Table 4. For these participants, it may be worthwhile reviewing these results.

Table 4: Recalculated ‘Compressive Strength’ results

Code	Compressive Strength		
	Submitted (MPa)	**Recalculated** (MPa)	**Difference** (MPa)
T2 (Sample B)	56	55.6	-0.4
F8 (Sample B)	53.8	54.1	0.3
M3 (Sample A)	35.0	35.3	0.3
U7 (Sample B)	56.1	56.4	0.3

Statistical Outliers

Overall a satisfactory level of testing was achieved by all participants for ‘Compressive Strength’. There were no outliers identified for ‘Compressive Strength’.

Failure Modes

Of all the participants who returned the required information, 19.4% reported 'Cap Failure' for Sample A and none for Sample B. In addition, 12.9% reported 'shear failure' for Sample A and 22.6% for Sample B. All other participant's results reported either a 'Normal' or 'Conical Failure'. Table 5 shows the 'normal/conical' failure statistics vs. abnormal ('Cap' and 'Shear') failures.

Regardless of the failure mode, the median values are very close to the combined results in section 4. 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 5: Normal/Conical and Shear/Cap failure statistics for samples A & B

Compression Statistic MPa	**Sample A**	**Sample B**
	Normal - Conical failure results only.	
Median (MPa)	37.1	54.7
NIQR	1.11	2.26
Number of Participants	21	24
Compression Statistic MPa	**Sample A**	**Sample B**
	Abnormal - Cap or shear failure results only.	
Median (MPa)	36.5	54.8
NIQR	1.07	1.30
Number of Participants	10	7

Capping Methods

Out of the participants who returned the required information, 15 participants (48%) used rubber caps, with 9 participants (29%) using grounded ends, and there were 7 participants (23%) using Sulphur capping.

In this program, it was impossible to determine if there was any statistical variation due to the capping method employed; this was 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 participants 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, for this program, 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. This report focused on results that differed by greater than or equal to 10 kg/m^3. For this program there were no participants with a difference greater than or equal to 10 kg/m^{3-}.

It is essential that the calculation process is correct and accurate. Instructions on the calculation method 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 $V=\pi r^2h$ 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 have an effect. 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.

Statistical Outliers

Overall a satisfactory level of testing was achieved by all participants for ‘Mass per Unit Volume’. There were no outliers for ‘Mass per Unit Volume’.

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.

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4. Statistics: Z-Score & Graph

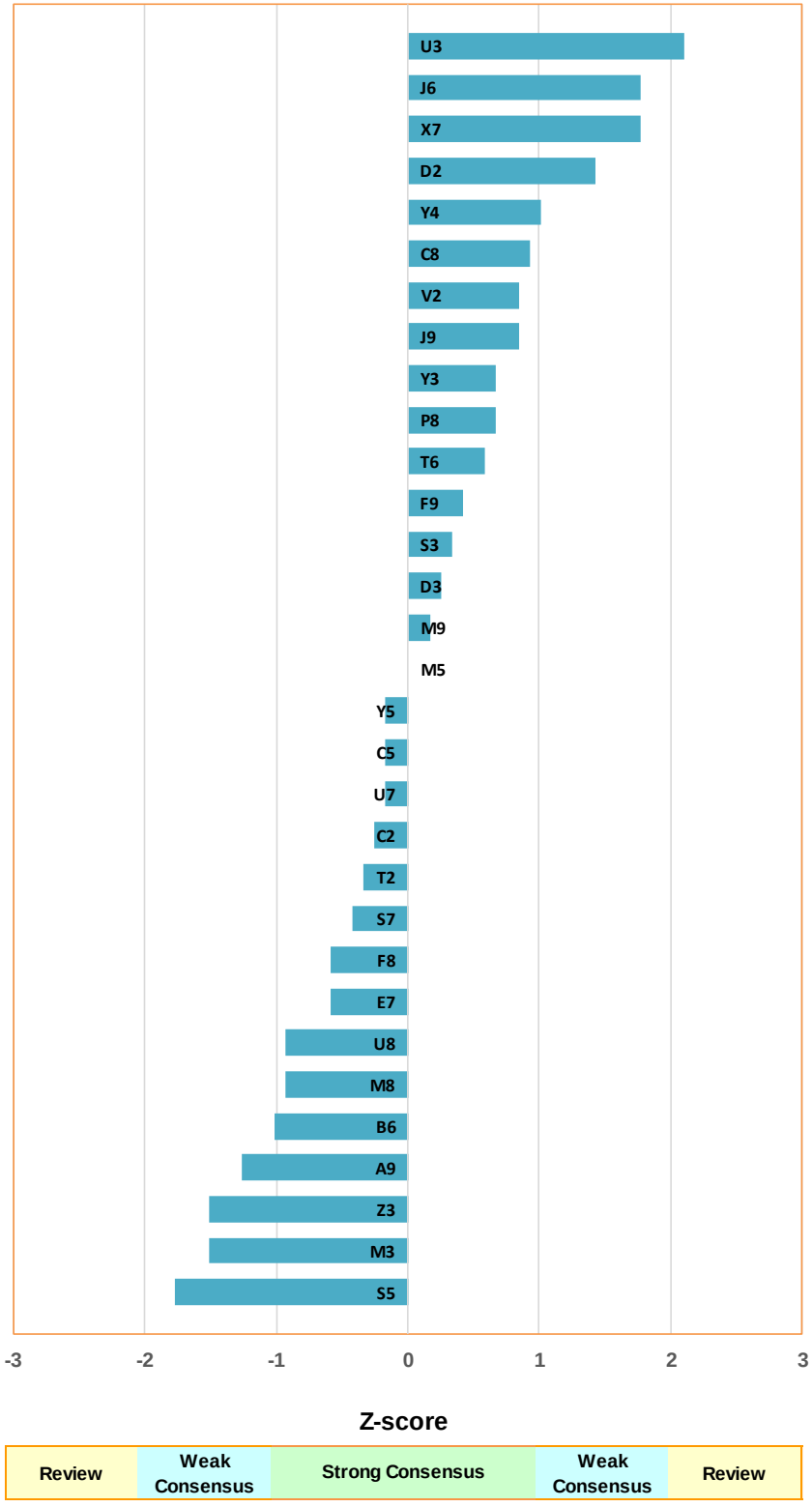
Sample A - Compressive Strength: Z - Scores

