

**Report No. 1116**

**Rocks Proficiency Testing Program**

**Round 1**

**January 2019**

**Acknowledgments**

PTA wishes to gratefully acknowledge the technical assistance and sample supply provided for this program by Ms Gayani Samaradiwakara and Mr Stephen Durham of Golder Associates Pty Ltd, VIC.

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PO Box 7507 SILVERWATER NSW 2128, Australia

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**Uniaxial Compressive Strength**

Uniaxial Compressive Strength.....A4  
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## 1. FOREWORD

This report summarises the results of a proficiency testing program on the determination of selected tests in rocks. It constitutes the first round of an ongoing series of programs. This program is accredited to ISO/IEC 17043:2010 “*Conformity assessment - General requirements for proficiency testing*” by International Accreditation New Zealand (IANZ).

The program was conducted in October 2018 by Proficiency Testing Australia (PTA). The aim of the program was to assess laboratories’ abilities to competently perform the prescribed analyses.

The Program Coordinator was Dr Emilia Cincu and the Technical Advisers were Ms Gayani Samaradiwakara and Mr Stephen Durham of Golder Associates Pty Ltd, VIC. This report was authorised by Mrs Karen Cividin, PTA Quality Manager.

## 2. FEATURES OF THE PROGRAM

- (a) Participants were provided with four plaster cylinders, two labelled PTA Sample A and two labelled PTA Sample B.
- (b) A total of 17 Australian laboratories received samples. Of these 17 laboratories, one was unable to submit all results by the due date.
- (c) Laboratories were provided with the *Instructions to Participants* and *Results Sheet* (see Appendix C). Laboratories were requested to perform the tests according to their routine methods and to record their results on the *Results Sheet*.
- (d) Prior to sample distribution, a number of randomly selected samples were analysed for homogeneity. Based on the results of this testing (see Appendix B), the homogeneity of the samples was established.
- (e) Each laboratory was randomly allocated a unique code number for the program to ensure confidentiality of results. Reference to each laboratory in this report is by code number only. Please note that a number of laboratories reported more than one set of results and, therefore, their code numbers (with letter) could appear several times in the same data set.
- (f) Results (as reported by participants) with corresponding summary statistics (i.e. number of results, median, uncertainty of the median, normalised interquartile range, robust coefficient of variation, minimum, maximum and range) are presented in Appendix A (for each sample and for each of the analyses performed).

- (g) A robust statistical approach, using z-scores, was utilised to assess laboratories' testing performance (see Section 4). Robust z-scores and z-score charts relevant to each test are presented in Appendix A.
- (h) The document entitled *Guide to Proficiency Testing Australia, 2016* (reference [1]) defines the statistical terms and details the statistical procedures referred to in this report.
- (i) A tabulated listing of laboratories (by code number) identified as having outlier results can be found on page 7.

### 3. FORMAT OF THE APPENDICES

- (a) Appendix A contains the analysis of results reported by laboratories for the samples. This section contains the following for each determinant, where appropriate:
  - a table of results and calculated z-scores;
  - a list of summary statistics; and
  - ordered z-score charts.
- (b) Appendix B contains details of the homogeneity and stability testing.
- (c) Appendix C contains copies of the *Instructions to Participants and Results Sheet*.

### 4. STATISTICAL DESIGN OF THE PROGRAM

- (a) Outlier Results and Z-scores

In order to assess laboratories' testing performance, a robust statistical approach, using z-scores, was utilised. Z-scores give a measure of how far a result is from the consensus value (i.e. the median), and gives a "score" to each result relative to the other results in the group.

A z-score close to zero indicates that the result agrees well with those from other laboratories, whereas a z-score with an absolute value greater than or equal to 3.0 is considered to be an outlier and is marked by the symbol "§".

The table on page 7 summarises the outlier results detected.

- (b) Results Tables and Summary Statistics

Each of these tables contains the results returned by each laboratory, including the code number for the method used, and the robust z-score calculated for each result.

Results have been entered exactly as reported by participants. That is, laboratories which did not report results to the precision (i.e. number of decimal places) requested on the Results Sheet have not been rounded to the requested precision before being included in the statistical analysis.

A list of summary statistics appears at the bottom of each of the tables of results and consists of:

- the number of results for that test/sample (*No. of Results*);
- the median of these results, i.e. the middle value (*Median*);
- the uncertainty of the median; a robust estimate of the standard deviation of the *Median*;
- the normalised interquartile range of the results (*Normalised IQR*);
- the robust coefficient of variation, expressed as a percentage (*Robust CV*) - i.e.  $100 \times \text{Normalised IQR} / \text{Median}$ ;
- the minimum and maximum laboratory results; and
- the range (*Maximum - Minimum*).

The median is a measure of the centre of the data.

The normalised IQR is a measure of the spread of the results. It is calculated by multiplying the interquartile range (IQR) by a correction factor which converts the IQR to an estimate of the standard deviation. The IQR is the difference between the upper and lower quartiles (i.e. the values above and below which a quarter of the results lie, respectively).

For normally distributed data, the uncertainty of the median is approximated by:

$$\sqrt{\frac{\pi}{2}} \times \frac{\text{normIQR}}{\sqrt{n}} \quad n = \text{number of results}$$

In this round, the spread of results for UCS Density and Splitting Tensile Strength were considered too low to calculate robust z-scores (normalised IQR 0.007 and 0.014). As a result, a target coefficient of variation (CV) was used to calculate the z-scores. The target CV, expressed as a percentage, is a fixed value used to calculate the z-score when the spread of results is too low or too large. For both UCS Density and Splitting Tensile Strength results, a target CV of 10% was used.

The target standard deviation (SD) is calculated as the target CV multiplied by the median.

In the case of UCS Density and Splitting Tensile Strength results, the robust z-score (denoted by Z) for a laboratory's sample A result was calculated as:

$$Z = \frac{A - \text{median}(A)}{\text{target SD}(A)}$$

where A is a sample in a testing program.

Please see reference [1] for further details on these robust summary statistics.

(c) Ordered Z-Score Charts

On these charts each laboratory's robust z-score is shown, in order of magnitude, and is marked with its code number. From these charts, each laboratory can readily compare its performance relative to the other laboratories.

These charts contain solid lines at +3.0 and -3.0, so that outliers are clearly identifiable as those laboratories whose "bar" extends beyond these "cut-off" lines. The y-axis of these charts has been limited, so very large z-scores appear to extend beyond the chart boundary.

The following table summarises the results submitted by participants for the program.

**TABLE A: SUMMARY STATISTICS**

Test	No. of Results	Median	Normalised IQR
<b>Point Load Strength Index</b>			
I <sub>s</sub> - Average Uncorrected Point Load Strength	18	1.120	0.159
I <sub>s(50)</sub> - Average Point Load Strength	18	1.150	0.159
<b>Uniaxial Compressive Strength</b>			
Uniaxial Compressive Strength	13	8.000	1.408
Moisture Content	13	42.60	6.67
Density	13	1.630	0.007
<b>Rock Moisture Content</b>			
Moisture Content	11	43.20	6.41
<b>Rock Deformability</b>			
Uniaxial Compressive Strength	7	8.600	0.820
Tangent Young's Modulus	7	1.800	0.284
Secant Young's Modulus	6	2.555	0.374

Test	No. of Results	Median	Normalised IQR
Density	7	1.630	0.023
Moisture Content	7	43.20	8.83
Splitting Tensile Strength			
Mean Splitting Tensile Strength	7	1.300	0.014

## 5. PTA AND TECHNICAL ADVISER'S COMMENTS

Out of 17 participating laboratories, one was unable to submit all results in time to be included in the statistical analysis and final report.

### Overall performance against prior expectations

A total of four laboratories have been identified as having reported one or more outlier results, as depicted in Table B. From a total of 134 results, 12 outliers have been identified, representing 8.9%. For Uniaxial Compressive Strength and Splitting Tensile Strength, no outliers have been identified.

All laboratories with outliers or and absolute z-scores between 2.0 and 3.0 are encouraged to review their procedures.

### Variation within and between participants

Statistical analysis for Poisson's Ratio could not be performed as the results were not normally distributed. Laboratory Codes 11A and 11B obtained results that were 3-4 times lower than the rest of the participants', therefore these results were considered non-statistical outliers.

Laboratory Code 12 obtained a high number of outlier results and is encouraged to review their procedures. The laboratory reported an erroneous result (148) for Secant Young's Modulus which was excluded from the statistical analysis but it is listed as an outlier in table B on page 7.

### Variation between methods and procedures

Most of the participants performed the required testing by either Australian standards or ASTM methods specified in the *Instructions to Participants*. The other test methods included were RMS T223 and ISMR. It was concluded that there were no major differences between the test methods used.



