GEOTECHNICAL PROFICIENCY TESTING FOR FIELD-BASED SOIL PLASTICITY AND EXPANSIVITY ASSESSMENT: DO WE NEED IT?

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ABSTRACT

The intention of this study was to assess whether proficiency testing, as outlined in ISO/IEC 17043:2010, could be beneficial for field assessment of selected soil properties, similar to the laboratory 'interlab' system.

The geotechnical profession is unique amongst engineering disciplines, as project-specific specialised quantitative testing is not always used to establish material properties used for analysis and design. For the numerous smaller projects, plasticity, for example, is typically assessed on-site through experience as opposed to laboratory testing. This experience is specific to each consultant and, in conjunction with no requirements for inter-consultant comparison, presents the position where industry-wide consistency is unknown.

The study undertook a proficiency test on soil plasticity logging between various geotechnical consultants using the procedure outlined in ISO/IEC 17043:2010 section 4.4. Participating consultants received a uniform soil sample for logging by at least two staff members. The participating companies and engineers were kept anonymous throughout the study. The participants were also asked to interpret the soil class according to AS 2870:2011. Results were collated and compared to a laboratory tested control sample to assess logging and interpretation consistency.

The implications of any variance between participants and laboratory tests were also explored. Whilst plasticity was the parameter chosen for investigation, the results of the exercise provide an insight into whether proficiency testing by a regulatory body or professional organisation would benefit the industry and its customers. Processes that reduce the inconsistency and variance in the field based assessment of soil performance characteristics could reduce the risk of excessive conservatism or the risk of underestimating plasticity and underspecifying foundations.

1 BACKGROUND

The accuracy of soil logging and testing data undertaken by geotechnical engineers, geologists, and technicians is of the upmost importance in arriving at reasonable final recommendations given to clients. This is particularly the case for smaller projects where laboratory testing is not typically undertaken due to financial or timing restrictions. This testing, although typically undertaken by experienced and skilled professionals, is not verified by a governing body. As such, the results obtained from field logging can often be significantly influenced by personal and company experience. In order to reduce the potential for inconsistent assessment within consultancies in-house logging sessions are the typical approach adopted to reduce potential variance. These sessions inevitably rely on the training and experience of senior staff, often in line with the company's experience.

The subjectivity of soil logging is well known and, as such, consultancies will avoid providing recommendations solely based on logged or tested data from other companies as there is an acceptance that there is inevitable inter-company variance in field based logging. Adopting this approach can be detrimental to clients as this can lead to duplication of investigations, which will add time and cost to projects.

A variety of recommendations in reference to a number of different standards are provided for logged soil data. In respect of standards, AS 2870:2011 is noted within the Auckland region as the standard that is widely used in the design of foundations underlain by soils that may have a high shrink/swell risk. Assessment of the potential expansivity of founding soils for small projects, as mentioned above, will often not include laboratory testing undertaken due to financial constraints. Therefore, classification according to this standard is commonly undertaken based on in-the-field logging and testing.

This lack of requirement for consistent verification by a governing body is unique to the geotechnical field and the practice of laboratory supported assessment is typically only applied for larger projects where the project budget allows for this to be undertaken. Although laboratories without accreditation exist, IANZ accredited laboratories are typically preferred in New Zealand. IANZ acts as an agency for the majority of accredited laboratories in New Zealand ranging from food to material testing. As part of the accreditation process, the laboratory must prove competence of the specified test method both internally and externally. In order to prove that the laboratory is in line with other laboratories in a given test, 'interlabs' are undertaken between laboratories. This process is undertaken according to the standard ISO/IEC 17043:2010, which is discussed in further detail below.

2 METHOD FOR TESTING

2.1 ISO/IEC 17043:2010

This standard was prepared by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) to provide guidelines and advice to undertake laboratory proficiency testing to laboratories, accreditation bodies, regulatory bodies and other interested parties. The standard includes procedures to undertake proficiency testing, analysis of results, and guidance on corrective actions for improvement. This standard is commonly used by laboratories in New Zealand to undertake inter-laboratory testing as a component of IANZ accreditation.

Section 4.4, Design of proficiency testing schemes, was used in the design of the proficiency test undertaken in this study. This section outlines procedures for undertaking proficiency testing including instructions to participants, preparation of samples, statistical analysis, confidentiality requirements and reporting. It should be noted that some procedures outlined within this standard were not undertaken such as the formal reporting and corrective action procedures as this proficiency test was undertaken for the purpose of study as opposed to regulatory or accreditation purposes.

2.2 NZGS PLASTICITY CLASSIFICATION

Field soil classification by New Zealand geotechnical engineers and geologists is typically undertaken in reference to the ‘Field Description of Soil and Rock: Guideline for the classification and description of soil and rock for engineering purposes’ (NZ Geotechnical Society, 2005).