Code	Test Result MPa	Z Score	Code	Test Result MPa	Z Score
M5	36.8	0.00	U7	36.6	-0.17
D3	37.1	0.25	C8	37.9	0.93
C2	36.5	-0.25	M8	35.7	-0.93
Y5	36.6	-0.17	P8	37.6	0.67
A9	35.3	-1.26	S7	36.3	-0.42
V2	37.8	0.84			
S3	37.2	0.34			
T2	36.4	-0.34			
J6	38.9	1.77			
Z3	35.0	-1.52			
U3	39.3	2.11			
M9	37	0.17			
X7	38.9	1.77			
U8	35.7	-0.93			
X4	NR				
B6	35.6	-1.01			
F9	37.3	0.42			
T8	NR				
C5	36.6	-0.17			
Y4	38	1.01			
F8	36.1	-0.59			
D2	38.5	1.43			
J9	37.8	0.84			
M3	35.0	-1.52			
E7	36.1	-0.59			
T6	37.5	0.59			
Y3	37.6	0.67			
S5	34.7	-1.77			

Statistic	*Value*	
Number of results	**31**	
Median	**36.8**	
Median MU	**0.27**	
First Quartile	**36.1**	
Third Quartile	**37.7**	
IQR	**1.60**	
Normalised IQR	**1.19**	
CV (%)	**3.2**	
Minimum	**34.7**	()
Maximum	**39.3**	()
Range	**4.6**	()

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 - Mass Per Unit Volume: Z - Scores