## **Possible sources of error, suggestions for improvement of performance**

Participants were advised to test the samples in as received condition. However, it was noted that Laboratory Code 12 placed modulus samples in a 50°C oven prior to testing, possibly to achieve dry surface to glue strain gauges. This approach does not comply with the requirements of test method, AS 4133.4.3.2. The test method states that “strain gauges should only be used for non-friable samples which permit an effective bond between the rock surface and strain gauge. Alternatively, techniques are necessary for rocks that fall outside this category of for rocks whose moisture content precludes the necessary bond between the gauges and rock surface”.

The moisture condition at the time of testing can have significant impact on the deformation and measured strength of the rock. Therefore, it is recommended that laboratories review their process if they have not tested the samples in as received condition as specified in the instructions.

Other possible sources of error that might affect the outcome of the proficiency testing program include, but are not limited to:

- Interpretation of test methods and procedures;
- Calibration/condition of equipment;
- Incorrect calculations;
- Transcriptional errors;
- Technician competency; and
- Precision in calculations and reporting.

### Metrological Traceability and Measurement Uncertainty of Assigned Values

Consensus values (median) derived from participants' results are used in this program. These values are not metrologically traceable to an external reference.

As the assigned value for this program is the median of the results submitted by the participants, the uncertainty of the median has been calculated and is presented in Appendix A.

### Analysis of Results by Method Groups

Methods RMS T223 and AS 4133.4.1, ASTM D3967 and ISRM are technically equivalent, therefore results generated using these methods have been pooled for analysis.

## 6. OUTLIER RESULTS

Laboratories reporting outlier results are listed in the following table:

**TABLE B: SUMMARY OF STATISTICAL OUTLIERS**

Test	Laboratory Code No.
Point Load Strength Index	
I <sub>s</sub> - Average Uncorrected Point Load Strength	22
I <sub>s(50)</sub> - Average Point Load Strength	22
Uniaxial Compressive Strength	
Uniaxial Compressive Strength	-
Moisture Content	12
Density	17
Rock Moisture Content	
Moisture Content	12
Rock Deformability	
Uniaxial Compressive Strength	12
Tangent Young's Modulus	12
Secant Young's Modulus	12
Poisson's Ratio	11A and 11B
Density	12
Moisture Content	12
Splitting Tensile Strength	
Mean Splitting Tensile Strength	-

## 7. REFERENCE

- [1] *Guide to Proficiency Testing Australia*, 2016 (This document can be found on the PTA website, [www.pta.asn.au](http://www.pta.asn.au))

# APPENDIX A

## Results and Data Analysis

### Point Load Strength Index

$I_s$  - Uncorrected Point Load Strength.....A1

$I_{s(50)}$  - Point Load Strength.....A2

### Uniaxial Compressive Strength

Uniaxial Compressive Strength.....A4

Moisture Content.....A5

Density.....A7

### Rock Moisture Content

Moisture Content.....A8

### Rock Deformability

Uniaxial Compressive Strength.....A10

Tangent Young's Modulus.....A11

Secant Young's Modulus.....A13

Poisson's Ratio.....A14

Density.....A15

Moisture Content.....A16

### Splitting Tensile Strength

Mean Splitting Tensile Strength.....A17

<b>Is - Uncorrected Point Load Strength (MPa - two significant figures)</b>				
<b>Laboratory Code</b>	<b>Average Result</b>	<b>Robust Z-Score</b>		<b>Method</b>
1	1.19	0.44		AS 4133.4.1
2A	1.25	0.82		RMS T223
3	1.09	-0.19		AS 4133.4.1
4	1.096	-0.15		AS 4133.4.1
5A	1.2	0.50		AS 4133.4.1
5B	1.2	0.50		AS 4133.4.1
8	#	na		#
9A	1.1	-0.13		AS 4133.4.1
10B	1.00	-0.75		AS 4133.4.1
11A	1.29	1.07		AS 4133.4.1
11B	1.33	1.32		AS 4133.4.1
12	0.91	-1.32		AS 4133.4.1
14	0.86	-1.63		#
17	1.38	1.63		AS 4133.4.1
18	0.99	-0.82		AS 4133.4.1
19	1.14	0.13		AS 4133.4.1
20	1.1	-0.13		AS 4133.4.1
21	0.85	-1.69		AS 4133.4.1
22	5.2	25.60	§	AS 4133.4.1-2007

No. of Results	18
Median	1.120
Normalised IQR	0.159
Uncertainty of the Median	0.047
Robust CV	14.2%
Minimum	0.85
Maximum	5.20
Range	4.35

Notes:

“§” indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

<b>Is(50) - Point Load Strength (MPa - two significant figures)</b>				
<b>Laboratory Code</b>	<b>Average Result</b>	<b>Robust Z-Score</b>		<b>Method</b>
1	1.2	0.31		AS 4133.4.1
2A	1.20	0.31		RMS T223
3	1.10	-0.31		AS 4133.4.1
4	1.2325	0.52		AS 4133.4.1
5A	1.2	0.31		AS 4133.4.1
5B	1.2	0.31		AS 4133.4.1
8	#	na		#
9A	1.0	-0.94		AS 4133.4.1
10B	0.98	-1.07		AS 4133.4.1
11A	1.19	0.25		AS 4133.4.1
11B	1.26	0.69		AS 4133.4.1
12	0.89	-1.63		AS 4133.4.1
14	0.82	-2.07	?	#
17	1.25	0.63		AS 4133.4.1
18	0.98	-1.07		AS 4133.4.1
19	1.11	-0.25		AS 4133.4.1
20	1.0	-0.94		AS 4133.4.1
21	0.85	-1.88		AS 4133.4.1
22	4.6	21.65	§	AS 4133.4.1-2007

No. of Results	18
Median	1.150
Normalised IQR	0.159
Uncertainty of the Median	0.047
Robust CV	13.9%
Minimum	0.82
Maximum	4.60
Range	3.78

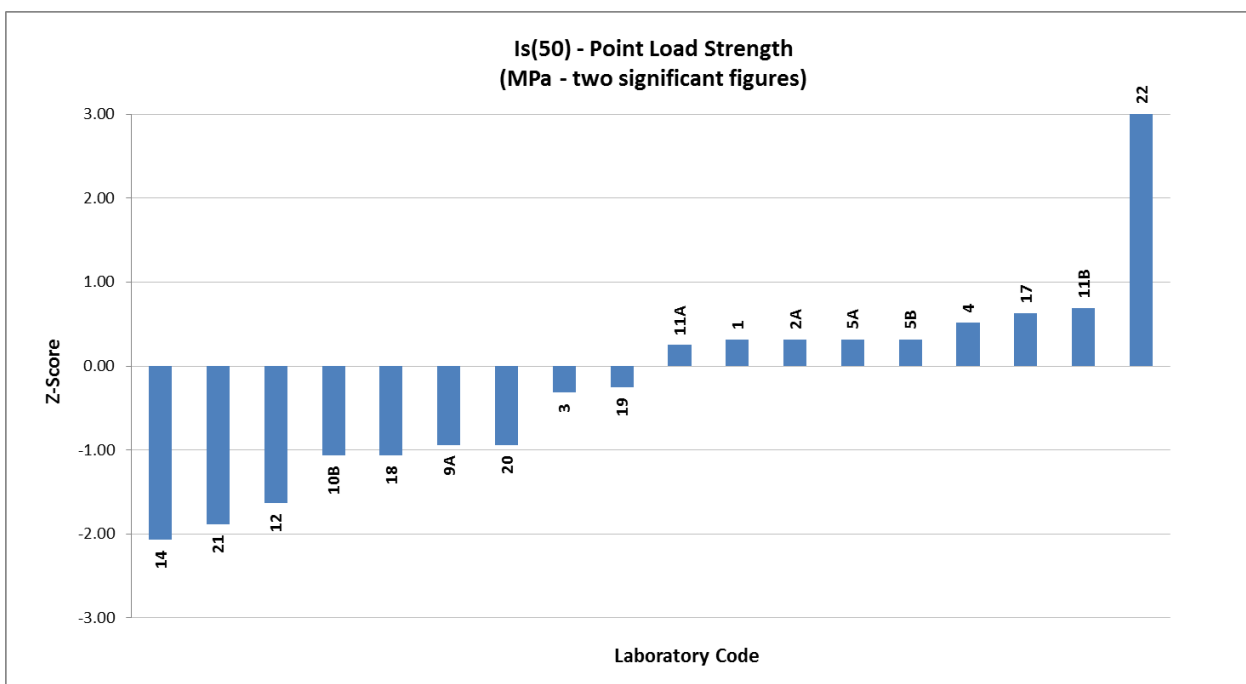
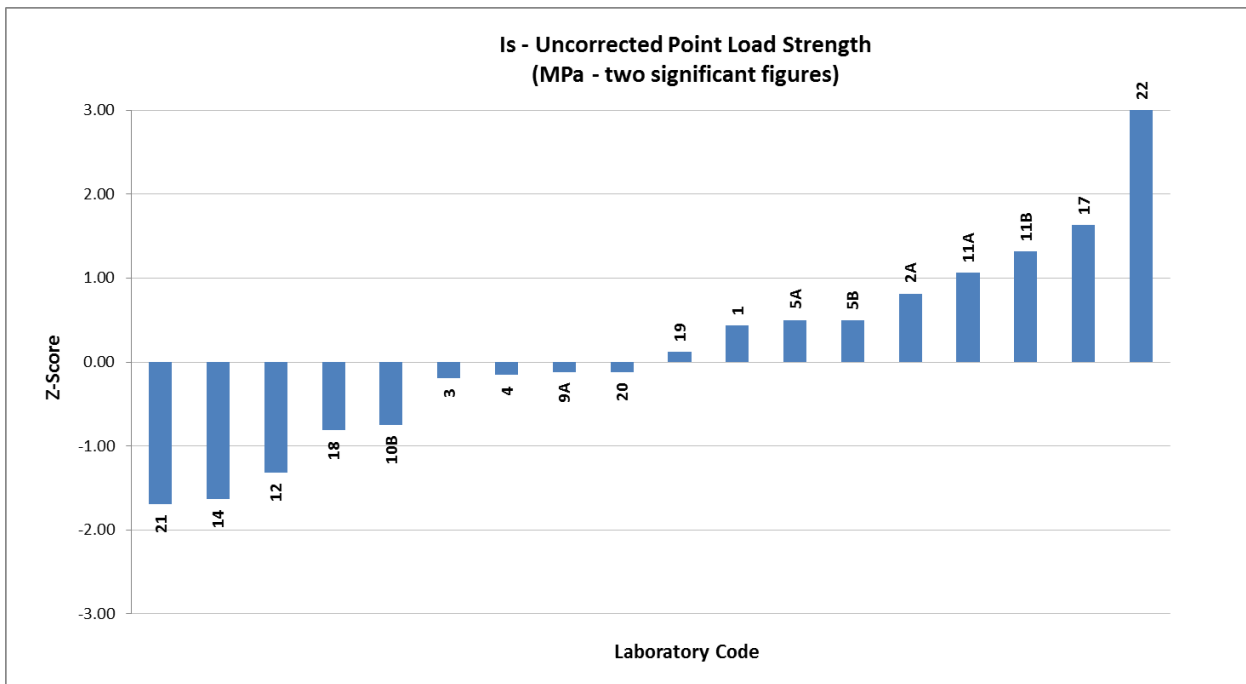
## Notes:

"?" indicates an absolute z-score greater than 2.0 but less than 3, i.e.  $2.0 < |z\text{-score}| < 3.0$

"§" indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable



<b>Uniaxial Compressive Strength (MPa-two significant figures)</b>			
<b>Laboratory Code</b>	<b>Result</b>	<b>Robust Z-Score</b>	<b>Method</b>
1	8.9	0.64	AS 4133.4.2.2
2A	#	na	#
3	6.56	-1.02	AS4133.4.2.1
4	#	na	#
5A	8.8	0.57	AS 4133.4.2.2 and AS 4133.1.1.1
5B	8.3	0.21	AS 4133.4.2.2 and AS 4133.1.1.1
8	10.10	1.49	AS 4133.4.2.2
9A	#	na	#
10B	5.73	-1.61	AS 4133.2.2
11A	7.81	-0.13	AS 4133.4.2.2
11B	6.97	-0.73	AS 4133.4.2.2 and AS 4133.1.1.1
12	6.9	-0.78	AS 4133.4.2.2
14	#	na	#
17	6.67	-0.94	AS 4133.4.2.2
18	#	na	#
19	8.37	0.26	#
20	#	na	#
21	8.8	0.57	AS 4133.4.2.2 and AS 4133.1.1.1
22	8.0	0.00	AS 4133.4.2.2-2013

No. of Results	13
Median	8.000
Normalised IQR	1.408
Uncertainty of the Median	0.490
Robust CV	17.6%
Minimum	5.73
Maximum	10.10
Range	4.37

## Notes:

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

Moisture Content (nearest 0.1%)			
Laboratory Code	Result	Robust Z-Score	Method
1	42.6	0.00	AS 4133.4.2.2
2A	#	na	#
3	45.8	0.48	AS4133.4.2.1
4	#	na	#
5A	52.8	1.53	AS 4133.4.2.2 and AS 4133.1.1.1
5B	52.1	1.42	AS 4133.4.2.2 and AS 4133.1.1.1
8	30.4	-1.83	AS 4133.4.2.2
9A	#	na	#
10B	34.7	-1.18	AS 4133.2.2
11A	42.1	-0.07	AS 4133.4.2.2
11B	43.8	0.18	AS 4133.4.2.2 and AS 4133.1.1.1
12	22.3	-3.04	§ AS 4133.4.2.2
14	#	na	#
17	46.4	0.57	AS 4133.4.2.2
18	#	na	#
19	37.4	-0.78	#
20	#	na	#
21	41.6	-0.15	AS 4133.4.2.2 and AS 4133.1.1.1
22	55.7	1.96	AS 4133.4.2.2-2013

No. of Results	13
Median	42.60
Normalised IQR	6.67
Uncertainty of the Median	2.32
Robust CV	15.7%
Minimum	22.3
Maximum	55.7
Range	33.4

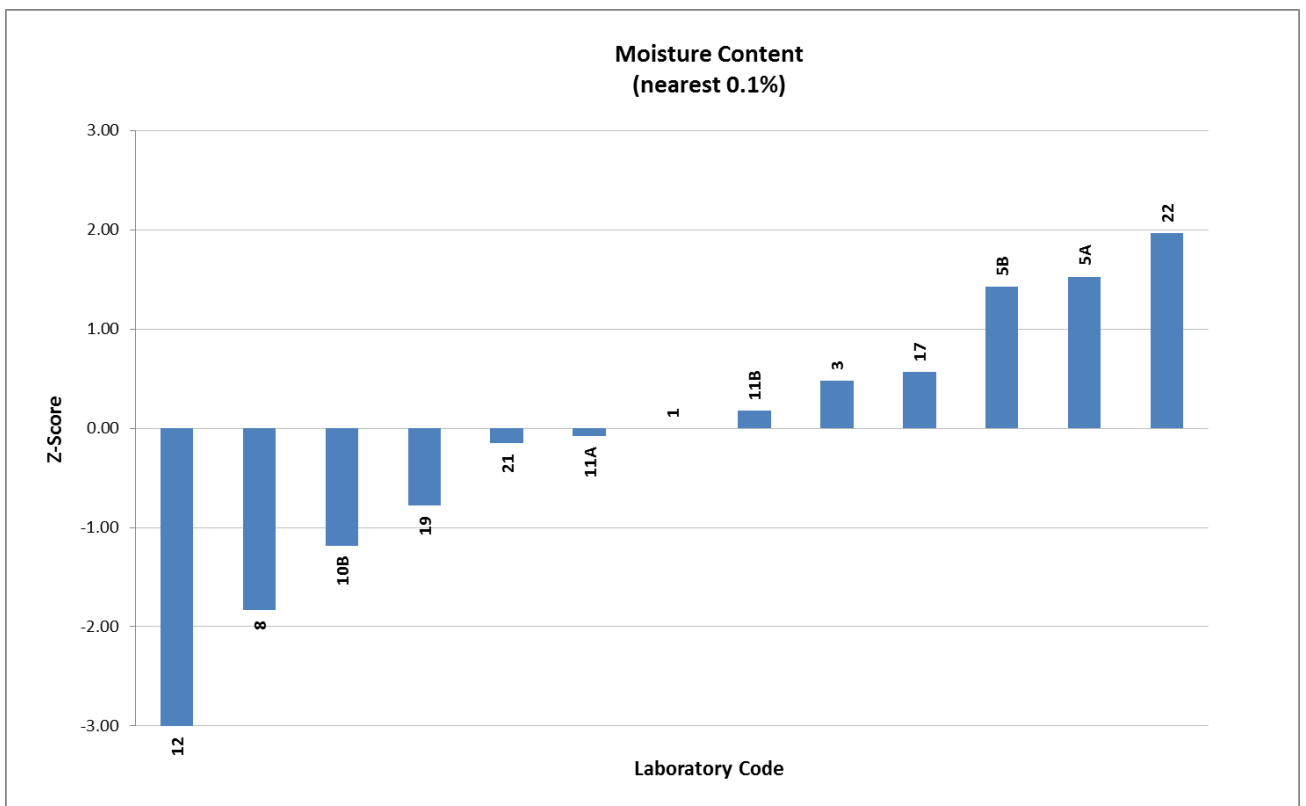
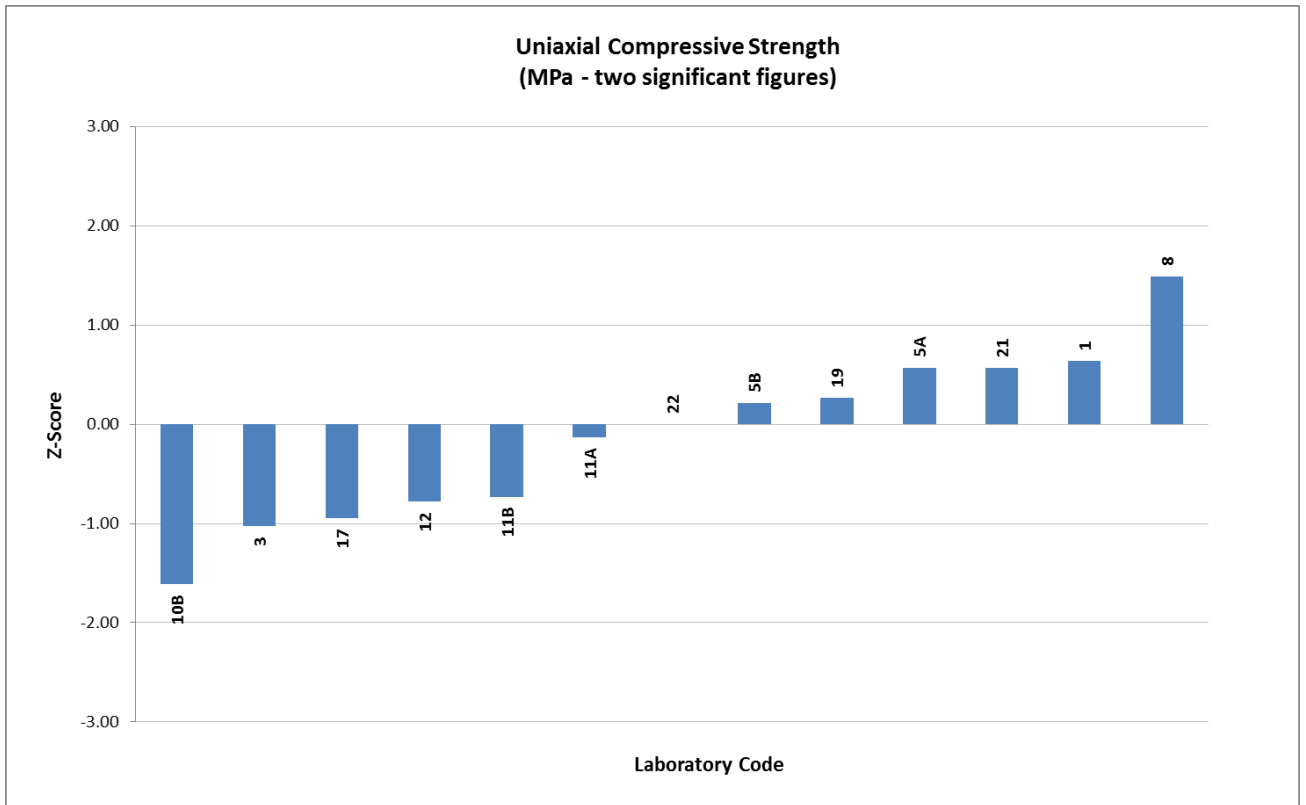
Notes:

"§" indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable





Density (t/m <sup>3</sup> ) (nearest 0.01)			
Laboratory Code	Result	Robust Z-Score	Method
1	1.63	0.00	AS 4133.4.2.2
2A	#	na	#
3	1.626	-0.02	AS4133.4.2.1
4	#	na	#
5A	1.63	0.00	AS 4133.4.2.2 and AS 4133.1.1.1
5B	1.63	0.00	AS 4133.4.2.2 and AS 4133.1.1.1
8	1.46	-1.04	AS 4133.4.2.2
9A	#	na	#
10B	1.90	1.66	AS 4133.2.2
11A	1.62	-0.06	AS 4133.4.2.2
11B	1.62	-0.06	AS 4133.4.2.2 and AS 4133.1.1.1
12	1.25	-2.33	? AS 4133.4.2.2
14	#	na	#
17	1.11	-3.19	§ AS 4133.4.2.2
18	#	na	#
19	1.63	0.00	#
20	#	na	#
21	1.63	0.00	AS 4133.4.2.2 and AS 4133.1.1.1
22	1.65	0.12	AS 4133.4.2.2-2013

No. of Results	13
Median	1.630
Normalised IQR	0.007
Uncertainty of the Median	0.003
Target SD	0.163
Target CV	10%
Robust CV	0.5%
Minimum	1.11
Maximum	1.90
Range	0.79

## Notes:

"?" indicates an absolute z-score greater than 2.0 but less than 3, i.e.  $2.0 < |z\text{-score}| < 3.0$

"§" indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

A target CV and SD were used for z-score calculation

Rock Moisture Content (%)				
Laboratory Code	Result	Robust Z-Score		Method
1	42.6	-0.09		AS 4133.1.1.1
2A	#	na		#
3	48.9	0.89		#
4	#	na		#
5A	52.8	1.50		AS 4133.1.1.1
5B	52.1	1.39		AS 4133.1.1.1
8	#	na		#
9A	#	na		#
10B	#	na		#
11A	42.1	-0.17		AS 4133.1.1
11B	43.2	0.00		AS 4133.4.1.1
12	22.3	-3.26	§	AS 4133.1.1.1
14	#	na		#
17	46	0.44		AS 4133.1.1.1
18	#	na		#
19	37.4	-0.90		AS 4133.1.1.1
20	#	na		#
21	41.6	-0.25		AS 4133.1.1.1
22	55.5	1.92		AS 4133.1.1.1-2005

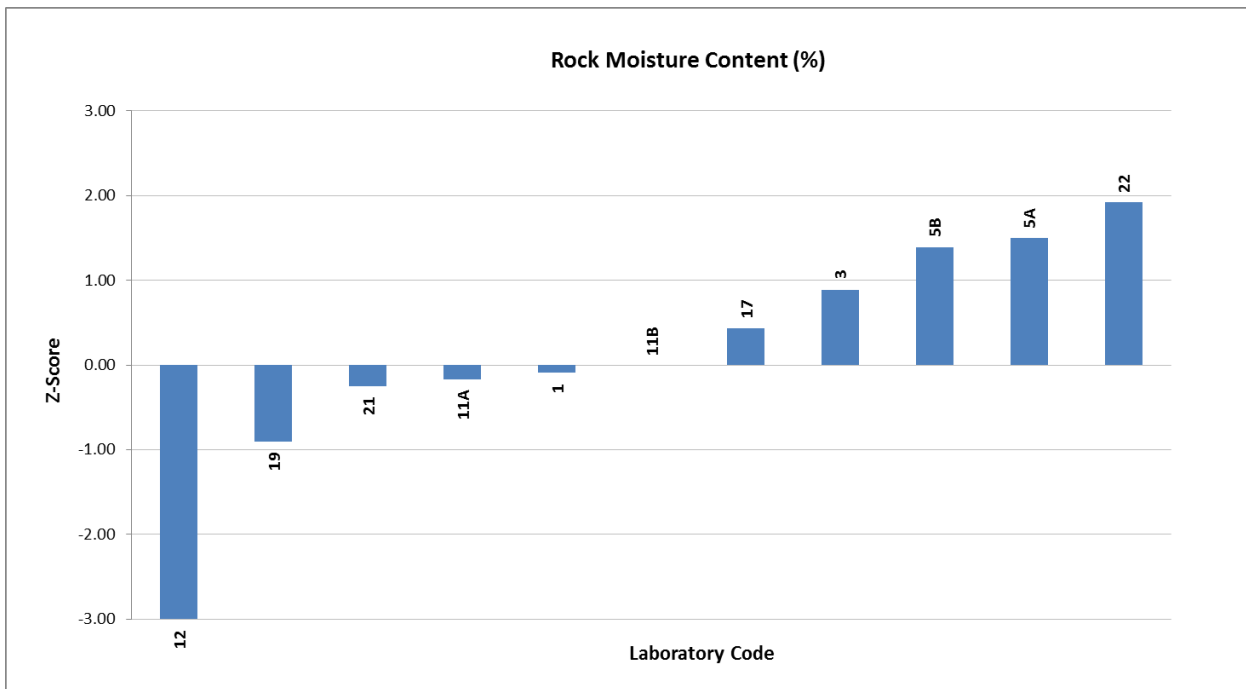
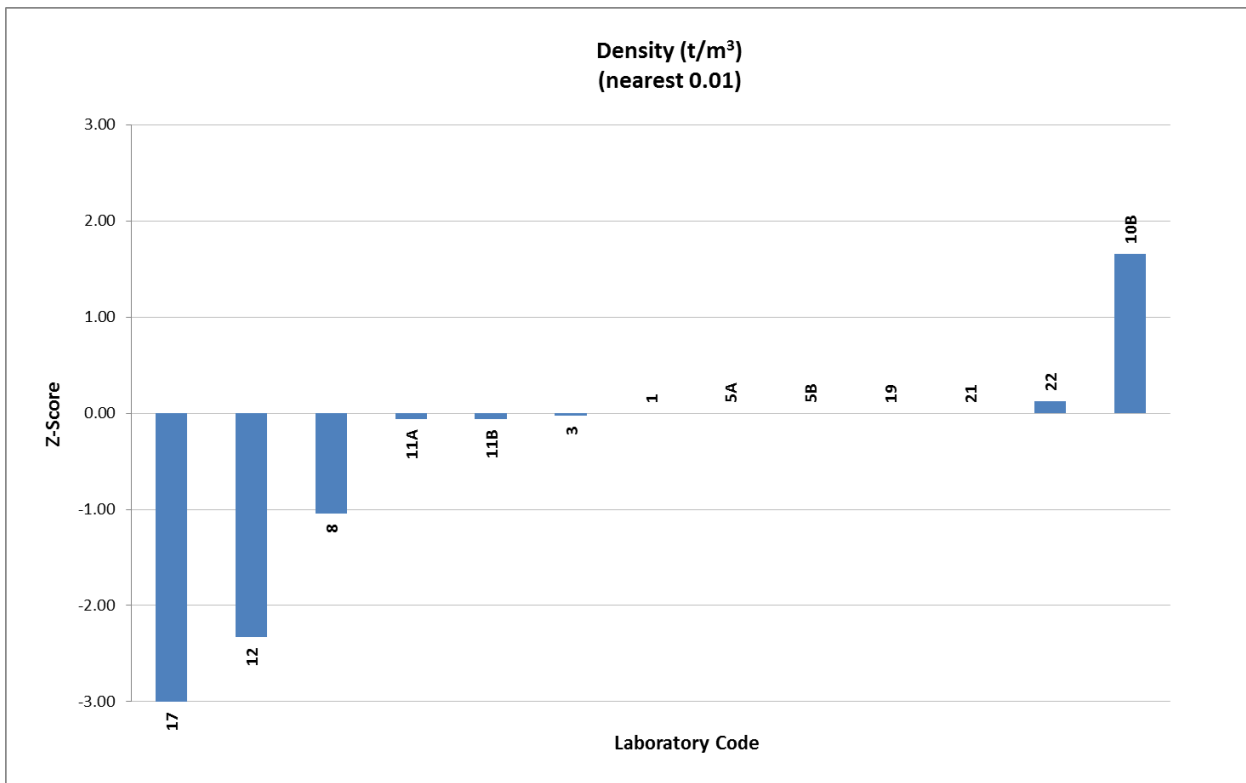
No. of Results	11
Median	43.20
Normalised IQR	6.41
Uncertainty of the Median	2.42
Robust CV	14.8%
Minimum	22.3
Maximum	55.5
Range	33.2

