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CBR – 2022 (109)

Proficiency Testing Program Report

NATA
WORLD RECOGNISED ACCREDITATION

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 December 2022.

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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 August 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.

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Amendment History

Reports may be downloaded from the LabSmart Services website.
Version 1 – Issued 21 December 2022

Contents

1. Program Aim

The proficiency program was conducted in June 2022 with participants throughout Australia. The program involved the performance of:

- AS 1289.6.1.1 (2014) – Determination of the California Bearing Ratio of a soil – Standard laboratory method for a remolded specimen.

This program is intended to provide feedback and confidence to the construction materials testing industry regarding the competency of participants (and the industry) to perform this test. 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 (Section 5.2.5).

This report has been prepared using robust statistics. In addition, test data has been reviewed for consistency. A comprehensive technical comment is provided to assist participants to improve the overall performance of this test (Section 3). Information regarding the conduct and design of the program etc., can be found under section 5.

2. Performance

2.1. Identified Outliers

In discussing the outcome of this program, the following have been used to determine aspects of testing performance that needs to be investigated or reviewed.

Statistical

- Z-scores based on submitted CBR results

Non-statistical

- Errors
- Identification of inconsistencies
- Non-adherence to test method
- Accuracy of calculations
- Accuracy of graphing

See section 5.2.5 & 5.10 for further detail.

2.2. Program Summary

In most proficiency testing programs, the identification of outliers is relatively straightforward. This is not the situation with CBR testing due to the large standard deviation experienced in CBR proficiency programs. There are also many steps in the testing process that contribute to the quality of the final CBR result.

Participants with statistical outliers, a departure from the test method or errors need to **investigate** the aspect of testing shown in Table 1. Those with significant departures compared to other participants need to **review** the aspects summarised in Table 1.

In Table 1, there are no participants listed under some sections (e.g. 'load cell'), this is not because there are no concerns identified, only that the test method does not necessarily identify, address, or quantify these aspects of the test affecting the accuracy/precision.

The more times a participant's code appears in Table 1, the greater the need for follow up.

Table 1: Participants identified where investigation or review follow up is warranted

Aspect of testing	Section	**Investigate**	**Review**
Accuracy of data	*3.2.1*	**-**	**-**
CBR results	*3.3.1*	**-**	**D6** & **G4**
Identification of inconsistences and errors	*3.3.2*	**-**	**-**
Load cell	*3.4.1*	**-**	**-**
Seating Load	*3.4.2*	**-**	**L4**, **N8**, **R5**, **U6**, **N3**, **S6** & **Y9**
Penetration rate	*3.4.3*	**-**	**-**
Test (Penetration/Load) data	*3.4.4*	**-**	**-**
Accuracy of graph	*3.4.5*	**-**	**E9**, **L4**, **N8**, **R5**, **P3**, **V2**, **T9**, **G7**, **D6**, **R8**, **T6**, **X8**, **G6**, **U6**, **K3**, **C2**, **E3**, **G4** & **P8**
Zero-Point Correction	*3.4.6*	**-**	**-**
Pre-compaction curing	*3.5.1*	**X8**, **W8**, **J6**, **M9** & **P8**	**-**
CBR compaction	*3.5.2*	**-**	**L9**, **D6**, **R8**, **U7**, **U8**, **E3**, **C5**, **C2**, **T9**, **G7**, **P8**, **U9** & **S9**
OMC & MDD	*3.5.3*	**-**	**-**
Achievement of OMC	*3.5.4*	**X8**, **W8**, **J6**, **M9** & **P8**	**-**
Achievement of LDR	*3.5.4*	**-**	**-**
Calculation of LDR & LMR, including Inconsistencies detected		**V2**, **U9**, **X8**, **W8**, **J6**, **U6**, **K3**, **M9**, **E5**, **P8**, **T9**, **U8** **E3** & **C5**	**-**

2.3 Program Summary

Based on LabSmart Services previous programs, there has been an observable improvement in CBR testing over the last thirteen years.

To the many participants and organisations who have participated in LabSmart Services CBR programs, “well done” and “thank you” for your participation.

This program identified those aspects of the test that affect accuracy (direct influences) and those aspects of the test that are less controllable (indirect influences).

A CBR graph would appear to be the only way of checking the validity of the results obtained. In many cases, the graphs prepared do not adequately fulfil this function.

A continued reduction in testing errors, better graphing and supervisor checking would greatly improve the accuracy and proficiency of CBR testing.

Improvements to the test method by better defining the test process (e.g. graphing), limits and expected outcomes would also significantly increase the accuracy of the test.

It should be noted that most of the above comments are related to the accuracy of the test. It is unlikely that improving the accuracy of testing is going to improve the current variation in CBR results shown.

Enough proficiency programs have now been conducted to show that the current spread (variation) in results is both a reliable and accurate estimate.

This proficiency program provides an increased understanding of current test practices and potential sources of variation. It also allows monitoring of improvements in testing and provides the opportunity for participants to improve their competency. A summary of the program statistics is shown in Table 2.

Table 2: Summary of statistics for the CBR program.

Statistic	CBR
Number of participants	35
Median	36.2
Normalized IQR	7.04
Minimum*	22.0
Maximum*	54.4
Range*	32.4
CV (%)	19.5

**Min, Max & Range are with outliers excluded*

3. Technical Comment

3.1 General

3.1.1 Measurement Uncertainty

Aspects of the test can be split into whether they have a direct (measurable) or indirect (not measurable) effect on the calculated CBR result. This is part of the process taken when calculating measurement uncertainty.

Direct influences can be measured or estimated (section 3.4). This generally involve participant errors or inconsistencies in testing. Testing can be developed by improving the accuracy in which these aspects of the test are performed. For example:

- Accuracy of the load cell
- Accuracy of 'Seating Load'
- Accuracy of penetration
- Accuracy of the rate of penetration
- Accuracy of recording force readings
- Number of data points selected
- Accuracy of the graph prepared
- Accuracy of the 'Zero-Point Correction'
- Rounding of results

Indirect influences cannot be practically measured or improved easily (section 3.5). It generally involves non–compliance with the test method requirements or limits. Test variation is minimised by strict adherence to the test method. For example:

- OMC & MDD
- Moisture content
- LDR & LMR
- Compaction, i.e. layer thickness, compaction pattern, number of blows
- Curing of sample

3.1.2 Good laboratory practice

Proficiency program participants are expected to comply with the requirements of the program and meet basic laboratory standards and procedures. Good laboratory practices cover those aspects of laboratory operations that are in keeping with NATA accreditation. Some aspects that are particularly relevant for this program are:

- Supervision of testing
- Following the test method
- Following proficiency testing instructions
- Correctly filling out paperwork, i.e. PT log sheet
- Checking of calculations and data, i.e. free of errors
- Reality check of results i.e. does it fit the type of material submitted

Compared to earlier CBR proficiency testing programs, there has been significant improvement in most of the above areas. However, as detailed in subsequent sections, there is still room for improvement in the performance of CBR testing.

If the participants will not satisfy the above basic requirements, it also raises concern about what other omissions or errors are occurring during testing that remain undetected.

3.1.3 Supply of test information

Many participants supplied all the testing details requested. This additional information (see section 5.2.7) is important as it is used to validate the results received and to assist in providing feedback in the following sections.

Participants are always welcome to contact the program coordinator if they require further explanation as to what information is required or how to proceed with testing.

However, most participants did not supply all the requested data or supplied incorrect data. These participants are encouraged to review what they submitted against other participants to improve the data supplied in the future.

3.1.4 Errors

Errors may arise from several sources, including incorrect calculation, transcription error, the wrong methodology used, not following the test method, etc. Many of the comments in the following sections relate to errors.

Although some of these may have only a minimal impact, they do accumulate. Others can have a significant impact, such as incorrect graphing techniques and ‘Zero-Point Correction’.

3.2 Statistics

The use of statistics is a very useful and practical means of analysing test data. Below are some aspects that affect statistical outcomes.

3.2.1 Accuracy of data

If the test data is in error, then any statistics calculated may also be in error. Any interpretations made, based on the statistics, may therefore also be in error. Most proficiency programs can handle a few inaccurate results without any concern about the veracity of the program outcome. Most of the technical comment in this report concerns the accuracy of the CBR test results.

It should be noted that, As a rule, LabSmart always takes the data supplied in the ‘Result Log’ sheet over any additional information. This is done to keep everything fair for all participants.

3.2.2 Variation in CBR results

Enough proficiency programs have now been conducted to show that the current assessment of the spread in results is both reliable and accurate (Table 3).