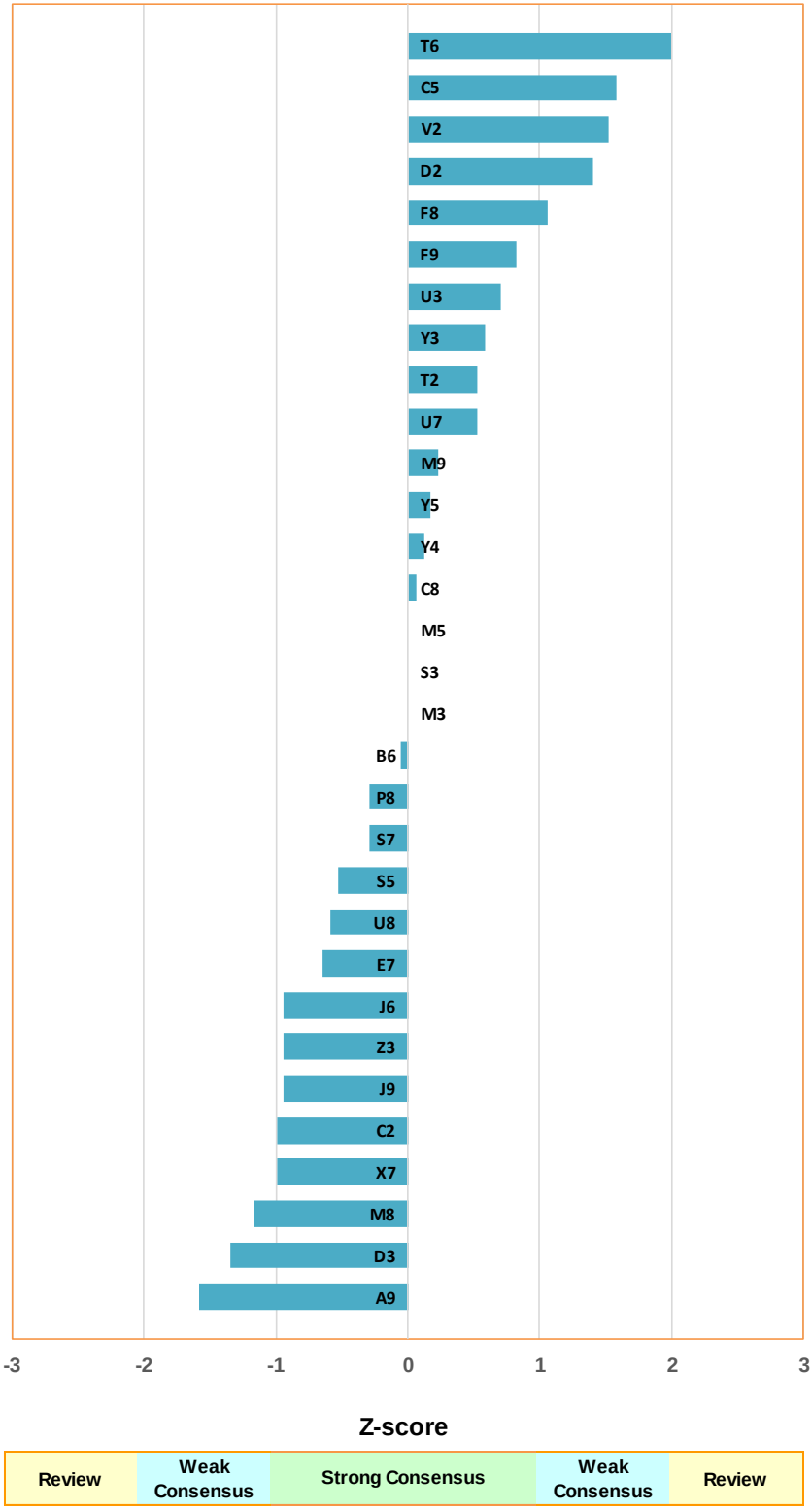
Code	Test Result kg/m³	Z Score
M5	2316	0.00
D3	2293	-1.35
C2	2299	-1.00
Y5	2319	0.18
A9	2289	-1.58
V2	2342	1.52
S3	2316	0.00
T2	2325	0.53
J6	2300	-0.94
Z3	2300	-0.94
U3	2328	0.70
M9	2320	0.23
X7	2299	-1.00
U8	2306	-0.59
X4	NR	
B6	2315	-0.06
F9	2330	0.82
T8	NR	
C5	2343	1.58
Y4	2318	0.12
F8	2334	1.06
D2	2340	1.41
J9	2300	-0.94
M3	2316	0.00
E7	2305	-0.65
T6	2350	1.99
Y3	2326	0.59
S5	2307	-0.53

Code	Test Result kg/m³	Z Score
U7	2325	0.53
C8	2317	0.06
M8	2296	-1.17
P8	2311	-0.29
S7	2311	-0.29

Statistic	*Value*	
Number of results	**31**	
Median	**2316**	
Median MU	**3.83**	
First Quartile	**2303**	
Third Quartile	**2326**	
IQR	**23.00**	
Normalised IQR	**17.05**	
CV (%)	**0.7**	
Minimum	**2289**	()
Maximum	**2350**	()
Range	**61**	()

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 - Mass Per Unit Volume: Z - Score Graph