This guideline provides direction for the logging of plasticity where three categories are described: highly plastic, low plasticity, and non-plastic. Highly plastic material is described as a soil that can be moulded or deformed over a wide range of moisture contents and show no signs of ‘quick’ or dilatant behaviour. Inversely, low plasticity material remains malleable over a small range of water contents and can show quick or dilatant behaviour. Although not noted in the NZGS guideline, non-plastic material is interpreted as not showing any signs of cohesion at any moisture content and cannot be moulded into a 3mm thread (as outlined in NZS4402:1986 test 2.3). This description of plasticity is similar to the description of the plasticity index, defined as the range in moisture contents in which the soil displays plastic behaviour. Therefore, field logging to this guideline should estimate the plasticity index of the soil, although whether this is widely adopted is unknown. This would seem reasonable as the estimation of other characteristics on site, such us liquid limit, is not practical.

Although this guideline specifies three categories of plasticity (non, low and high) it is very common that soils are logged with intermediate categories such as moderately plastic. This is commonly divided further into borderline categories such as low to moderate plasticity typically representing a high end low plasticity soil or low end moderate plasticity soil. This is typically adopted as the plasticity classes outlined in the NZGS guideline are viewed as being too coarse for the soils usually encountered. This appears reasonable as, based on the authors experience, many soils within the Auckland region fall between low and high plasticity and are logged as moderately plastic. It should also be noted that other standards globally include intermediate categories and Casagrande (1948) recommended intermediate categories be adopted.

The objective of this study is to explore variance in logging across multiple consultants and therefore intermediate categories of plasticity were accepted. This addition of intermediate categories allowed participants to refine their opinion of the sample’s plasticity.

2.3 AS 2870:2011 SITE SOIL CLASS

This standard has been prepared by Standards Australia Committee BD-025 for the purpose of providing specific performance criteria and specific designs for footing systems in relation to ground expansitvity. This is commonly adopted by structural engineers within the Auckland region to assist in their foundation design and as such, geotechnical professionals are commonly requested to provide site soil classes.

Site soil classes are defined using characteristic surface movement, which is the expected movement when changing from wet soil conditions to dry soil conditions. These categories are detailed in Table 2.3 within AS 2870:2011 and are shown in Table 1 below.

Table 1: Classification by characteristic surface movement

Characteristic Surface Movement, y_s (mm)	Site Soil Class
$0<y_s\leq20$	S
$20<y_s\leq40$	M
$40< y_s\leq60$	H1
$60< y_s\leq75$	H2
$y_s>75$	E

The characteristic surface movement is estimated by undertaking the procedure described in section 2.3 of AS 2870:2011. AS 2870 provides typical values to be adopted for factors such as H_s (depth of design suction change) and Δu_s (change in suction at soil surface) dependant on site location. The instability index, I_{pt}, is determined by modifying the shrinkage index, I_{ps}, by a lateral restraint factor, α (typical values are given within section 2.3).

The shrinkage index can be determined via three methods. Laboratory testing undertaken in accordance with AS 1289.7.1.1, AS 1289.7.1.2, and AS 1289.7.1.3 directly determines the shrinkage index. The shrinkage index can also be determined through correlations with other related laboratory tests such as Atterberg limits and linear shrinkage. Finally, the shrinkage index can be determined in the field by a suitably qualified and experienced person, which is the method explored further in this study.

2.4 TESTING PROCEDURE

Eleven offices across seven companies agreed to participate in the proficiency test; Riley Consultants (Auckland and Christchurch), Tonkin+Taylor Ltd (Auckland and Christchurch), ENGEO (Auckland and Christchurch), KGA Geotechnical (Auckland and Christchurch), Engineering Geology (Auckland), Lander Geotechnical (Auckland), and Geocivil (Whangarei). Participating offices were each assigned a randomly generated company number and participants within companies were also designated numbers in order to provide the anonymity.

Two soil samples were prepared for logging by each participant. Sample 1 was sourced from the Hamilton region and was of the Walton Subgroup. Sample 2 was sourced from the greater Auckland region and was of the Waipapa Group. Where possible, each participant was provided with an individual sample for logging to attempt to maintain uniform moisture content between each participant. Each sample was requested to be logged for plasticity according to the categories shown above, and the site soil class according to AS 2870:2011. The two soil samples were also sent to a laboratory for Atterberg limit and linear shrinkage testing.

Following testing, the results were processed and a copy of the tables and graphs shown below were provided to each of the participants to assist in identifying whether further training is required.

3 RESULTS

3.1 ANALYSIS PROCEDURE

The results were collated and tabulated in order to determine average values and standard deviations for each company and for the entire sample. In order to present and statistically assess the results, the categories were assigned numbers ascending with plasticity or soil class, therefore assigning equal weight to each classification. The results for both plasticity logging and site soil class classification were graphed to provide a visual representation of results.