Table 3: Comparison of CBR program results for the last twelve years

Year	**Program**	**Median**	**CV**	Range (Less Outliers)	Range (With Outliers)
2022	**109**	**36**	**19.5**	**32.40**	**32.40**
2021	103	43	19.9	37.8	46.9
2020	97	38	31.6	40.2	40.2
2019	91	59	26	65.4	65.4
2018	81	51	23	54.4	59
2017	74	52	22	53.5	94.8
2016	67	155	21	141.2	171.4
2015	59	140	20	80.0	122.0
2014	54	74	31		100.7
2013	46	37	29		35.0
2012	37	44	20		41.3
2011	48	61	35		82.3
2009	16	30	32		42.5

The industry has expressed concerns that from an engineering “End User” perspective that such large variations in CBR results are impractical. It is also undesirable from a laboratory testing perspective. However, without changing the test method, the variation is what the current method produces.

As has been indicated in previous proficiency programs, it is the middle 50% of participants results that is far larger than it should be. It is this group of results that is of primary interest when considering ways in which to reduce the spread.

Much of the technical feedback relates to improving the accuracy of CBR testing. This will not improve the spread of results, but they will become more accurate.

Further work on improving the test method is needed in order to improve (decrease) the spread shown by the middle 50% of participants.

3.2.3 Repeatability

This program focuses on the variation (spread) of results between laboratories (reproducibility).

It is questionable that with the large variation shown in CBR results, an estimate of repeatability (performance of two identical samples) would yield reliable information.

For some tests, the homogeneity data can be used as a guide to the repeatability. However, for CBR, such an estimate may be unreliable as the precision may be good (same machine and pace rate etc.), but it is unknown if the overall accuracy is good or poor.

3.3 CBR Results

3.3.1 CBR results

Z-scores and associated statistics were calculated on the CBR results (as submitted) and are detailed in section 4. For this program, we had no outliers. As the CBR program has a wide spread of results, participants with z-scores greater than 2 or -2 would also benefit by reviewing their results (**D6** & **G4**).

3.3.2 Identification of inconsistencies and errors

There are many steps within the conduct of the test (methodology) that can become a source of error or where inconsistencies can occur. As well there are limits posed by the test method itself that may also contribute, for example, compaction and moisture content. See sections 3.4 and 3.5 to explore these aspects further.

The use of a detailed CBR graph is a quick and reliable means of checking results. A rough mathematical check was undertaken by the program coordinator for all participants. Those with significant differences were re-graphed, and the CBR recalculated.

It should be also noted that during these steps, a common issue encountered was the use of incorrect units of measurements and rounding. In most cases, once adjustments were made, many of these issues were resolved. It is recommended that all participants take time to review their results before submission. A summary of all results 'as submitted' can be found in section 6.

3.4 Direct Influences

The following sections cover many aspects of the test methodology. From previous programs, it has been noted that even with corrections resulting from re-graphed data and using unrounded results, it has only a marginal effect on the outcome of the proficiency program. In other words, the corrections tend to be random, with some corrected CBR values increasing while others decrease.

Overall, it suggests that while the accuracy of testing can and should be improved, there may be little change to the overall spread of results obtained for the CBR test.

3.4.1 Load cell

In section 6, the load values are shown for each participant. Some laboratories used more data points than requested (great to see).

Most participants in this program reported using load cells; two participants (**T9** & **G7**) did not supply any information on whether they used a Load Cell or Load Ring. No participant reported using a Load Ring. Most devices were calibrated to 'Class 'A' or a combination, e.g. A/B/C. Participants generally used load cells with a range up to 50kN.

Selection of the correct load cell capacity depends on the laboratory's experience and, where possible prior knowledge of the material to be tested. Unfortunately, due to the large range of CBR results possible from participants, the program organisers cannot give this information prior to testing.

If a load cell or ring does not have enough capacity during testing, it is important that testing is stopped on approach to the maximum capacity of the load cell/ring. Exceeding the capacity of a load cell/ring can cause permanent damage (not visually obvious to a user).

Another consideration is the resolution at the lower end of the load scale to accurately measure the 'Seating Load'. It may be difficult to accurately measure small loads for load cells used in this program that are on the larger side (e.g. 50kN).

Often this is not a lack in ability of the load cell, but a reflection of the normal calibration practices, where the calibration may not extend to the low load values required for Seating Loads or low CBR values. Laboratories may need to request calibration facilities, where possible, to specifically cover the Seating Loads required when undertaking the load cell calibration.

3.4.2 Seating Load

The ‘Seating Load’ is considered the ‘Zero-Point’ from which the load values and penetration commence, and it is essential that the piston is in contact with a stable surface.

Except for **L4**, **N8**, **R5**, **U6**, **N3** & **Y9**, all participants indicated that the Seating Load was reset to zero. Not setting ‘back to zero’ can lead to an inaccuracy in the load scale, creating an offset. (participants listed here should **review** these practices)

In this program, participants used a wide range of Seating Loads, but most participants used a Seating Load of around 250N. The test method indicates that for a CBR greater than 30%, a Seating Load of 250N should be used, whereas 50N should be used for CBRs less than 30%. The Median of the program was 36.2%, and as a result, the spread of results for this program crosses both Seating Load ranges. Based on the Median and spread of results, it would be unfair for LabSmart to target any one participant for their Seating Load, meaning no participant will be highlighted here.

However, participants should keep in mind that within the NATA document ‘*Infrastructure and Asset Integrity - Technical issues in geotechnical testing’* (October 2019), within Section 7 (Seating loads for CBR testing), it is stated that the above Seating Load ranges ‘*…are considered to be the values inferred within the standard, rather than the ‘smallest possible load’...*’. Therefore, participants **N3** & **S9** should **review** their Seating Loads as they do not conform to this statement.

It should also be noted that errors in both processes (Seating Load applied and resetting back to zero) may influence the CBR. An error in the penetration of ± 0.5mm could lead to a change of ± 4.5% CBR. This may not seem much, but in the rounding process, when reporting, this may cause a difference of 10% in the CBR result.

3.4.3 Penetration rate

The test method indicates that the machine used must be capable of "…forcing the penetration piston into the specimen at a uniform (not pulsating) rate of 1.0± 0.2 mm/min during the complete test….". It is not entirely clear, based on input from previous programs, if the standard means an 'average rate' or if it means it must be met at 'all times'. If it is taken as an average rate, you could theoretically have half the penetration at 0.5 mm/min and the other half at 1.5 mm/min and still arrive at the average rate of 1.0 mm/min.

For 'hand' operated devices, it is hard to check other than an overall average. A motorised platform was used by most participants, with seven participants (**S6**, **T8**, **L4**, **N8**, **X8**, **W8** & **R5**) reporting that they used a 'hand' operated unit.

With load cell units, they usually allow the rate to be checked as you go on a 'per 0.5 mm of travel' etc. This can be done on a 'test by test' basis, so it is a very good record of meeting the requirements of the standard.

In previous programs, the rate was requested, with most participants reporting the test method requirement rather than the actual rate achieved. For this program, more detailed information was requested from participants, i.e. average, minimum, and maximum rates achieved.

Many participants did not fill out this section of the 'Result Log' sheet, and it is also unclear how many participants who did fill out this section did it accurately. With so many participants not filling this section out correctly, further comment is problematic. However, more information can be found in section 6.

The penetration rate is linked to the slope of the load/penetration curve. It is, therefore, significant in determining the CBR and hence the set limits placed on the rate of travel by the test method.

3.4.4 Test (penetration / load) data

The number of penetration points selected is extremely important. Most participants recorded the requested additional load/penetration data, and some recorded more, a very good outcome. For this program no participants reported using a Load Ring.

The test method specifies a minimum data set (0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm penetrations).

The ‘key’ word in the test method is “at least”. In other words, if you know the material well (i.e. have a CBR history of the material), then you should be able to use fewer points; otherwise, you need to record loads at more points.

Additional data points are needed to:

- Allow for the discount of an abnormal data value
- Have sufficient points left so that the discounting of a point does not compromise the test result
- Have sufficient points to fit a straight line and a curve
- Have sufficient points above the straight section of the graph.
- Have sufficient points to be able to tell that you have an abnormal data point

It is also evident that too few data points can have a measurable difference in the obtained result, as much as suspect data. Greater confidence in the result and accuracy is obtained when more points are taken.

3.4.5 Accuracy of the graph prepared

In the previous CBR proficiency program, all participants results were re-graphed. In this program, only a selected group have been re-graphed. Consequently, any inconsistencies found will not need to be investigated.

Graphing is discussed in this program due to its importance in deriving an accurate result and being able to check the CBR result obtained. The CBR test method does not emphasise this aspect.

Graphing of results has been an issue for all previous CBR proficiency programs. Overall, graphing has improved vastly over this time.

Regardless of what graph is submitted to the client, a detailed graph for use by the laboratory is important as it is the primary method of checking that a reasonable result has been obtained.

The test method is also not very descriptive regarding the quality of the graph prepared. In previous proficiency programs, considerable feedback was given.