Sample B - Compressive Strength: Z - Scores

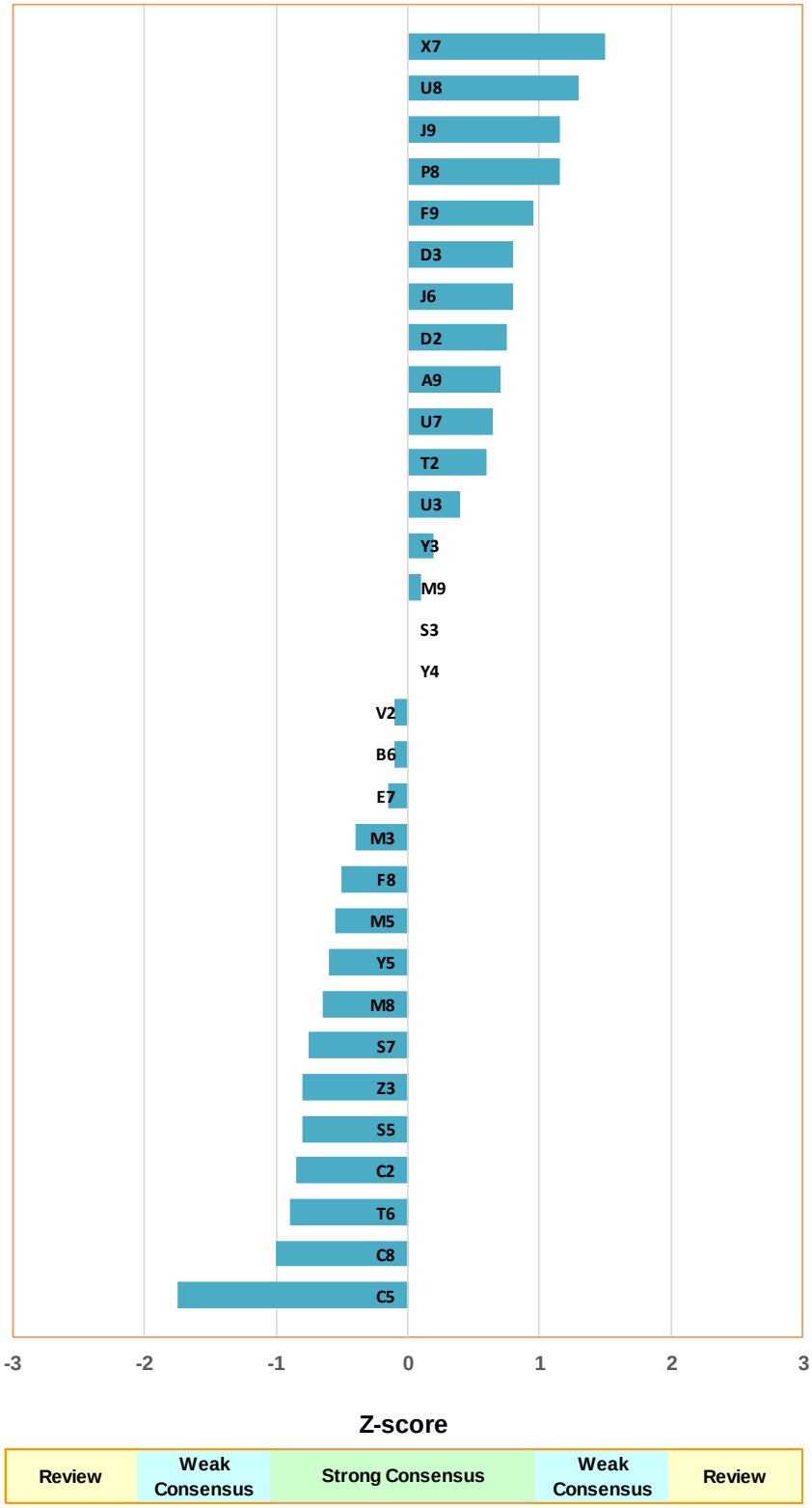
Code	Test Result MPa	Z Score
M5	53.7	-0.55
D3	56.4	0.80
C2	53.1	-0.85
Y5	53.6	-0.60
A9	56.2	0.70
V2	54.6	-0.10
S3	54.8	0.00
T2	56.0	0.60
J6	56.4	0.80
Z3	53.2	-0.80
U3	55.6	0.40
M9	55	0.10
X7	57.8	1.50
U8	57.4	1.30
X4	NR	
B6	54.6	-0.10
F9	56.7	0.95
T8	NR	
C5	51.3	-1.75
Y4	54.8	0.00
F8	53.8	-0.50
D2	56.3	0.75
J9	57.1	1.15
M3	54.0	-0.40
E7	54.5	-0.15
T6	53.0	-0.90
Y3	55.2	0.20
S5	53.2	-0.80

Code	Test Result MPa	Z Score
U7	56.1	0.65
C8	52.8	-1.00
M8	53.5	-0.65
P8	57.1	1.15
S7	53.3	-0.75

Statistic	*Value*	
Number of results	**31**	
Median	**54.8**	
Median MU	**0.45**	
First Quartile	**53.6**	
Third Quartile	**56.3**	
IQR	**2.70**	
Normalised IQR	**2.00**	
CV (%)	**3.7**	
Minimum	**51.3**	()
Maximum	**57.8**	()
Range	**6.5**	()

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 - Mass Per Unit Volume: Z - Scores