Notes:

“§” indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable



Rock Deformability - Uniaxial Compressive Strength (MPa-two significant figures)				
Laboratory Code	Result	Robust Z-Score		Method
1	9.0	0.49		AS 4133.4.3.2
2A	#	na		#
3	#	na		#
4	#	na		#
5A	8.8	0.24		AS 4133.4.3.2
5B	8.6	0.00		AS 4133.4.3.2
8	#	na		#
9A	#	na		#
10B	#	na		#
11A	7.78	-1.00		AS 4133.4.3.2
11B	6.73	-2.28	?	AS 4133.4.3.2
12	18.7	12.32	§	4133.4.3.2
14	#	na		#
17	#	na		#
18	#	na		#
19	#	na		#
20	#	na		#
21	#	na		#
22	8.2	-0.49		AS4133.4.3.2-2013

No. of Results	7
Median	8.600
Normalised IQR	0.820
Uncertainty of the Median	0.388
Robust CV	9.5%
Minimum	6.73
Maximum	18.70
Range	11.97

## Notes:

"?" indicates an absolute z-score greater than 2.0 but less than 3, i.e.  $2.0 < |z\text{-score}| < 3.0$

"§" indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

Rock Deformability - Tangent Young's Modulus (GPa-two significant figures)			
Laboratory Code	Result	Robust Z-Score	Method
1	1.6	-0.70	AS 4133.4.3.2
2A	#	na	#
3	#	na	#
4	#	na	#
5A	1.8	0.00	AS 4133.4.3.2
5B	1.8	0.00	AS 4133.4.3.2
8	#	na	#
9A	#	na	#
10B	#	na	#
11A	2.15	1.23	AS 4133.4.3.2
11B	1.88	0.28	AS 4133.4.3.2
12	8.7	24.31	§ 4133.4.3.2
14	#	na	#
17	#	na	#
18	#	na	#
19	#	na	#
20	#	na	#
21	#	na	#
22	1.5	-1.06	AS4133.4.3.2-2013

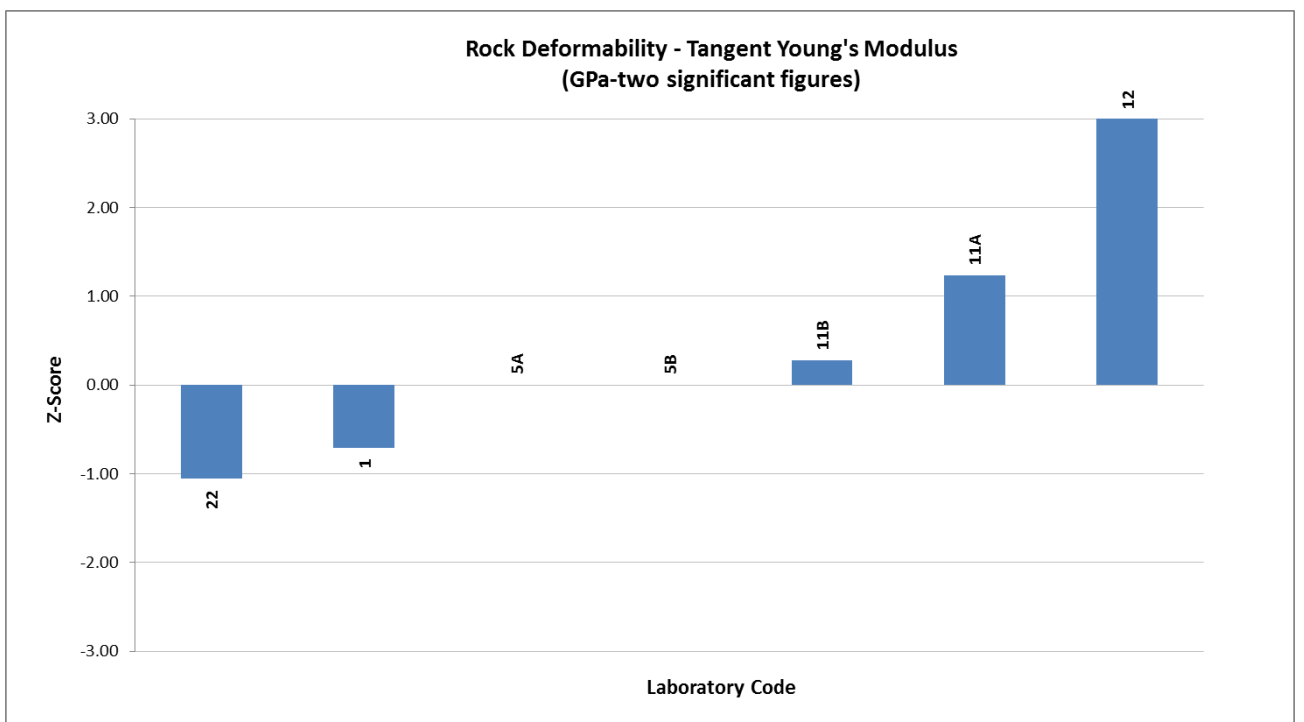
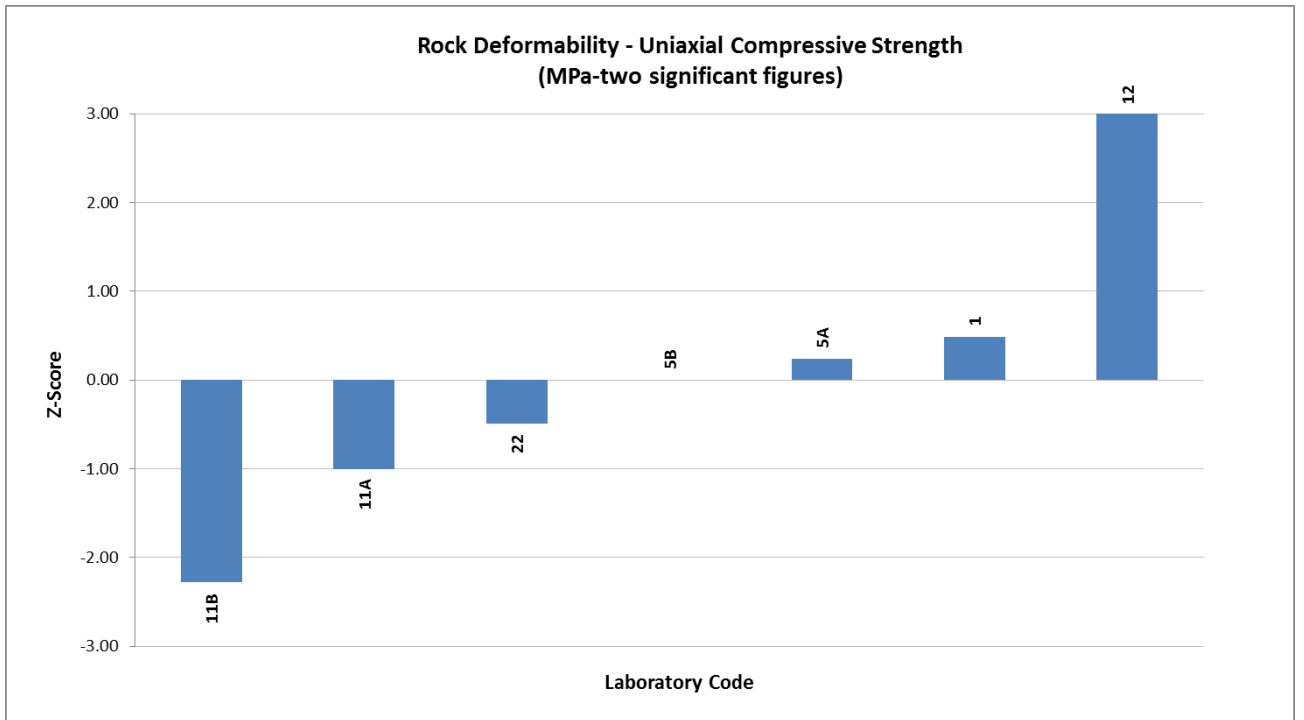
No. of Results	7
Median	1.800
Normalised IQR	0.284
Uncertainty of the Median	0.134
Robust CV	15.8%
Minimum	1.50
Maximum	8.70
Range	7.20