Nineteen participants did not submit a graph (**54%**). These participants (**E9**, **L4**, **N8**, **R5**, **P3**, **V2**, **T9**, **G7**, **D6**, **R8**, **T6**, **X8**, **G6**, **U6**, **K3**, **C2**, **E3**, **G4** & **P8**) need to **review** the lack of a graph. Two participants submitted hand-drawn graphs (**S6** & **T8**), with all other participants submitting computer-generated graphs.

3.4.6 Zero-Point Correction

Overall, most participants calculated a 'Zero-Point Correction' and applied it.

'Seating Load' and 'Zero-Point Correction' combined generally result in small changes to the final result. However, sometimes small changes can significantly affect the CBR result, particularly when a BR value is rounded up or down to the nearest 10%. A variation of ± 10% CBR is not unrealistic.

Participants used a wide range of methods in applying their 'Zero-Point Correction' and it can be difficult for LabSmart to replicate the exact same 'Zero-Point Correction'. Many things can affect LabSmart's ability to recalculate participant 'Zero-Point Correction', but the main one comes down to the use of different automated software and variance in hand-drawn approaches.

A 'Zero-Point Correction' is not always acceptable depending on the curve generated. But based on the data supplied, most participants appear to have applied the 'Zero-Point Correction'' in an acceptable manner.

3.4.7 Rounding of CBR

The reason for rounding is not entirely clear in the Australian Standard. It perhaps acknowledges that CBR values are quite variable, and rounding makes the results easier to use and compare when grouped together, i.e. takes out some of the fluctuations.

Laboratories were asked for the unrounded BR/CBR values rather than rounded BR/CBR values. Part of the design consideration of this program was to try and isolate as well as minimise sources of variation. The process of 'rounding' was identified as adding to the variation of determining CBR. The statistics associated and test variation with the CBR results will often increase slightly if rounded results are used. At other times it may slightly decrease the variation shown.

3.5 Indirect Influences

The following aspects of the testing methodology are difficult to relate to the final CBR test result. They can be measured individually, but their influence on the CBR result is more difficult due to the 'unknown interactions' they have on each other.

However, it is clear that more accurate measurement of these aspects of the test in conjunction with the better definition within the test method should assist with improving the overall accuracy of the test.

3.5.1 Pre-compaction curing

Participants used a range of curing times, with all participants reporting using cure times of 2 hours and above. The curing times specified by the test method are the minimums. More curing, if done correctly, is better than less.

The test method now requires laboratories to select the appropriate curing time based on material, Liquid Limit and departure from OMC.

There was a wide range of 'liquid limit' values used and hence a wide range of curing times. The 2017 amendment to the test method allows for the 'liquid limit' to be estimated based on experience. Most participants based the curing on their 'estimate' of 'liquid limit'.

An estimate of the MC of the material 'as received' and whether within 2% of the OMC was not specifically requested as part of this program.

Section 6c of the test method requires the material to be within ±0.5% of the specified moisture when compacting. For this program, OMC was 11.6%. The allowed range for this program was 11.1% to 12.1%. Participants **X8**, **W8**, **J6**, **M9** & **P8** indicated MCs outside of this range; however, based on the data supplied, all of these participants may have incorrectly filled out this section of the 'result logs' sheet as the data provided doesn't appear to be within an expected range (especially for **M9** who seems to have supplied the LMR), this should be **investigated**.

3.5.2 CBR compaction

The proficiency program required participants to perform the CBR compaction using the OMC and MDD values provided at 100 % standard compaction.

Test methods relating to compaction are very specific about the energy input into the process. This is largely governed by the spread of hammer blows and the number of blows used. The revised CBR method now stipulates the pattern to be used when compacting the CBR mould. However, the test method does not specifically require the number of blows delivered to be recorded, as it is an important part of the test it should be recorded.

It is expected that by compacting a calculated amount of material to a set height that the desired density will be achieved. The blows will vary depending on the material type and moisture. Depending on how this is done, a variation in the number of blows per layer is the typical outcome. However, between layers, these should remain reasonably close.

For the determination of OMC/MDD using standard compaction, 25 blows per layer is used. An input of around 53 blows is required for the larger CBR mould to achieve the same energy.

More or less blows than 53 may be needed for a variety of reasons:

- The inaccuracy of the OMC and MDD initially
- Blows not delivered in a regular pattern
- Nature of the material may cause it to move around the mould excessively
- Material added is higher or lower than the prescribed layer depth

The blows delivered provides an insight into whether any of the above issues may have had an effect.

Relying on the dry density calculated is useful, but it is a calculated value and mainly dependent on how representative and accurate the moisture determination was.

How much variation is reasonable? This is at present unknown, but for this program, a variation of 40 to 60 has been used with a variation between layers of 5 blows. The following participants shown in Table 4 do not meet these criteria and should review their results.

Table 4: Participants with a high or low number of compaction blows

CBR Compaction			
< 40 Blows per layer	**> 60 blows per layer**	**Difference in blows greater than 5 between layers**	**No result**
L9, **D6**, **R8**, **U7**, **U8, E3**, **C5** & **C2**	**T9** & **G7**	**L9, U7, C5** & **P8**	**U9** & **S9**

It may not affect the dry density obtained, but there is concern that it may influence the final CBR result.

For low compaction, it may influence:

- segregation of particles,
- uneven compaction,

For high compaction, effects such as:

- orienting the soil particles,
- segregation of particles,
- causing fissures,
- breaking up of particles,
- uneven compaction,

All of which could influence the CBR without affecting the dry density value achieved. CBR results may be higher or lower depending on the influence. It is unclear if this has been investigated in recent times.

3.5.3 OMC & MDD

Different determinations of OMC & MDD by different laboratories will give rise to a spread of results (Variation). To limit the effect of this variation on the CBR testing in this proficiency program, the OMC & MDD have been predetermined. This information was supplied to participants (See instructions Appendix A) so that all participants used the same OMC & MDD values.

3.5.4 LDR and LMR

Achievement of OMC & LDR

Participants were requested to compact their sample to 2.006 t/m^3 and 11.6% moisture. The standard set out the limits associated with participants trying to meet these compaction requirements. Clause 6h, states the Density should be with 1% of the specified Density ratio and Clause 6c, states that the moisture at compaction (W_1) should not differ by more than 0.5%.

Table 5: Participants that are outside the limits set for LMR and LDR OR W_1

Target MDD (t/m^3)	Density Range t/m^3	**LDR Range ± 1%**	Investigate
2.006	1.986 2.026	**99.0** **101.0**	-
Target OMC (%)	**Moisture Range ± 0.5%**	LMR Range %	Investigate
11.6	**11.1** **12.1**	95.7 104.3	**X8, W8, J6, M9 & P8**

Except for the participants listed in Table 5 all participants achieved the desired range set out by the standard for OMC and MDD, which was a very good outcome. However, it is believed that those participants listed in table 5 may have incorrectly filled out their paperwork; more information on this can be found in the next section (Calculation of LDR & LMR, including Inconsistencies detected).

Calculation of LDR & LMR, including Inconsistencies detected

Participants were requested to submit the following:

- The sample moisture immediately before compaction (w1) in accordance with clause 6(c) of the standard.
- Moisture content variation (Wv)
- The Laboratory Moisture Ratio (LMR)
- The Laboratory Density Ratio (LDR) and
- Dry Density (before soaking)

These intermediate results are noted in the test method as needing to be reported or required to determine compliance with the test method.

The reported LDR and LMR values were recalculated using the reported moisture from clause 6(c) and Density (before soaking).

Several participants had difficulty in calculating the intermediate results detailed above.

The participants listed in Table 6 showed inconsistencies in the values submitted, throwing doubt on compliance with the test method and should be **investigated**. Not all inconsistencies are listed here; LabSmart asked for several results to be reported with greater accuracy than the standard. Therefore, LabSmart gave the benefit of the doubt to those participants that may have been affected by rounding effects.

Table 6: Participants with inconsistencies in calculating LMR and LDR

Information submitted	Review
Moisture (Clause 6c) (W_1)	**X8, W8, J6, M9 & P8**
Variation in moisture content (Wv) [not on final report but useful as a check]	**V2, U9, X8, W8, J6, U6, K3**, **M9**, **E5** & **P8**
LMR does not match reported moisture*	**T9**, **X8**, **W8**, **J6**, **U8**, **M9**, **E3** & **P8**
LDR does not match reported dry density*	**K3** & **C5**

For participants listed in Table 6, It is suspected that, in many cases, these participants incorrectly filled out their ‘Result Log’ sheets. Notes for participants highlighted are:

For Moisture W_1 (Clause 6c) [Moisture at packing]

- **X8**, **W8**, **J6** & **P8** appear to have supplied moisture contents of the material upon receipt instead of the sample moisture immediately prior to compaction (W_1) in accordance with clause 6(c) of the standard.
- **M9** appears to have supplied LMR percentages instead of Moisture Content Variation (W_1).