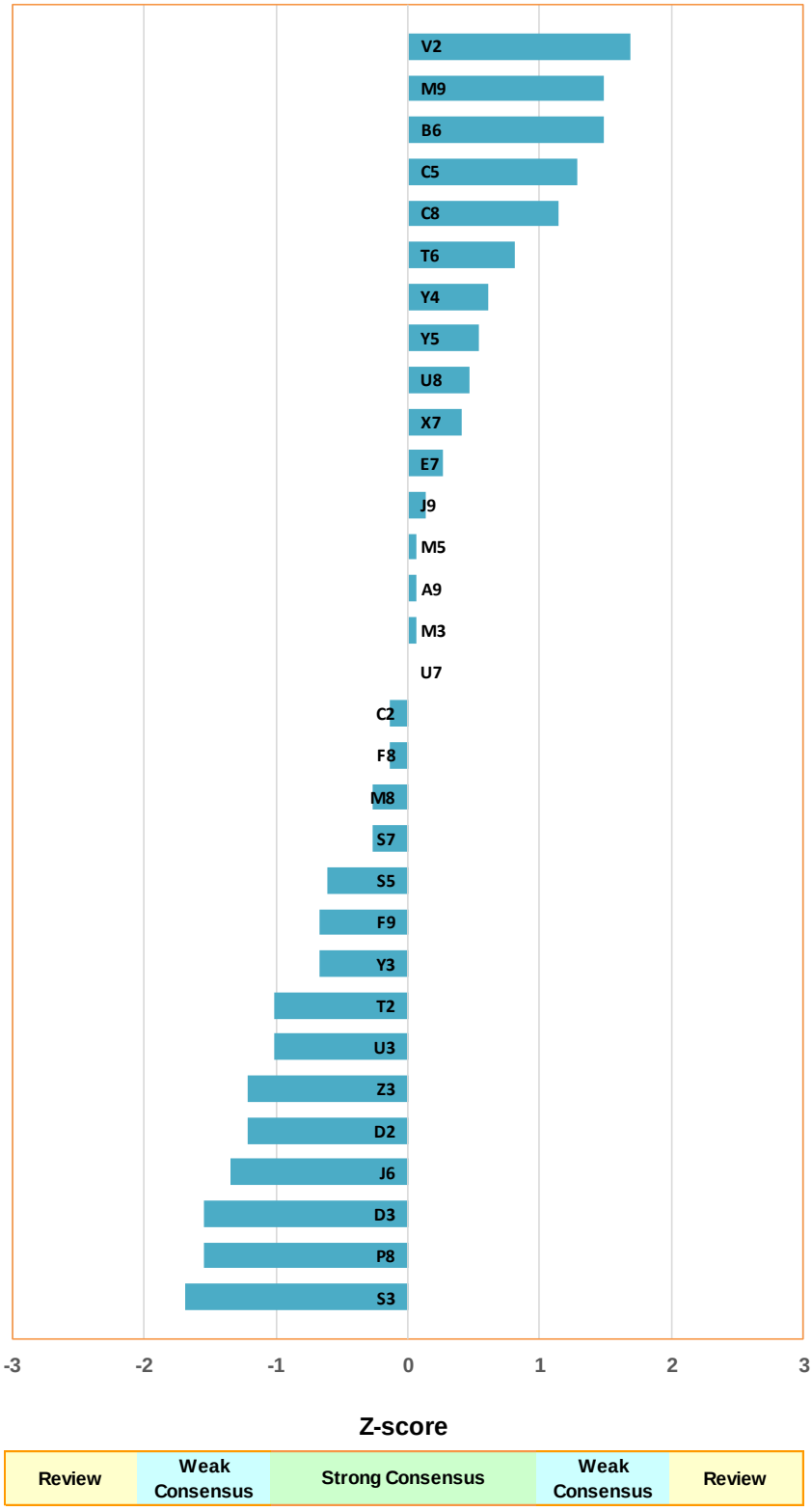
Code	Test Result kg/m³	Z Score
M5	2319	0.07
D3	2295	-1.55
C2	2316	-0.13
Y5	2326	0.54
A9	2319	0.07
V2	2343	1.69
S3	2293	-1.69
T2	2303	-1.01
J6	2298	-1.35
Z3	2300	-1.21
U3	2303	-1.01
M9	2340	1.48
X7	2324	0.40
U8	2325	0.47
X4	NR	
B6	2340	1.48
F9	2308	-0.67
T8	NR	
C5	2337	1.28
Y4	2327	0.61
F8	2316	-0.13
D2	2300	-1.21
J9	2320	0.13
M3	2319	0.07
E7	2322	0.27
T6	2330	0.81
Y3	2308	-0.67
S5	2309	-0.61

Code	Test Result kg/m³	Z Score
U7	2318	0.00
C8	2335	1.15
M8	2314	-0.27
P8	2295	-1.55
S7	2314	-0.27

Statistic	*Value*	
Number of results	**31**	
Median	**2318**	
Median MU	**3.33**	
First Quartile	**2306**	
Third Quartile	**2326**	
IQR	**20.00**	
Normalised IQR	**14.83**	
CV (%)	**0.6**	
Minimum	**2293**	()
Maximum	**2343**	()
Range	**50**	()

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 - Mass Per Unit Volume: Z - Score Graph



5. Program Information

5.1. Z-score Summary

The proficiency program was conducted in October/November of 2022. A 'Z-score Summary' was issued on the 5th of December, 2022. The summary is intended as an early indicator of participant performance; all results were accepted as they were submitted except for adjusting units of measurement (i.e. Grams to Kilograms).

A summary was e-mailed to participants and was also 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 semiannual. 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 year to year.

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 that can 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. 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 the performance of a test.

5.2.4. Participant assessment

The assessment of each participant 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 with the submitted paperwork. See section 5.10 for further details.

5.2.5. Reporting of results - Significant figures

The number of decimal places (significant figures) reported for a test has a bearing on the statistical analysis and, therefore, the interpretation of the results. There is a need to strike a balance between what is desirable from a statistical viewpoint while recognising how the results are used in practice.

Too few decimal places (e.g. due to rounding) can cause an increase in 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 complement the aim of the proficiency program.