Notes:

"§" indicates an outlier, i.e.  $|z\text{-score}| \geq 3.0$

"#" indicates no response was provided by the laboratory

"na" indicates not applicable



Rock Deformability - Secant Young's Modulus (GPa-two significant figures)				
Laboratory Code	Result	Robust Z-Score		Method
1	2.7	0.39		AS 4133.4.3.2
2A	#	na		#
3	#	na		#
4	#	na		#
5A	2.6	0.12		AS 4133.4.3.2
5B	2.0	-1.49		AS 4133.4.3.2
8	#	na		#
9A	#	na		#
10B	#	na		#
11A	3.07	1.38		AS 4133.4.3.2
11B	2.51	-0.12		AS 4133.4.3.2
12	148	na	§	4133.4.3.2
14	#	na		#
17	#	na		#
18	#	na		#
19	#	na		#
20	#	na		#
21	#	na		#
22	2.2	-0.95		AS4133.4.3.2-2013

No. of Results	6
Median	2.555
Normalised IQR	0.374
Uncertainty of the Median	0.191
Robust CV	14.6%
Minimum	2.00
Maximum	3.07
Range	1.07

Notes:

"§" indicates and erroneous result that was excluded from statistical analysis

"#" indicates no response was provided by the laboratory

"na" indicates not applicable



Rock Deformability - Poisson's Ratio				
Laboratory Code	Result	Robust Z-Score		Method
1	0.384	na		AS 4133.4.3.2
2A	#	na		#
3	#	na		#
4	#	na		#
5A	0.26	na		AS 4133.4.3.2
5B	0.4	na		AS 4133.4.3.2
8	#	na		#
9A	#	na		#
10B	#	na		#
11A	0.085	na	§	AS 4133.4.3.2
11B	0.060	na	§	AS 4133.4.3.2
12	0.25	na		4133.4.3.2
14	#	na		#
17	#	na		#
18	#	na		#
19	#	na		#
20	#	na		#
21	#	na		#
22	0.24	na		AS4133.4.3.2-2013

No. of Results	7
----------------	---

## Notes:

"§" indicates a non-statistical outlier

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

Rock Deformability - Density (as tested) (t/m <sup>3</sup> to the nearest 0.01)			
Laboratory Code	Result	Robust Z-Score	Method
1	1.61	-0.89	AS 4133.4.3.2
2A	#	na	#
3	#	na	#
4	#	na	#
5A	1.64	0.44	AS 4133.4.3.2
5B	1.64	0.44	AS 4133.4.3.2
8	#	na	#
9A	#	na	#
10B	#	na	#
11A	1.63	0.00	AS 4133.4.3.2
11B	1.62	-0.44	AS 4133.4.3.2
12	1.37	-11.54	§ 4133.4.3.2
14	#	na	#
17	#	na	#
18	#	na	#
19	#	na	#
20	#	na	#
21	#	na	#
22	1.64	0.44	AS4133.4.3.2-2013

No. of Results	7
Median	1.630
Normalised IQR	0.023
Uncertainty of the Median	0.011
Robust CV	1.4%
Minimum	1.37
Maximum	1.64
Range	0.27

Notes:

“§” indicates an outlier, i.e. |z-score| ≥ 3.0

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

Rock Deformability - Moisture Content (nearest 0.1%)				
Laboratory Code	Result	Robust Z-Score		Method
1	42.3	-0.10		AS 4133.4.3.2
2A	#	na		#
3	#	na		#
4	#	na		#
5A	52.4	1.04		AS 4133.4.3.2
5B	51.3	0.92		AS 4133.4.3.2
8	#	na		#
9A	#	na		#
10B	#	na		#
11A	41.8	-0.16		AS 4133.4.3.2
11B	43.2	0.00		AS 4133.4.3.2
12	16.4	-3.04	§	4133.4.3.2
14	#	na		#
17	#	na		#
18	#	na		#
19	#	na		#
20	#	na		#
21	#	na		#
22	53.5	1.17		AS4133.4.3.2-2013

No. of Results	7
Median	43.20
Normalised IQR	8.83
Uncertainty of the Median	4.18
Robust CV	20.4%
Minimum	16.4
Maximum	53.5
Range	37.1

Notes:

"§" indicates an outlier, i.e. |z-score|  $\geq$  3.0

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

Splitting Tensile Strength (MPa- two significant figures)			
Laboratory Code	Average Result	Robust Z-Score	Method
1	1.3	0.00	ASTM D3967
2A	#	na	#
3	1.44	1.08	ISRM
4	#	na	#
5A	1.3	0.00	ASTM D3967
5B	1.3	0.00	ASTM D3967
8	#	na	#
9A	#	na	#
10B	#	na	#
11A	1.27	-0.23	ASTM D3967
11B	1.24	-0.46	ASTM D3967
12	#	na	#
14	#	na	#
17	#	na	#
18	#	na	#
19	#	na	#
20	#	na	#
21	#	na	#
22	1.3	0.00	ASTM D3967