For Variation in moisture content (Wv) [Target OMC - Moisture at packing]

- It is unknown what **V2**, **U9** & **U6** supplied in this field, as they supplied Moisture (Clause 6c) as 11.6 which means there Wv should be 0.
- Participants **X8** & **W8** did not fill this section out but also are flagged as not supplying the correct W_1 Value.
- **J6** can not be verified as the Value supplied for Moisture (Clause 6c) appears to be incorrect.
- **K3**, **M9** & **E5** appear to have supplied LMR instead of variance from OMC.
- **P8** did the calculation right, but as they most likely supplied the wrong W_1 (see above), the answer is not correct

LMR [Moisture at packing (W_1) divided by Target OMC as a percentage]

- As listed above as it is suspected that **X8**, **W8**, **J6, M9 & P8** did not supply the right W_1 these results can not be checked
- Using the participant's **T9**, **U8** & **E3** W_1 results, recalculations don’t support the outcome supplied by the participant.

LDR [Density at packing divided by Target Density as a percentage]

- Using the participant's **K3** & **C5** density at packing results, recalculations don’t support the outcome supplied by the participant.

4. Statistics: Z-Score & Graph

CBR - Sample A : Z-Score Graph: Z - Scores

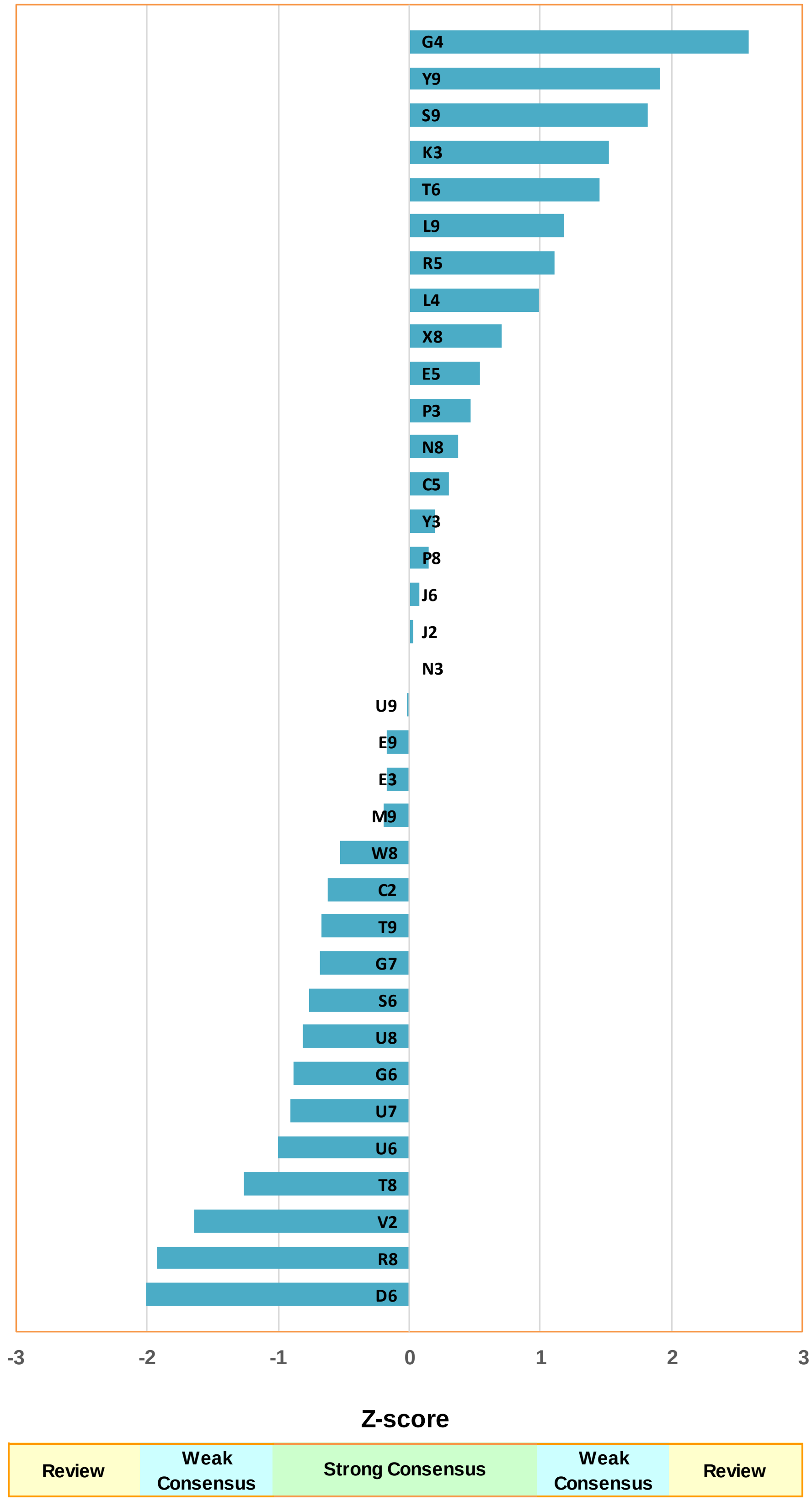
Code	Test Result %	Z Score
E9	35.0	-0.17
S6	30.8	-0.77
T8	27.3	-1.26
L4	43.2	0.99
N8	38.8	0.37
R5	44.0	1.11
L9	44.5	1.18
P3	39.5	0.47
V2	24.6	-1.65
U9	36.1	-0.01
T9	31.5	-0.67
G7	31.4	-0.68
D6	22.0	-2.02
R8	22.6	-1.93
Y3	37.6	0.20
U7	29.8	-0.91
T6	46.4	1.45
X8	41.2	0.71
W8	32.5	-0.53
J6	36.7	0.07
G6	30.0	-0.88
U8	30.5	-0.81
U6	29.1	-1.01
J2	36.4	0.03
N3	36.2	0.00
K3	46.9	1.52
C2	31.8	-0.62
M9	34.8	-0.20

Code	Test Result %	Z Score
E3	35.0	-0.17
S9	49.0	1.82
C5	38.3	0.30
G4	54.4	2.58
E7		
F7		
E5	40.0	0.54
Y9	49.7	1.92
P8	37.2	0.14
N2		

Statistic	*Value*	
Number of results	**35**	
Median	**36.2**	
Median MU	**1.49**	
First Quartile	**31.1**	
Third Quartile	**40.6**	
IQR	**9.50**	
Normalised IQR	**7.04**	
CV (%)	**19.5**	
Minimum	**22.0**	()
Maximum	**54.4**	()
Range	**32.4**	()

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.

CBR - Sample A : Z-Score Graph: Z - Score Graph



5. Program Information

5.1 Z score Summary

The proficiency program was conducted during June 2022. A 'Z-score Summary' was issued on the 16th of August, 2022. A copy was e-mailed to all participants who submitted results. The summary is intended as an early indicator of participant performance. This program report supersedes the Z-score Summary. Further information can be found in section 5.9 'Statistics'.

The z-scores generally do not vary significantly between the "Summary" and the "Final Report".

5.2. Program Design

5.2.1 Design

This program is one of a series of CBR programs conducted by LabSmart Services over the last thirteen years.

The CBR test is a complex test from a measurement uncertainty perspective despite its apparent technical simplicity. Unfortunately, the CBR test method does not provide guidance about some aspects of the test, such as repeatability or reproducibility. There also appears a lack of guidance on both the performance and the interpretation of the test within the industry. The range of test results obtained in a proficiency program, for any given sample, has been far wider than is generally acceptable to the industry. This adds to the difficulty in interpreting the outcome of CBR proficiency testing programs.

Part of the design of each program involves asking for the right information. The correct analysis of the data collected then allows feedback to be offered to enable participants to improve in their performance of this test.

The program was designed to provide technical feedback regarding performance as well as possible improvements in performance. Other considerations involving the design of the program are detailed throughout section 5.

5.2.2 Selection of material for the program

The test in this proficiency program is operator skill/experience dependent.

Different materials are selected for each program to mirror the range of materials encountered in practice and hence the results obtained. The higher the CBR value, the greater the variation encountered.

This program provides a sample that gives results in the range that would be commonly tested by laboratories. 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.

5.2.3 OMC & MDD

The determination of OMC and MDD is usually an initial stage undertaken prior to performing a CBR test. The determination of these two parameters can show a significant variation. In turn, having an impact on the variation obtained for CBR results.

The intention of the program is to minimise the influence on the CBR results that could arise from laboratories determining these values in-house and reduce the likelihood of different OMC and MDD values being applied.

To assist in reducing this variation, participants were requested to pack their CBRs to a MDD of 2.006 t/m^3 with an OMC of 11.6% (LabSmart determined these values prior to the program).