Participants’ results were analysed as received regardless of whether there were ‘more or less’ significant figures than the number requested by the program.

5.2.6. 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 that the test method requires laboratories to maintain. The additional information is used to interpret participants' performance and provide technical comments, including feedback on outliers and possible participant improvement.

5.2.7. 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.

5.2.8 Confidentiality

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

5.3. Sample Preparation

Two Batches of concrete were prepared using two different mix designs. For each mix, there was a minimum of 70 cylinders cast. Each cylinder was individually numbered. Cylinders were then cured in water baths after casting.

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. 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

There were no Quarantine requirements for this program.

5.6. Sample Dispatch

Samples were dispatched to participants on the 2nd of November 2022 using Pack and Send. Dispatched samples are tracked from dispatch to delivery for each participant by LabSmart Services.

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. The laboratory was issued the same instruction as the participants to approximate the same conditions (i.e. same test date, curing parameters, etc.).

The homogeneity data was reviewed and found to be satisfactory. A summary of the homogeneity data is provided in Table *6*.

Table 6: 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	33.8	2311	**H11**	53.8	2318
H2	32.2	2341	**H12**	52.3	2308
H3	31.6	2335	**H13**	52.6	2298
H4	33.3	2319	**H14**	53.3	2301
H5	34.3	2325	**H15**	56.1	2307
H6	34.2	2331	**H16**	54.9	2313
H7	32.5	2303	**H17**	55.0	2319
H8	33.4	2308	**H18**	55.6	2310
H9	32.6	2311	**H19**	53.3	2338
H10	32.2	2311	**H20**	53.3	2297
Average	33.0	2317	**Average**	54.0	2311
Standard Deviation	0.9	10.4	**Standard Deviation**	1.3	12.2
Range	2.7	32	**Range**	3.8	41
Coefficient of Variation (%)	2.8	0.45	**Coefficient of Variation (%)**	2.4	0.53

5.8. Participation

Out of the 33 participants who entered the program, 31 participants returned results in time to be included in the report.

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.

The use of median and quartiles reduces the effect that outliers have on the statistics and other influences. As a consequence, 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 in this report approximate standard deviations. For each test, a z-score graph is shown. Use the graph to visually check statistically how you compare to other participants.

The following bar is shown at the bottom of each graph. This helps to visualize where each participant's result falls quickly.

Review	Weak Consensus	Strong Consensus	Weak Consensus	Review

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 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 download 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 as needed. 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 the performance of tests and revised z-scores. The inclusion of late results or corrections is at the discretion of the program coordinator. In some instances, this may change some of the z-scores slightly, 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

The statistics generated from one proficiency program are not usually comparable to those from another proficiency testing program. Only very general comparisons may be possible. The reason statistics from one program may not be compared to another 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 organisations involved
- Program design and the statistics employed

The program outcome represents a ‘snapshot’ of the competency within the industry and hence provides an overview of the industry. The more participants involved in the program than the more representative the overview.

5.9.3. Measurement uncertainty

The statistics detailed in this program (for each test) do not replace the need for laboratories to calculate measurement uncertainty when required by the client or NATA. However, 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 Outliers

One of the issues faced by proficiency testing providers 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 that 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. In this program's case, if a Non-Statistical Outlier was detected, it was taken as received and mentioned within this report.

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 outlier’.