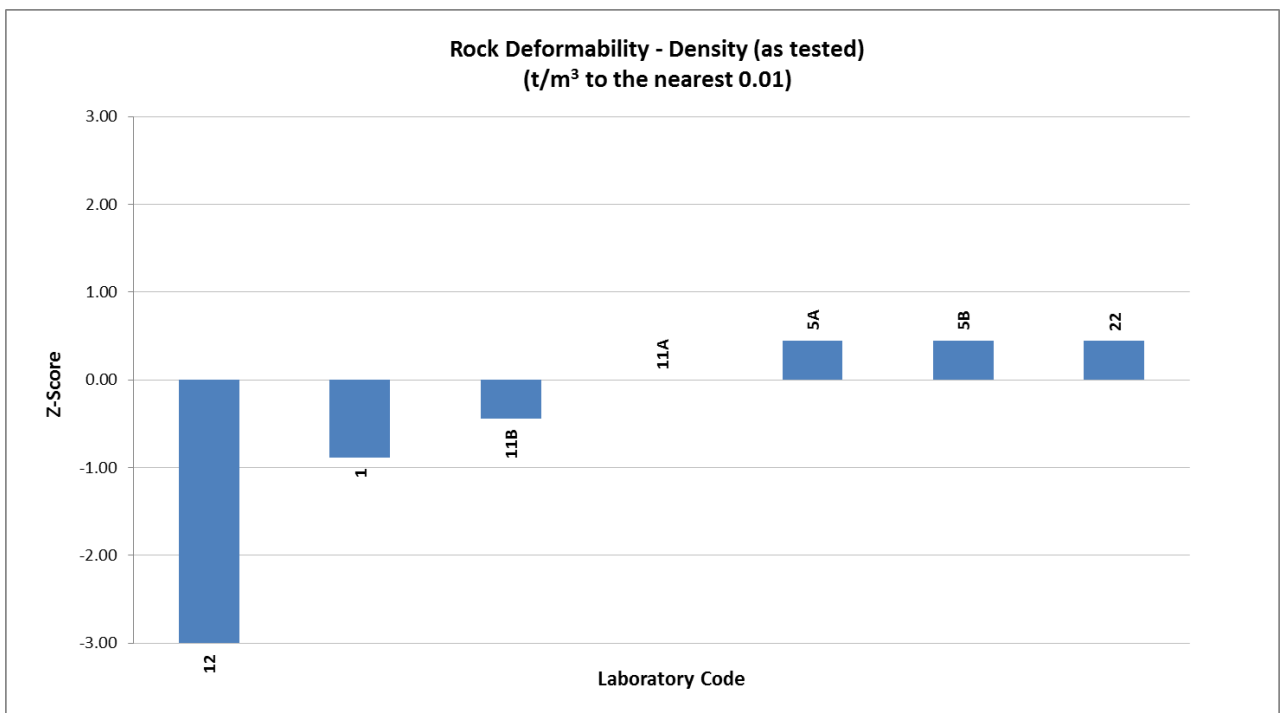
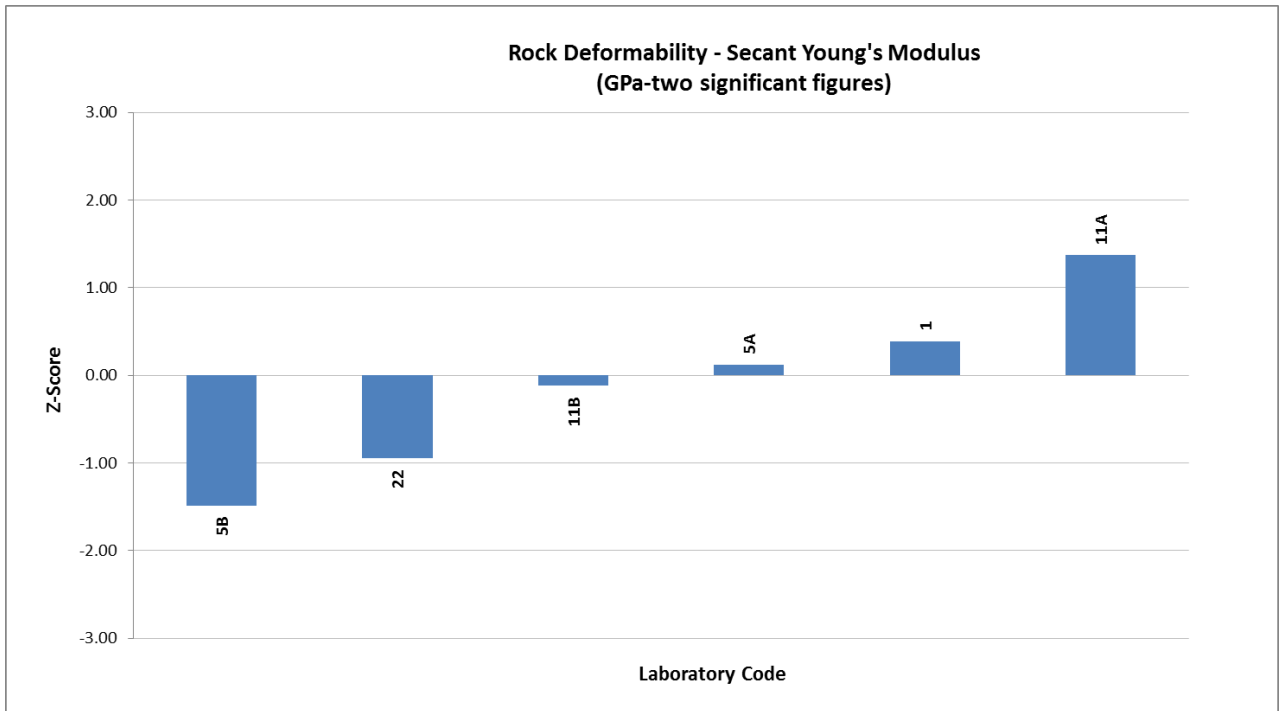
No. of Results	7
Median	1.300
Normalised IQR	0.014
Uncertainty of the Median	0.006
Target SD	0.130
Target CV	10%
Robust CV	1.0%
Minimum	1.24
Maximum	1.44
Range	0.20

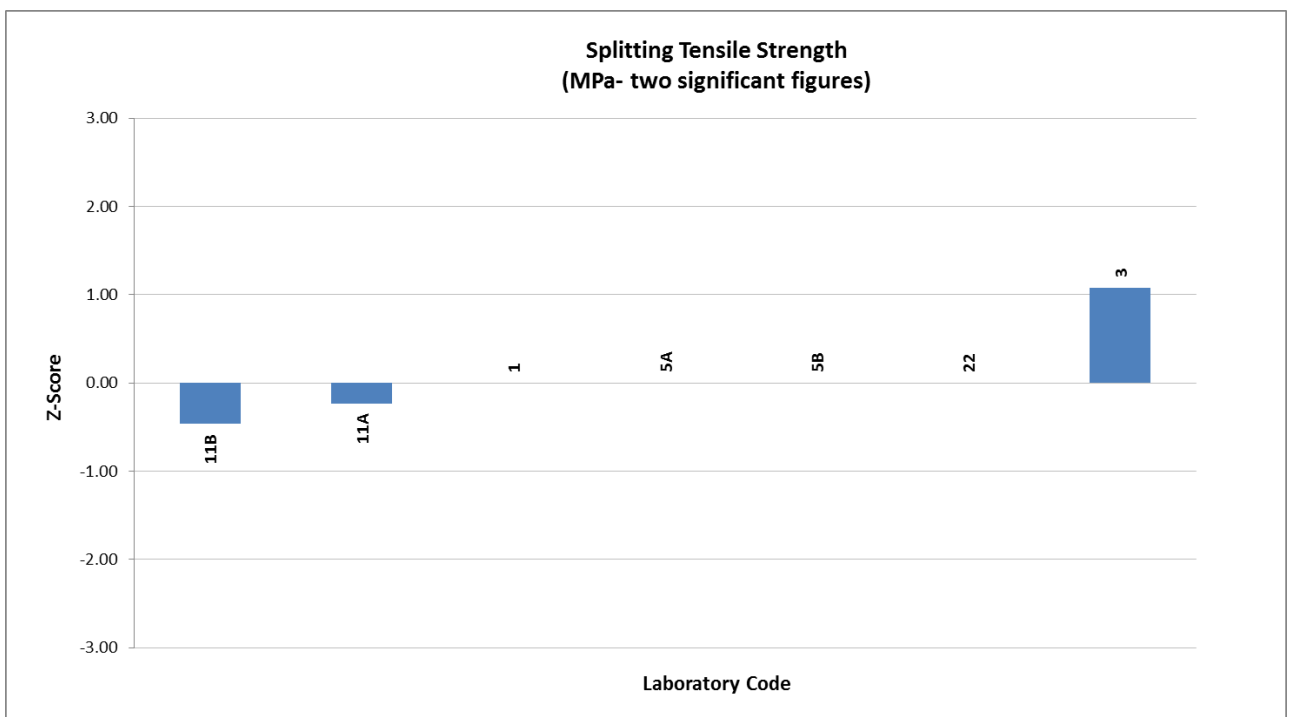
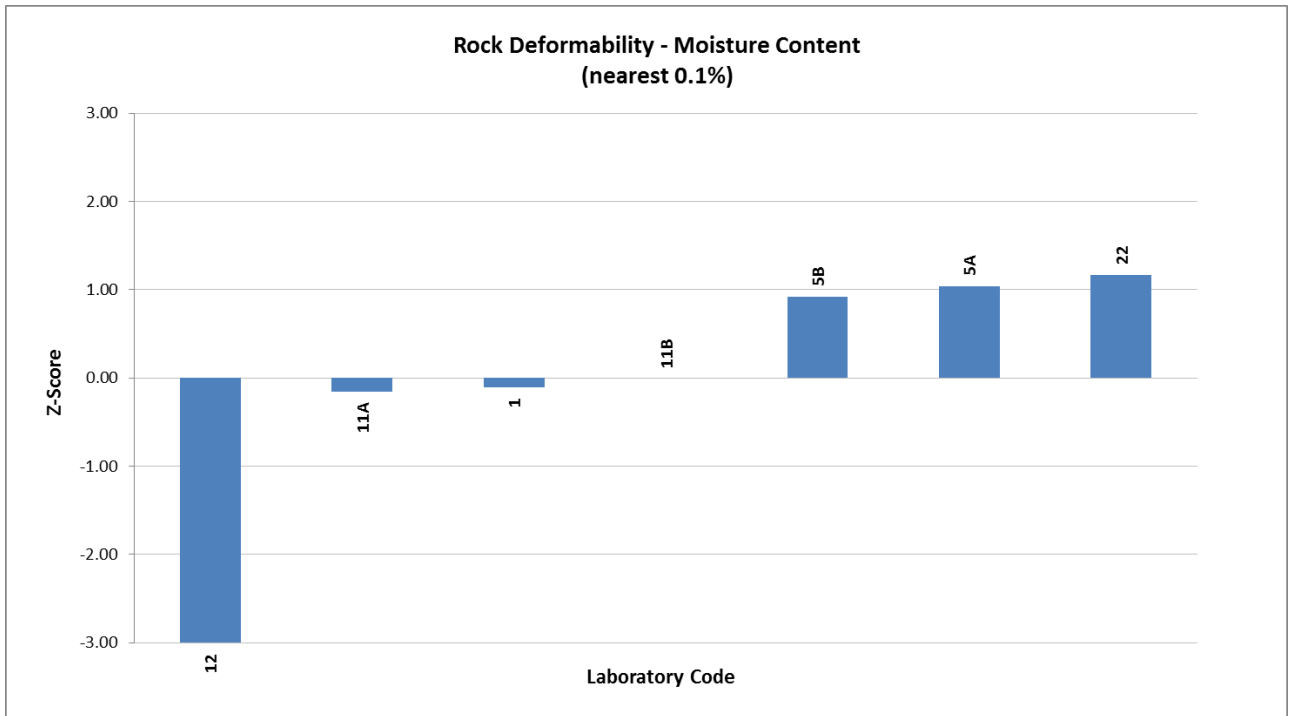
## Notes:

"#" indicates no response was provided by the laboratory

"na" indicates not applicable

A target CV and SD were used for z-score calculation





# **APPENDIX B**

## **Homogeneity Testing**

### Homogeneity Testing

The samples utilised in this program were supplied by Golder Associates Pty Ltd, Melbourne Laboratory. For this program, samples were cast in two separate days: Samples A on Day 1 and Samples B on Day 2. Five random samples from each day were selected and tested for homogeneity. Statistical analysis showed that the samples were sufficiently homogeneous so that any results identified as outliers could not be attributed to sample variability.

The results of the homogeneity testing, along with the summary statistics are provided in the tables below.

<b>SAMPLE ID</b>	<b>L/D RATIO</b>	<b>DENSITY (t/m<sup>3</sup>)</b>	<b>UCS (MPa)</b>
A3	2.9	1.68	8.49
A18	2.9	1.66	8.39
A27	2.9	1.65	8.45
A33	2.6	1.68	8.78
A48	2.6	1.69	8.6

<b>Mean</b>		<b>1.67</b>	<b>8.54</b>
<b>Standard Deviation</b>		<b>0.02</b>	<b>0.15</b>
<b>Coefficient of Variation</b>		<b>0.98%</b>	<b>1.80%</b>
<b>Lowest Value</b>		<b>1.65</b>	<b>8.39</b>
<b>Highest Value</b>		<b>1.69</b>	<b>8.78</b>
<b>Range</b>		<b>0.04</b>	<b>0.39</b>

<b>SAMPLE ID</b>	<b>L/D RATIO</b>	<b>DENSITY (t/m<sup>3</sup>)</b>	<b>UCS (MPa)</b>
B5	2.7	1.65	8.86
B21	2.7	1.65	8.96
B30	2.7	1.66	9.03
B36	2.7	1.66	8.47
B47	2.7	1.66	9.02

<b>Mean</b>		<b>1.66</b>	<b>8.87</b>
<b>Standard Deviation</b>		<b>0.01</b>	<b>0.23</b>
<b>Coefficient of Variation</b>		<b>0.33%</b>	<b>2.62%</b>
<b>Lowest Value</b>		<b>1.65</b>	<b>8.47</b>
<b>Highest Value</b>		<b>1.66</b>	<b>9.03</b>
<b>Range</b>		<b>0.01</b>	<b>0.56</b>



# APPENDIX C

## Documentation

Instructions to Participants .....	C1
Results Sheet .....	C3

PROFICIENCY TESTING AUSTRALIA  
Proficiency Testing Program

ROCKS ROUND 1

**INSTRUCTIONS TO PARTICIPANTS**

**PLEASE NOTE CYLINDERS ARE TO BE TESTED ON THE 30/10/2018**

**Keep them in their original packaging at room temperature till date of testing and test as received condition.**

Please read instructions carefully **BEFORE** commencing testing.

To ensure that the results of this program can be analysed properly, participants are asked to carefully note the following:

1. Four cylinders (nominally 50 mm diameter x 150 mm length) have been supplied to each laboratory: two cylinders with identification A and other two B. Trim each cylinder at both ends to avoid the test results being affected by the end of core conditions when cutting into the correct lengths for testing.

**2. AS 4133.4.1 Determination of point load strength index - (clause 3.3 Axial test)**

Use one cylinder with identification A. Please report the 4 results together with the average of 4 results.

**3. AS 4133.4.2.2/1.1.1 Determination of uniaxial compressive strength/ Determination of the moisture content**

Use one cylinder with identification B. Specimen is to be tested at length to diameter ratio between 2.5 and 2.7.

**4. AS 4133.4.3.2 Determination of deformability of rock in uniaxial compression**

Use one cylinder with identification B. Specimen is to be tested at length to diameter ratio between 2.5 and 2.7.

**5. ASTM D3967 Splitting tensile strength on intact rock specimen**

Use one cylinder with identification A. Please report the 4 results together with the average of 4 results.

6. The results for all determinations are to be recorded on the results sheet to the accuracy and reporting basis indicated where possible. **Please ensure you check your rounding details.**

7. For this program your laboratory has been allocated the code number shown on the results sheet. All reference to your laboratory in reports associated with this program will be with this code number, thus ensuring confidentiality of results.

8. All laboratories must return the results sheet no later than **6 November 2018** to:

**Emilia Cincu**  
**Proficiency Testing Australia**

**Fax: 02 9743 6664**  
**Email: [emilia.cincu@pta.asn.au](mailto:emilia.cincu@pta.asn.au)**

PROFICIENCY TESTING AUSTRALIA  
ROCKS 1 - Proficiency Testing Program

Results Sheet

TEST DATE: 30/10/2018

Lab Code:

TEST (report to)	Value				Method
<b>Point Load Strength Index</b>					
$I_s$ –Uncorrected Point Load Strength (MPa-two significant figures)	Sub-specimen 1	Sub-specimen 2	Sub-specimen 3	Sub-specimen 4	
$I_s$ –Average Uncorrected Point Load Strength (MPa-two significant figures)					
$I_{s(50)}$ –Point Load Strength Index (MPa-two significant figures)	Sub-specimen 1	Sub-specimen 2	Sub-specimen 3	Sub-specimen 4	
$I_{s(50)}$ – Average Point Load Strength Index (MPa-two significant figures)					
<b>Uniaxial Compressive Strength</b>					
Uniaxial Compressive Strength (MPa-two significant figures)					
Failure mode					
Average Diameter (nearest 0.1 mm)					
Average Height (nearest 0.1 mm)					
Moisture Content (nearest 0.1%)					
Density (as tested) (t/m <sup>3</sup> to the nearest 0.01)					
Rate of displacement (mm/min)					
Test duration (min)					
<b>Rock Moisture Content</b>					
Moisture Content (%)					

<b>Rock Deformability</b>					
Uniaxial Compressive Strength (MPa-two significant figures)					
Tangent Young's Modulus (GPa-two significant figures)					
Secant Young's Modulus (GPa-two significant figures)					
Poisson's Ratio					
Methods of determination of Young's Modulus and the axial stress level or levels					
Failure Mode					
Average Diameter (nearest 0.1 mm)					
Average Height (nearest 0.1 mm)					
Length to diameter ratio					
Density (as tested) (t/m <sup>3</sup> to the nearest 0.01)					
Moisture Content (nearest 0.1%)					
Rate of displacement (mm/min)					
Test duration (min)					
<b>Splitting Tensile Strength</b>					
Splitting Tensile Strength (MPa-two significant figures)	Sub- specimen 1	Sub- specimen 2	Sub- specimen 3	Sub- specimen 4	
Mean Splitting Tensile Strength (MPa-two significant figures)					
Average Diameter (nearest 0.1 mm)					
Average Height (nearest 0.1 mm)					
Loading rate (N/s)					
Test duration (min)					

**Please ensure to check rounding details.**

Date of receipt: \_\_\_\_\_

Moisture condition on receipt (SSD or dry): \_\_\_\_\_

Date of tests \_\_\_\_\_

Signature: \_\_\_\_\_

Comments:

.....  
.....  
.....  
.....

Return no later than **6/11/2018** to:

**Emilia Cincu**  
**Proficiency Testing Australia**

**Phone: 02 9736 8397**

**Fax: 02 9743 6664**

**Email: [emilia.cincu@pta.asn.au](mailto:emilia.cincu@pta.asn.au)**

*- End of Report -*