This approach has been used to minimise variation; however, other aspects may still contribute to the variation observed. OMC/MDD values may vary from person to person, but this may not be so important if the same person determines OMC/MDD and CBR. That is, a low compaction on the OMC/MDD should give the same compaction on the CBR. Overall, it is still considered that a set OMC/MDD will contribute the least variation.

5.2.4 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 that is 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 next most useful tool a laboratory has in better understanding the performance of a test.

5.2.5 Participant assessment

In discussing the outcome of this program, the following have broadly been used to determine outliers and areas for investigation/review.

Statistical

- Z-scores based on submitted CBR results

Non-statistical

- Errors
- Identification of inconsistencies
- Non-adherence to test method
- Accuracy of calculations
- Accuracy of graphing

Participants are asked to “investigate” statistical outliers. Assessment of each participant is based on a z-score that is related to the program consensus value (median). This is used to determine any statistical outliers.

Errors in testing, test method not followed or where test parameters are outside the limits set in the test method all need to be “**investigated**”. See section 5.10.

Other matters identified are shown as “**Review**”. These are matters that would help improve testing, and in most cases, would be considered outside normal testing parameters. It is sometimes difficult to determine as the CBR test method often does not provide enough guidance.

Compliance to 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 (see section 5.2.7). Participants may also be asked to investigate any discrepancies with the submitted paperwork. See section 5.2.8 for further details.

5.2.6 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 and test method accuracy 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 10% means that any number between 45 and 54 will become 50%. If the largest Value is 45 in a set of results, it is pushed out to 50 through rounding. Rounded results may better reflect the repeatability and reproducibility of the test according to the rounding in the test method but are not as useful when considering laboratory performance.

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.

5.2.7 Additional test information requested

This program requested additional information as detailed in Section 6, not usually reported. However, the additional information is consistent with the test's performance and the records the test method requires laboratories to maintain or is consistent with ‘good laboratory’ practices. The additional information is used to interpret the participant’s performance and assist with providing technical comment, including feedback on outliers and possible participant improvements. It is also used to validate the results received.

Participant results can be rejected if they do not conform to the program requirements. The correctness and quality of the information supplied is assessed as to the veracity of the information or results submitted. An adverse assessment may lead to the whole of the participant’s results being rejected or asked to investigate/review some aspect of what has been submitted.

5.2.8 Data checks

As often observed, 'operator errors' can occur in the result calculation process. Every participant's results were verified as reasonable. Checks, however, are only as accurate as the raw data supplied by each participant. These checks also help ensure that the data is comparable. Any inconsistencies during this process are identified as possible feedback for participant improvement. In some cases, inconsistencies identified may need to be investigated by participants.

Proficiency testing providers are obligated under their accreditation standard to remove results known to be incorrect or where a participant has not followed the test method, including adherence to prescribed limits. Not providing all data requested, particularly where it is used to assess the validity of the results obtained (e.g. compaction, MC), is also a valid reason to reject a CBR result. These matters are not 'black & white' but require some interpretation as to each component's importance.

Keeping results that may be suspect in the statistical pool may distort the statistical outcome. However, if all the results that are found to be inaccurate or not meet the test method etc. were rejected from this program, the pool of results would be significantly decreased. A balance must be struck.

Participants need to be aware that the program coordinator performing the checks may not have access to the full set of results for each participant (e.g. significant figures, etc.). This can sometimes cause differences between what the participant has calculated and what the program coordinator calculates.

Also, due to the large amount of data associated with this program, it is entirely possible that the coordinator may not have recalculated some participants' results correctly, although a considerable effort is made to prevent this from occurring.

5.2.8 Confidentiality

All information, including test results, are treated confidentially. The 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

Sufficient material of a homogeneous appearance was obtained for the proficiency program. The lot was partially dried then mixed to ensure, as far as possible, to produce a homogeneous material throughout. The material was sampled and placed into numbered plastic bags.

Ten samples were drawn at regular intervals from the lot for homogeneity testing.

Each participant received a randomly drawn sample from the remaining samples. A unique sample code was assigned to each sample.

5.4. Packaging and instructions

A tag was added to each plastic bag identifying the sample to be associated with this program and was sealed with a zip tie and placed into a sturdy box. The sample weighed approximately 9 kg. Instructions and a 'Results Log' sheet were also enclosed (See Appendix A & B). Participants were instructed to test according to the nominated test method and report to the accuracy indicated on the 'Results Log'.

5.5. Quarantine

Samples sent to Western Australia and Tasmania were heat treated to comply with quarantine requirements.

5.6. Sample dispatch

Samples were dispatched to participants in June 2022 via courier (Pack and Send). Dispatched samples were tracked from 'dispatch to delivery' for each participant.

5.7. Homogeneity testing

Homogeneity samples were selected, at evenly spaced intervals, from the prepared samples. Samples for homogeneity testing were packaged in the same way as participant samples. Additionally, the same instruction sheets given to participants were given to the NATA accredited laboratory performing the homogeneity testing.

Ten samples were tested for homogeneity.

The overall variability associated with the homogeneity samples was considered satisfactory. The average of the homogeneity samples also lies within 1 s.d of the program median value. This provides confidence that any outliers identified in the program represent statistically valid outliers. A statistical analysis of the homogeneity testing results is provided in Table 6.

Table 6: Homogeneity results

Code	CBR % (Unrounded)	CBR % (Rounded)
H1	35.5	35
H2	39.6	40
H3	38.2	40
H4	30.6	30
H5	43.9	45
H6	50.1	50
H7	38.3	40
H8	46.9	45
H9	31.8	30
H10	39.5	40
Average	39.4	39.5
Standard Deviation	6.18	6.43
Range	19.5	20.0
Coefficient of Variation (%)	15.68	16.29

5.8. Participation

Thirty-Eight participants from around Australia entered the program. Out of these participants, thirty-five participants returned results in time to be included in the Z-score summary (and, in turn be included in the final report). Participants were requested to return their results by the 29th of July, 2022.

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. 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.

Assessment of participant's data is undertaken to ensure the data is statistically comparable. Checks are undertaken to ensure the data calculated matches that reported by the participant and that the appropriate corrections etc. have been applied if required. The level of checking required varies from program to program. If inconsistencies are identified, the data may be removed or amended with the discrepancy highlighted.

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 are an approximate of the standard deviation. 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 (Figure 1) is shown at the bottom of each graph. This helps to quickly visualise where each participant's results fall.

Figure 1: Z-score interpretation bar

Review	Weak Consensus	Strong Consensus	Weak Consensus	Review

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.

Participant assessment is not based purely on statistical analysis. Compliance to proficiency program requirements, including the correct calculation of results and adherence to program 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.

Further details on the statistics used in this proficiency program can be obtained from LabSmart Services or downloaded 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 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 are 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 significant impact, it will be discussed within 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. However, it should be noted that more participants involved in a given program, then 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 calculated 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

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. This can cause biased (or unfair) outcomes for other participants.

To limit the effect that erroneous results may 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 'non-statistical' erroneous results.