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

6. Summary of Participants Results

Summary of participants results - Sample A

Code	Sample Received	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
M5	16/11/2022	good	Wet	Temperate	Rubber	199	100.2	100.8	3.656	2316	292	36.8	Normal	23/11/2022
D3	7/11/2022	slight air bubbles	SS Wet	Temperate	Rubber	200	100.2	100.4	3.624	2293	293	37.1	Normal	23/11/2022
C2	7/11/2022	No defects	SS Wet	Temperate	Sulphur	200	100.2	100.0	3.616	2299	287	36.5	Conical F	23/11/2022
Y5	-	None	SS Wet	Temperate	Rubber	199	100.2	100.2	3.643	2319	288	36.6	Shear F	23/11/2022
A9	-	nil	SS Wet	Temperate	Rubber	198	100.2	99.6	3.552	2289	277	35.3	Cap Failure	23/11/2022
V2	7/11/2022	Nil	SS Wet	Temperate	End Grind	197	100.2	100.4	3.646	2342	299	37.8	Abnormal SF	23/11/2022
S3	7/11/2022		SS Wet	Temperate	Rubber	199	100.6	100.6	3.659	2316	295	37.2	Cap Failure	23/11/2022
T2	-	/	SS	Temperate	Rubber	200	100.0	100.2	3.6594	2325	286.6	36.4	Shear F	23/11/2022
J6	21/11/2022	None/Good	SS Wet	Tropical	Rubber	200	100.2	99.8	3.614	2300	306	38.9	Cap Failure	23/11/2022
Z3	-	none	Wet	Tropical	Rubber	200	100.5	100.4	3.635	2300	278	35.0	Cap Failure	23/11/2022
U3	9/11/2022	small chip	Wet	Tropical	Rubber	199	100.0	100.0	3.638	2328	309	39.3	Normal	23/11/2022
M9	-	none	SS	Tropical	Rubber	201	99.8	99.6	3.639	2320	290	37	Cap Failure	23/11/2022
X7	7/11/2022	-	SS Dry	Temperate	End Grind	201|196	101.8	101.7	3.664	2299	317	38.9	Normal	23/11/2022
U8	-	good	SS Wet	Temperate	Rubber	200	100.0	100.2	3.630	2306	281	35.7	Cap Failure	23/11/2022
X4														
B6	7/11/2022		SS Wet	Tropical	End Grind	196	100.2	100.4	3.585	2315	281	35.6	Normal	23/11/2022
F9	7/11/2022		SS Wet	Tropical	End Grind	195	99.6	100.2	3.561	2330	292	37.3	Normal	23/11/2022
T8														
C5	-	Nil	Wet	Tropical	End Grind	196	100.0	99.8	3.600	2343	286.9	36.6	Normal	23/11/2022
Y4	7/11/2022		SS Wet	Temperate	Rubber	199	100.4	100.4	3.653	2318	301	38	Normal	24/11/2022
F8	14/11/2022		SS Wet	Tropical	Rubber	200	100.0	100.0	3.666	2334	283	36.1	Normal	23/11/2022
D2	4/11/2022	None	SS Wet	Temperate	End Grind	198	99.8	99.8	3.617	2340	301	38.5	Normal	23/11/2022
J9	4/11/2022	None	SS Wet	Temperate	End Grind	199	99.8	99.8	3.581	2300	296	37.8	Normal	23/11/2022
M3	-	nil	SS Wet	Tropical	End Grind	197	100.1	100.3	3.605	2316	278	35.0	Normal	23/11/2022
E7	7/11/2022	N/A	SS Dry	Temperate	Sulphur	199	100.0	99.8	3.5954	2305	282.7	36.1	Conical F	23/11/2022
T6	11/11/2022	No defects	SS Wet	Tropical	Sulphur	198	99.8	99.8	3.633	2350	295	37.5	Normal	23/11/2022
Y3	4/11/2022	-	SS Wet	Temperate	Sulphur	199	99.8	99.8	3.621	2326	294.00	37.6	Conical F	23/11/2022
S5	4/11/2022	-	SS Wet	Temperate	Sulphur	199	100	100	3.605	2307	272.3	34.7	Conical F	23/11/2022
U7	4/11/2022	-	SS Wet	Temperate	Sulphur	199	99.8	99.8	3.620	2325	286.44	36.6	Conical F	23/11/2022
C8	7/11/2022	-	SS Wet	Temperate	End Grind	199.00	99.9	99.9	3.614	2317	297	37.9	Normal	23/11/2022
M8	-	none	SS Wet	Temperate	Sulphur	200	99.8	99.8	3.592	2296	279	35.7	Shear F	23/11/2022
P8	15/11/2022	Packaging Intact	SS Wet	Temperate	Rubber	200	100.0	100.0	3.630	2311	295	37.6	Normal	23/11/2022
S7	15/11/2022	Nil	SS Wet	Tropical	Rubber	199	100.0	100.0	3.612	2311	285	36.3	Normal	23/11/2022