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

6 Participants Test Results

Code	E9	S6	T8	L4	N8	R5	L9
Number	1	2	3	4	5	6	7
Date Received	1/7/22	5/7/22	11/7/2022	8/7/22	8/7/22	8/07/22	13/7/22
Condition of Material Received	Moist	Excellent	good	Moist	Moist	Fair- Moist	d / Bag Sea
Moisture Content As Received (%)	8.9	0.2	0.0	9.1	8.6	9.0	8.9
LL Determined by clause 5(d)	iii	i	iii	iii	iii	iii	iii
LL Value used	Low	25	<35	ow (<=35%	w plastici	<35	nular >2 h
Method Used to Conduct CBR Test	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.
Method Used to Determine Moisture Contents	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.
Data Last Calibrated	July 2020	27/11/20	26/11/202	12/8/2021	12/08/202	12/8/2022	6/10/2020
Calibrated Range	0-50kN	0-50kN	0-50kn	0-50kn	0-50kn	0-50kn	0kN x 0.00
Load Cell or Load Ring	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell
Calibration Class	A	A	A	A	A	A	A
Hand Driven or Motorised	M	H	H	H	H	H	M
Average (mm/min)	1mm/min	N/A	-	1m/min	1m/min	1m/min	1.00
Lowest (mm/min)	-	N/A	-	N/A	N/A		0.98
Highest (mm/min)	-	N/A	-	N/A	N/A		1.03
Tested By	. Chamber	BW/MIA	Ethan Hin	mes O'Bri	eter Gaan	niel Wau	M. Cleelan
How Long was Sample Cured For (	27.5	96	96	67	67	70	26
Moisute (W1)	11.2	11.7	11.5	11.5	11.4	11.7	11.5
Moisture Content Variation (Wv)	0.4	0.1	0.1	0.1	0.2	0.1	-0.1
Compaction Method (Standard)	Y	Y	Y	Y	Y	Y	Y
Compaction (Manual Or Auto)	M	M	M	M	M	M	M
Number of Blows per Layer	53,53,53	40,42,40	45,40,40	47,49,46	42,42,42	45,44,44	35,25,25
Dry Density (t/m3)	2.010	2.004	2.008	2.012	2.013	2.010	2.025
Density Ratio % (LDR)	100.0	99.9	100.1	100.3	100.3	100.2	100.9
Moisture Ratio % (LMR)	96.6	100.9	99.1	99.0	98.2	101.1	99.1
Seating Load Used (N)	.250N	250	250	250	250	250N	250
Has seating load been set to zero	Y	Y	Y	N	N	N	Y
BR @ 2.5mm	30	26.7	20.8	35.4	32.3	36.6	34.0
BR @ 5.0mm	40	30.8	27.3	43.2	38.8	44.0	44.5
CBR (%)	35.0	30.8	27.3	43.2	38.8	44.0	44.5
Correction (mm)	0.6	1.9	0.6mm	1.8	1.5	1.6	1.7
Swell (%)	-0.1	0.1	0.0	-0.2	-0.2	-0.3	
Moisture (ww)	-	11.7		12.6	12.1	12.2	12.2
Moisture (w30)	11.2	12.3	11.5	12.2	11.8	12.1	13.2
Moisture (wr)	11.4	11.5	11.1	11.6	11.6	11.8	11.1
0	0		0.00	250	254	250	0.00
0.5	444	0.35	0.38	443	658	653	0.238
1	957	0.69	0.95	793	1022	1016	0.459
1.5	1658	1.00	1.51	1201	1492	1445	0.836
2	2328	1.30	1.94	1724	1912	2001	1.366
2.5	3020	1.63	2.38	2236	2486	2594	1.976
3	3845	2.05	2.94	2899	3119	3219	2.664
3.5	4684	2.46	3.39	3634	3752	3882	3.350
4	5481	2.96	3.96	4331	4363	4601	4.138
4.5	6223	3.59	4.61	5010	5050	5346	4.975
5	6972	4.20	5.18	5722	5779	6131	5.800
6	8295	5.30	5.89	7288	7076	7675	7.562
7.5	10092	7.21	6.88	9838	9085	10028	10.170
8	10682	7.77	7.37	10709	9810	10826	11.038
10	12994	10.41	9.59	13758	12705	13989	14.304
12.5	15778	13.65	12.58	17399	16324	18125	18.338
Comments							
Graph (Hand/Computer)	N/A	Hand	Hand	N/A	N/A	N/A	Computer

6 Participants Test Results

Code	P3	V2	U9	T9	G7	D6	R8
Number	8	9	10	11	12	13	14
Date Received	4/7/22	1/7/22	8/7/22	07/07/22	07/7/22	18/7/22	18/7/22
Condition of Material Received	Good	of Optim	aled - Mo	ed and in	Sealed	Moist	Moist
Moisture Content As Received (%	eceived - (	8.6	8.6	8.6		9	9.3
LL Determined by clause 5(d)	iii	iii	iii	iii	iii	iii	iii
LL Value used	um 4 Days	LL < 35%	s and Grav	low	low	and Grave	Visual
Method Used to Conduct CBR Test	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.
Method Used to Determine Moisture Contents	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.
Data Last Calibrated	15/6/2021	10/3/22	8/11/2021	08/3/22	08/3/22	21/9/21	15/2/2021
Calibrated Range	0000N x 1(	0-200kN	40-50000N	0-50kn	0-50kn	50kN	50kN
Load Cell or Load Ring	Load Cell	Load Cell	Load Cell			Load Cell	Load Cell
Calibration Class	A	A	A	AA	AA		
Hand Driven or Motorised	M	M	M	M	M	M	M
Average (mm/min)	0.85	1mm/min	1	1.00	1.00	1.02	
Lowest (mm/min)	0.81		1	0.98	0.98	0.95	0.95
Highest (mm/min)	0.90		1	1.01	1.01	1.09	1.05
Tested By	even Hans	VM	h Olleren	sie Richar	eth Raute	aul Franci	othea Bur
How Long was Sample Cured For (	287	24	2.1	24	24	2	2
Moisute (W1)	11.7	11.6	11.6	11.2	11.3	12.0	11.7
Moisture Content Variation (Wv)	0.1	3	0.4	-0.3	-0.3	0.4	-0.1
Compaction Method (Standard)	Y	Y	Y	Y	Y	Y	Y
Compaction (Manual Or Auto)	M	M	M	A	A	M	M
Number of Blows per Layer	53,53,50	43,42,39		62,63,63	63,63,63	25,25,25	28,28,28
Dry Density (t/m3)	2.004	2.01	2.006	2.012	2.011	2.003	2.006
Density Ratio % (LDR)	99.9	100	100.0	100.2	100.2	99.9	100.0
Moisture Ratio % (LMR)	100.9	100	100.1	97.9	97.7	103.2	100.6
Seating Load Used (N)	250	0.025	250	50	50	250	250
Has seating load been set to zero	Y	Y	Y	Y	Y	Y	Y
BR @ 2.5mm	30.2	19.6	30.6	24.9	24.6	18.9	17.6
BR @ 5.0mm	39.5	24.6	36.1	31.5	31.4	22.0	22.6
CBR (%)	39.5	24.6	36.1	31.5	31.4	22.0	22.6
Correction (mm)	1.5	0.51	1.6	0.7	0.9	0	0
Swell (%)	-0.1	0.0	0.0	-0.03	-0.05	-0.9	-0.76
Moisture (ww)	12.4	N/A	12.2	t peform	t peform	12.0	11.7
Moisture (w30)	12.5	13.2	12.3	12.7	12.6	12.4	11.9
Moisture (wr)	11.2	11.7	12.7	11.2	11.3	11.6	11.7
0	0	0.000	0.0	0	0	0	0
0.5	226	300	348	216	214	0.201	0.180
1	538	500	747	591	584	0.386	0.354
1.5	935	1000	1178	1062	1064	0.583	0.571
2	1411	1600	1680	1507	1508	0.814	0.818
2.5	1968	2100	2157	2154	2153	1.056	1.075
3	2588	2600	2727	2758	2758	1.325	1.365
3.5	3272	3050	3332			1.596	1.695
4	3980	3500	3925	3975	3978	1.894	2.079
4.5	4730	3950	4519			2.184	2.501
5	5496	4400	5080	5201	5194	2.569	2.888
6	7074	5360	6467			3.265	3.705
7.5	9303	6700	8424	7845	7843	4.434	5.076
8	10051	7650	9189			4.847	5.541
10	12761	8900	11918	10220	10218	6.545	7.269
12.5	16038		15017	12501	12498	8.279	9.319
Comments						ilded by T	
Graph (Hand/Computer)	N/A	N/A	Computer	N/A	N/A	N/A	N/A

6 Participants Test Results

Code	Y3	U7	T6	X8	W8	J6	G6
Number	15	16	17	18	19	20	21
Date Received	5/7/22	27/6/22	11/7/22			1/7/22	4/7/22
Condition of Material Received	Moist	Very Good	Good	Moist	Moist		Good
Moisture Content As Received (%	9.2	9.1	8.9	8.8	8.9	8.9	8.7
LL Determined by clause 5(d)	iii	i	iii	iii	iii		iii
LL Value used	Low	23%	Low	sval/tactil	sval/tactil	Medium	Low
Method Used to Conduct CBR Test	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.
Method Used to Determine Moisture Contents	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.
Data Last Calibrated	1/03/2021	1/7/21	24/1/22	27/10/21	)4/11/202	30/11/202(	8/2021
Calibrated Range	00-50kN	to 50.000	0-50kN	0-40kn	0-50kn	0-50kN	0-50kN
Load Cell or Load Ring	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell
Calibration Class	500N, A > 5	A	0.1 B, 0.27	A	A	5kN and ab	A
Hand Driven or Motorised	M	M	M	H	H	M	M
Average (mm/min)	0.9		1±0.2				1.0
Lowest (mm/min)	0.8	.0mm/mi					0.85
Highest (mm/min)	1.0						1.1
Tested By	id MacGre	TT	R. Gagui	CJ	MC	om Paulse	ody Forre
How Long was Sample Cured For (	241	48	24	48	72	144	24
Moisute (W1)	11.5	11.5	11.2	8.9	8.8	8.9	11.6
Moisture Content Variation (Wv)	0.1	0.1	0.4			0.1	0.0
Compaction Method (Standard)	Y	Y	Y	Y	Y	Y	Y
Compaction (Manual Or Auto)	M	M	M	M	M	M	M
Number of Blows per Layer	53,53,49	20,26,20	52,50,50	53,53,53	53,53,53	53,53,53	53,53,53
Dry Density (t/m3)	2.012	2.005	2.012	2.008	2.006	1.997	2.005
Density Ratio % (LDR)	100.3	100	100.3	100.1	99.9	99.5	99.9
Moisture Ratio % (LMR)	99.1	99.2	96.7	100.9	99.8	99.3	100.5
Seating Load Used (N)	250	0.241	250	250	250	250	250
Has seating load been set to zero	Y	Y	Y	Y	Y	Y	Y
BR @ 2.5mm	31.2	20.2	35.8	32.2	26.0	27.9	20.9
BR @ 5.0mm	37.6	29.8	46.4	41.2	32.5	36.7	27.5
CBR (%)	37.6	29.8	46.4	41.2	32.5	36.7	30.0
Correction (mm)	1.8	0	0.0	0	0	1.3	2.12
Swell (%)	0.0	0.0	0.0	-0.3	-0.5	-0.2	-0.2
Moisture (ww)	12.1	12.8	12.0	11.7	11.4	14.9	11.6
Moisture (w30)	11.7	11.8	12.2	12.3	12.3	12.6	11.4
Moisture (wr)	11.2	11.6	11.1	11.4	11.4	11.7	11.5
0	0	0	0.0	0	0	0	0.0
0.5	304	0.357	0.566	270	270	0.329	0.114
1	596	0.799	1.013	620	620	0.649	0.255
1.5	966	1.356	1.603	1026	1026	1.043	0.436
2	1438	1.999	2.327	1479	1479	1.502	0.673
2.5	1963	2.661	3.085	2001	2001	1.999	0.961
3	2530	3.354	3.921	2567	2567	2.583	1.310
3.5	3116	4.022	4.798			3.328	1.699
4	3734	4.673	5.725	3919	3919	4.000	2.150
4.5	4383	5.294	6.666			4.713	2.609
5	5044	5.899	7.570	5389	5389	5.444	3.136
6	6380	7.021	9.220			6.868	4.148
7.5	8450	8.596	11.547	9397	9397	8.928	5.861
8	9100	9.070	12.342			9.619	6.386
10	11751	10.943	15.070	13024	13024	12.305	8.488
12.5	14920	13.249	17.920	16451	16451	15.788	10.982
Comments							
Graph (Hand/Computer)	Computer	Computer	N/A	N/A	Computer	Computer	N/A

6 Participants Test Results

Code	U8	U6	J2	N3	K3	C2	M9
Number	22	23	24	25	26	27	28
Date Received	4/7/22	11/07/2022	29/6/22	30/6/22	12/7/22	5/07/2022	11/7/22
Condition of Material Received	Dry	good	Sealed Bag	atisfactor	Fine	good	tion, samp
Moisture Content As Received (%)	0.3	8.9	8.8	8.9	Fine	8.7	8.6
LL Determined by clause 5(d)	iii		iii	iii	iii	iii	iii
LL Value used	Low		<35			sual/tacti	and/Grave
Method Used to Conduct CBR Test	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.
Method Used to Determine Moisture Contents	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.
Data Last Calibrated	15/4/22	10/06/2022	10/5/22	23/2/22	18/5/22	4/05/2021	23/5/22
Calibrated Range	0-50kN	0-50kN	0-50kN	0-50kN	0-45kn	0-50kN	0 to 50kN
Load Cell or Load Ring	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell	Load Cell
Calibration Class		C	A	A	A	A	C
Hand Driven or Motorised	M	M	M	M	M	M	M
Average (mm/min)	1	1mm/min	1	1.1	tick	1	1.0
Lowest (mm/min)			1				0.9
Highest (mm/min)			1				1.1
Tested By	thony Harr	JC	ne Dekost	Sena K	N.D	Jaeda	ee Carper
How Long was Sample Cured For (	48	120	75	172	63.3	26.6	27
Moisute (W1)	11.8	11.6	11.9	11.3	11.5	11.2	100.9
Moisture Content Variation (Wv)	0.2	2.7	0.4	0.3	99.5	0.4	89.3
Compaction Method (Standard)	Y	Y	Y	Y	Y	Y	Y
Compaction (Manual Or Auto)	M		M	M	M	M	M
Number of Blows per Layer	11,11,11	55,55,54	50,50,50	40 Average	55,55,54	22,22,23	50,50,46
Dry Density (t/m3)	2.002	2.007	2.002	2.011	2.013	2.012	2.006
Density Ratio % (LDR)	99.8	100.1	99.8	100.2	100.5	100.3	100.0
Moisture Ratio % (LMR)	102.4	99.6	102.7	97.8	99.5	96.4	100.9
Seating Load Used (N)	250	N	250	70		250	250
Has seating load been set to zero	Y	N	Y	N	Y	Y	Y
BR @ 2.5mm	23.6	24.6	17.8	27.4	39.3	25.1	27.3
BR @ 5.0mm	30.5	29.1	30.1	36.2	46.9	31.8	34.8
CBR (%)	30.5	29.1	36.4	36.2	46.9	31.8	34.8
Correction (mm)	0.0	0	0.9	1.3	3.5	0.1	1.2
Swell (%)	0.0	-0.22	0.1	-0.1	0.0	-0.11	0.0
Moisture (ww)		12.2	11.9	11.9	12.7	12.0	2.006
Moisture (w30)	12.3	13.3	12.9	12.3	11.9	12.8	12.0
Moisture (wr)	11.2	12.0	12.0		11.6	11.2	11.4
0	0.001	0	0	70	0.0	0	0
0.5	0.245	820	311	410	0.116	550	190
1	0.489	1562	704	760	0.292	1196	460
1.5	0.785	2215	1176	1100	0.548	1876	900
2	1.122	2736	1716	1560	0.853	2506	1450
2.5	1.500	3259	2349	2080	1.246	3137	2090
3	1.957	3799	3043	2710	1.672	3797	2730
3.5		4307	3740	3310	2.203	4413	3420
4	2.968	4776	4487	3930	2.746	5051	4140
4.5		5293	5200	4620	3.351	5585	4840
5	4.097	5778	5956	5370	3.945	6153	5510
6		6776	7402	6910	5.284	7225	6780
7.5	7.074	8178	9610	8980	7.561	8923	8450
8		8820	10310	9760	8.376	9482	8990
10	10.087	10659	12929	12510	12.000	11530	11140
12.5	12.908	13022	15725	15850	14.941	13724	13550
Comments		g load use		n has resul			
Graph (Hand/Computer)	Computer	N/A	Computer	Computer	N/A	N/A	Computer

6 Participants Test Results

Code	E3	S9	C5	G4	E7	F7	E5
Number	29	30	31	32	33	34	35
Date Received		1/7/22	15/7/22	30/6/22			6/7/22
Condition of Material Received	Dry	Sealed	moist	as receive			s received
Moisture Content As Received (%)	0.30	Moist	9.2	9.2			s received
LL Determined by clause 5(d)		iii	iii	iii			iii
LL Value used	26	and-Grave	medium	w Plastici			Low
Method Used to Conduct CBR Test	S1289.6.1.	S1289.6.1.	S1289.6.1.	S1289.6.1.			S1289.6.1.
Method Used to Determine Moisture Contents	S1289.2.1.	S1289.2.1.	S1289.2.1.	S1289.2.1.			S1289.2.1.
Data Last Calibrated	29/06/22	7/2/22	23/03/22	26/4/21			10/11/21
Calibrated Range	.994-49.69	0-50kN	0-50kn	0-40kN			0-50kN
Load Cell or Load Ring	Load Cell	Load Cell	Load Cell	Load Cell			Load Cell
Calibration Class		A	A	A			A
Hand Driven or Motorised	M	M	M	M			M
Average (mm/min)	30	1	0.97	1.0			1
Lowest (mm/min)	25	1	0.74				
Highest (mm/min)	35	1	1.17				
Tested By	irubakcor	lla & Barr	D.webb	Kevin Cher			an Malon
How Long was Sample Cured For (	48	92.7	98	145			50
Moisute (W1)	11.5	11.2	11.5	11.7			11.4
Moisture Content Variation (Wv)	0.1	0.4	0.1	-0.1			98.0
Compaction Method (Standard)	Y	Y	Y	Y			Y
Compaction (Manual Or Auto)	M	M	M	M			M
Number of Blows per Layer	22,21,22		31,45,34	53,53,53			53,53,53
Dry Density (t/m3)	2.01	2.013	2.008	2.005			2.006
Density Ratio % (LDR)	100.0	100.3	100.2	100.0			100.0
Moisture Ratio % (LMR)	99.9	96.7	99.5	100.7			98.0
Seating Load Used (N)		156	0.250	248			250
Has seating load been set to zero	Y	Y	Y	Y			Y
BR @ 2.5mm	24.6	40.4	29.2	48.1			31.1
BR @ 5.0mm	32.5	49.0	38.3	54.4			40.0
CBR (%)	35	49.0	38.3	54.4			40.0
Correction (mm)	1.5	0	1.0	2.0			0
Swell (%)	-0.03	0	0	0.0			-0.1
Moisture (ww)	12.1		12.0	12.0			11.4
Moisture (w30)	12.3	12.9	12.1	11.6			12.0
Moisture (wr)	36.3	10.9	11.7	10.7			11.3
0	0	0	0	0			0.06
0.5	0.111	1548	0.280	346			0.18
1	0.308	2528	0.676	705			0.36
1.5	0.587	3478	1.208	1149			0.64
2	0.954	4442	1.798	1719			0.97
2.5	1.378	5335	2.450	2391			1.37
3	1.885	6262	3.107	3152			1.83
3.5	2.432	7164	3.899	3993			
4	3.026	8061	4.596	4736			2.96
4.5	3.649	8864	5.315	5761			
5	4.296	9701	6.109	5673			4.33
6	5.577	11332	7.576	8620			
7.5	7.497	13677	9.658	11824			8.11
8	8.112	14372	10.368	12862			
10	10.702	17130	13.070	16781			10.20
12.5	13.893	20295	16.502	21135			12.45
Comments							
Graph (Hand/Computer)	N/A	Computer	Computer	N/A			Computer