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

Summary of participants results - Sample B

Code	Sample Received	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
M5	16/11/2022	good	Wet	Temperate	Rubber	199	99.8	100.2	3.621	2319	421	53.7	Shear F	23/11/2022
D3	7/11/2022	Slight air bubbles	SS Wet	Temperate	Rubber	200	100.2	100.0	3.612	2295	444	56.4	Normal	23/11/2022
C2	7/11/2022	No defects	SS Wet	Temperate	Sulphur	197	100.0	100.2	3.590	2316	418	53.1	Conical F	23/11/2022
Y5	-	none	SS Wet	Temperate	Rubber	200	99.8	99.8	3.636	2326	419	53.6	Shear F	23/11/2022
A9	-	nil	SS Wet	Temperate	Rubber	198	100.2	99.8	3.606	2319	441	56.2	Conical F	23/11/2022
V2	7/11/2022	Nil	SS Wet	Temperate	End Grind	197	99.6	99.8	3.604	2343	426	54.6	Normal	23/11/2022
S3	7/11/2022	Voids	SS Wet	Temperate	Rubber	200	100.6	100.8	3.645	2293	436	54.8	Shear F	23/11/2022
T2	-	/		Temperate	Rubber	200	100.6	100.2	3.6464	2303	440	56.0	Shear F	23/11/2022
J6	21/11/2022	None/Good	SS Wet	Tropical	Rubber	200	100.4	100.2	3.635	2298	446	56.4	Abnormal SF	23/11/2022
Z3	-	none	Wet	Tropical	Rubber	201	100.0	100.0	3.631	2300	418	53.2	Normal	23/11/2022
U3	9/11/2022	Small Chip	Wet	Tropical	Rubber	199	100.0	99.8	3.593	2303	436	55.6	Normal	23/11/2022
M9	-	none		Tropical	Rubber	198	100.4	100.2	3.651	2340	434.6	55	Shear F	23/11/2022
X7	7/11/2022	-	SS Dry	Temperate	End Grind	199|195	100.0	100.2	3.567	2324	455	57.8	Normal	23/11/2022
U8	-	2 Large voids on side	SS Wet	Temperate	Rubber	200	100.0	100.2	3.660	2325	452	57.4	Normal	23/11/2022
X4														
B6	7/11/2022	minimal air voids	SS Wet	Tropical	End Grind	196	99.8	100.4	3.610	2340	430	54.6	Normal	23/11/2022
F9	7/11/2022	minimal air voids	SS Wet	Tropical	End Grind	197	99.8	100.0	3.564	2308	444	56.7	Normal	23/11/2022
T8														
C5	-	Nil	Wet	Tropical	End Grind	197	99.8	99.9	3.609	2337	402.2	51.3	Normal	23/11/2022
Y4	7/11/2022		SS Wet	Temperate	Rubber	199	100.4	100.6	3.682	2327	436	54.8	Normal	24/11/2022
F8	14/11/2022		SS Wet	Tropical	Rubber	200	100.0	99.6	3.623	2316	423	53.8	Shear F	23/11/2022
D2	4/11/2022	None	SS Wet	Temperate	End Grind	198	99.8	100.2	3.588	2300	442	56.3	Normal	23/11/2022
J9	4/11/2022	None	SS Wet	Temperate	End Grind	199	100.2	100.4	3.634	2320	451	57.1	Normal	23/11/2022
M3	-	Nil	SS Wet	Tropical	End Grind	197	99.8	100.2	3.588	2319	425	54.0	Normal	23/11/2022
E7	7/11/2022	N/A	SS Dry	Temperate	Sulphur	199	99.8	100.2	3.6293	2322	428.4	54.5	Conical F	23/11/2022
T6	11/11/2022	No defects	SS Wet	Tropical	Sulphur	199	100.0	100.0	3.649	2330	418	53.0	Normal	23/11/2022
Y3	4/11/2022	-	SS Wet	Temperate	Sulphur	201	100	100	3.643	2308	433.44	55.2	Conical F	23/11/2022
S5	4/11/2022	-	SS Wet	Temperate	Sulphur	200	100	100	3.627	2309	417.18	53.2	Conical F	23/11/2022
U7	4/11/2022	-	SS Wet	Temperate	Sulphur	200	99.8	99.8	3.626	2318	440.84	56.1	Conical F	23/11/2022
C8	7/11/2022	-	SS Wet	Temperate	End Grind	198	99.7	99.9	3.617	2335	413	52.8	Normal	23/11/2022
M8	-	none	SS Wet	Temperate	Sulphur	200	99.8	99.8	3.620	2314	419	53.5	Normal	23/11/2022
P8	15/11/2022	Packaging intact	Dry	Temperate	Rubber	201	99.9	100.0	3.624	2295	449	57.1	Normal	23/11/2022
S7	15/11/2022	Nil	SS Wet	Tropical	Rubber	199	100.4	100.4	3.645	2314	422	53.3	Normal	23/11/2022

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

Appendix A: Instructions for testers

LabSmart Services

Concrete Proficiency Program 2022 (111)

NATA

INSTRUCTIONS FOR TESTER

1. **Do not open the plastic bags until 23rd 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, damaged, or 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 **23rd 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 25th November 2022**
    ☞ 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 V2022.1 (111).docx

Appendix B: Results Log

LabSmart Services

Concrete Compression Proficiency Program – 2022 (111)

RESULTS LOG

For ***XXXX*** **Participation Code: XX**

Please test cylinders on the 23rd of November 2022
Please E-mail the completed results log by 25th November 2022
E-mail: info@labsmartservices.com.au

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 ❖	**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:.....
.....

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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 V2022.1 (111)

LabSmart Services

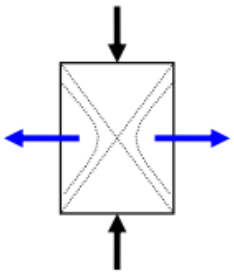
Concrete Compression Proficiency Program – 2022 (111)

Concrete Cylinder Failure Modes

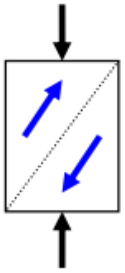
"Normal"

OR

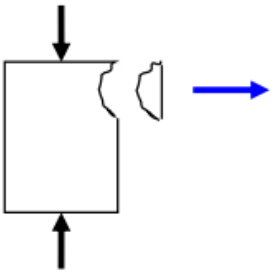
"Conical Failure"



"Shear Failure"



"Cap Failure"



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

Xx Concrete Pt Results Log V2022.1 (111)