6 Participants Test Results

Code	Y9	P8	N2				
Number	36	37	38	39	40	41	42
Date Received	5/7/22	1/7/22					
Condition of Material Received	Good	fine					
Moisture Content As Received (%	9.4	9.3					
LL Determined by clause 5(d)	iii	iii					
LL Value used	Low	d and Gran					
Method Used to Conduct CBR Test	S1289.6.1.	S1289.6.1.					
Method Used to Determine Moisture Contents	S1289.2.1.	S1289.2.1.					
Data Last Calibrated	7/7/21	9/2/22					
Calibrated Range	.06-99.5kN	50kN					
Load Cell or Load Ring	Load Cell	Load Cell					
Calibration Class	).06-0.1 B,	A					
Hand Driven or Motorised	M	M					
Average (mm/min)	1						
Lowest (mm/min)	1	1					
Highest (mm/min)	1						
Tested By	nes Cleme	id Ghefou					
How Long was Sample Cured For (	48	5					
Moisute (W1)	11.8	9.3					
Moisture Content Variation (Wv)	-0.2	2.3					
Compaction Method (Standard)	Y	Y					
Compaction (Manual Or Auto)	M	M					
Number of Blows per Layer	53,53,53	42,44,50					
Dry Density (t/m3)	2.005	2.000					
Density Ratio % (LDR)	99.9	99.7					
Moisture Ratio % (LMR)	101.5	100.5					
Seating Load Used (N)	250	240					
Has seating load been set to zero	N	Y					
BR @ 2.5mm	38.2	29.8					
BR @ 5.0mm	49.7	37.2					
CBR (%)	49.7	37.2					
Correction (mm)	0.8						
Swell (%)	-0.1	0					
Moisture (ww)		11.77					
Moisture (w30)	11.8	12.5					
Moisture (wr)	11.0	11.8					
0	0.250	0.001					
0.5	0.787	0.351					
1	1.386	0.692					
1.5	2.092	1.104					
2	2.875	1.556					
2.5	3.699	2.057					
3	4.589	2.597					
3.5	5.497	3.199					
4	6.437	3.831					
4.5	7.402	4.474					
5	8.391	5.138					
6	10.383	6.552					
7.5	13.180	8.716					
8	14.070	9.483					
10	17.517	12.362					
12.5	21.158	15.888					
Comments							
Graph (Hand/Computer)	Computer	N/A					

Appendix A: Instructions for testers

LabSmart Services

Proficiency Testing Program

California Bearing Ratio – 2022 (109)

INSTRUCTIONS FOR TESTER

1. Please check that the package you have received contains the following:

   - Instructions (for tester)
   - Results Log
   - Approximately 9 kg of soil sealed in a plastic bag labelled '2022 (109) CBR Sample'

   Contact LabSmart Services if the bags are damaged or any item is missing.

When can I start testing? As soon as you have read these instructions carefully and your supervisor has indicated that you may do so.

How long do I have to do the testing? You need to have the results back to LabSmart Services by 29th July 2022.

2. Due to the possibility of segregation during transportation, *mix the sample thoroughly prior to testing*.

3. There is no oversize material present in this sample.

4. You do not need to be accredited for AS 1289 6.1.1. You may use other equivalent methods, but it is preferable that AS 1289 6.1.1 be used. If you do use an alternative method, please make note in the comments section.

5. Conduct the CBR test to AS 1289 6.1.1 (2014) with the 2017 amendment using the following information:

   - Use a Maximum Dry Density (**MDD**) of **2.006 t/m^3** and an Optimum Moisture Content (**OMC**) of **11.6 %.**
   - Sample to be remoulded at **100% standard compaction.**
   - Adjust the moisture of the sample as per the test method (mixing thoroughly).
   - As per clause 6(c) of the test method, just prior to compaction, take a sample to determine final moisture content (w_1) has been achieved i.e. OMC ± 0.5%.
   - *LDR be within 100 ± 1.0%*
   - Apply a 4.5 kg surcharge.
   - Soak the sample as per the method for 4 days.
   - Swell is to be determined.
   - For this program, we recommend using the 250N seating load.
   - Take additional load readings at 3.5, 4.5, 6.0 and 8.0 mm penetration.

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6. Record the results on the enclosed "Results Log". Report each result according to the log sheet. **This will be different to the test method**.

7. The Laboratory Manager or person responsible for checking must sign the log sheet to indicate that it has been checked.

8. Please retain any unused material until the final report has been issued.

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

10. E-mail the "Result Log" to LabSmart Services by 29th July 2021.

☞ E-mail: info@labsmartservices.com.au

11. Please retain the completed "Results Log" as this contains your confidential participation code. You will need this code to 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.

12. Proficiency testing can also form part of a laboratories training records for the technician who performed the test.

NATA

Thank you for participating in this proficiency testing program.

Appendix B: Results Logs

LabSmart Services

Proficiency Testing Program - California Bearing Ratio – 2022 (109)

RESULTS LOG for: **xxxxxx** Participation Code: xx

☛ ***Please e-mail the completed results log by 29th July 2022***

E-mail: info@labsmartservices.com.au

Please follow the instructions carefully.

1. Please complete the following regarding the performance of the test:

General Testing Information:

Date Received:	
Condition of material as received:	
Moisture Content as received:	
LL determined by Clause 5(d): e.g. (i), (ii) or (iii)	
LL value used:	

Test Methods:

Method Used to Conduct CBR test: *(e.g. AS 1289 6.1.1 or equivalent, please list)*	
Method Used to determine moisture contents: *(e.g. AS 1289 2.1.1 or equivalent, please list)*	

CBR machine used for the tests:

Date last calibrated:			
Calibrated range (I.e.0-50 kN):			
Load Cell or Load Ring?			
Calibration (Class A, B, C?)			
Hand driven or motorised platform?			
Rate of penetration?	(Average)	(Lowest)	(Highest)

X XX 109 PT Results Log V2022.1 Page 1 of 3

2.

SAMPLE A		Report To	Result		
Tested by:		Name			
How long was the sample cured before compaction:		**1Hr**			
Moisture (Clause 6[c]) (W_1) (before compaction)		**0.1 %**			
Moisture content variation (W_v)		**0.1 %**			
Compaction Method:		Standard (Y/N)			
Compaction:		Manual or Auto			
Number of blows used per layer		Number			
Before Soaking	Dry density	**0.001 t/m^3**			
	Density Ratio (LDR)	**0.1 %**			
	Moisture Ratio (LMR)	**0.1 %**			
Seating load used? *(250N Recommended. See Instructions)*		**N**			
Has the seating load been set to zero?		(Y/N)			
BR @ 2.5 mm		**0.1 %**			
BR @ 5.0 mm		**0.1 %**			
Final CBR Value *(Unrounded preferred)*		**0.1%**			
Correction [Zero-Point Correction] *(Enter zero if no correction is performed)*		**0.1 mm**			
Swell		**0.1 %**			
After soaking	*Moisture w_w*	**0.1 %**			
	Moisture w_{30}	**0.1 %**			
	Moisture w_r	**0.1 %**			

3. Please attach a **copy of the CBR graph** and fill in the penetration/ load readings below (cross out and change if other penetration values are used); *you are welcome to attach a worksheet showing penetration/load readings; however, we need this section filled out.*

Penetration (mm)	Load (N)
0	
0.5	
1.0	
1.5	
2.0	
2.5	
3.0	
3.5	

Penetration (mm)	Load (N)
4.0	
4.5	
5.0	
6.0	
7.5	
8.0	
10.0	
12.5	

4. COMMENTS: **(Please ensure all sections are completed)**

……………………………………………………………………………………………………

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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 these sheets for your records.***

Have a query? Contact LabSmart on 0439 208 406.

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