3.2 LABORATORY RESULTS AND CLASS DETERMINATION

The samples were sent to a material testing laboratory for Atterberg limit and linear shrinkage testing. Sample 1 returned a liquid limit of 55%, a plastic limit of 21%, a plasticity index of 34%, and a linear shrinkage of 12%. Sample 2 returned a liquid limit of 45%, a plastic limit of 28%, a plasticity index of 17% and a linear shrinkage of 10%. From my interpretation the results categorise samples 1 and 2 as moderate and low or low to moderate plasticity respectively.

The site soil class according to AS 2870:2011 was assessed utilising the laboratory data and the correlations outlined in the 2008 BRANZ report ‘Addendum study report: soil expansivity in the Auckland region’ produced by Fraser Thomas Ltd. This report provides guidance in assessing the site soil class in accordance with AS 2870:2011. Both samples were assumed to originate in the Auckland region and have a typical suction value for Auckland soils. From this H_s was assumed to be 1.5m and Δu_s was assumed to be 1.2pF. The shrinkage index, I_{ps}, was assessed through correlations between linear shrinkage, liquid limit, and plasticity index shown on page 42 and 43 of the BRANZ report (Fraser Thomas Ltd, 2008). These correlations returned values of the shrinkage index as 2.15% and 1.9% for samples 1 and 2 respectively. Applying the aforementioned parameters into the characteristic surface movement formulae and correcting for restrained height and a 1/50 year design return period, resulted in movements of 42mm and 37mm for samples 1 and 2 respectively, which corresponds to class M-H and class M.

3.3 PROCESSED RESULTS

Forty eight responses were returned across the eleven participating offices. These responses were processed using the procedure described above and are shown in the tables and graphs below.

Table 2: Sample 1 Summary of Results

	Plasticity											
	Company											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Participant 1	LM	M	L	LM	L	MH	M	L	L	M	MH	
Participant 2	MH	LM	MH	L	L	N	H	M	M	M	M	
Participant 3	LM	M	L	M		MH	H	N		LM		
Participant 4	LM	L	M	LM		L	L	LM		M		
Participant 5	LM			MH			LM			M		
Participant 6	LM			M			LM					
Participant 7	L			M								
Participant 8	M											**Total**
Average (Class)	LM	LM	LM	M	L	LM	M	L	LM	M	M-MH	**LM**
Standard Deviation (No. Classes)	0.8	0.8	1.3	0.9	0.0	2.1	1.5	1.5	1.0	0.4	0.5	**1.3**
					Measured Plasticity Index (%)			34		**Inferred Plasticity Class**		**M**
AS2870												
Participant 1	S	H1	M	M	S		M	M				
Participant 2	M	M	H1	M	S		M	M				
Participant 3	M	S	M	M				S				
Participant 4	M	M	M	M				M				
Participant 5	M			H1			M					
Participant 6	M			H1			S					
Participant 7	S			S								
Participant 8	M											**Total**
Average (Class)	M	M	M	M	S		M	M				**M**
Standard Deviation (No. Classes)	0.4	0.7	0.4	0.6	0.0		0.4	0.4				**0.6**
	Measured LL (%)		55		**Measured Linear Shrinkage (%)**			12		**Inferred Site Soil Class**		**M-H**

Table 3: Sample 2 Summary of Results

	Plasticity											
	Company											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Participant 1	L	L	H	M	NL	M	LM	N	L	LM	MH	
Participant 2	M	M	M	M	NL	L	LM	LM	L	LM	H	
Participant 3	NL	L	H	L		H	M	LM		LM		
Participant 4	L	H	LM	L		N	M	N		LM		
Participant 5	M			M			L			L		
Participant 6	LM			L			L					
Participant 7	L			L								
Participant 8	LM											**Total**
Average (Class)	LM	M	MH	LM	NL	LM	LM	L	L	LM	MH-H	**LM**
Standard Deviation (No. Classes)	1.0	1.7	1.3	1.0	0.0	2.2	0.8	1.5	0.0	0.4	0.5	**1.5**
					Measured Plasticity Index (%)			17		**Measured Plasticity Class**		**LM/L**
AS2870												
Participant 1	M	M	H1	H1	S		S	S				
Participant 2	M	M	M	M	S		S	S				
Participant 3	S	M	H1	S				M				
Participant 4	S	S	M	S				S				
Participant 5	M			H1			H					
Participant 6	M			S			S					
Participant 7	S			E								
Participant 8	S											**Total**
Average (Class)	S-M	M	M-H1	M	S		S	S				**M**
Standard Deviation (No. Classes)	0.5	0.4	0.5	1.4	0.0		0.0	0.4				**0.9**
	Measured LL (%)		45		**Measured Linear Shrinkage (%)**			10		**Inferred Site Soil Class**		**M**

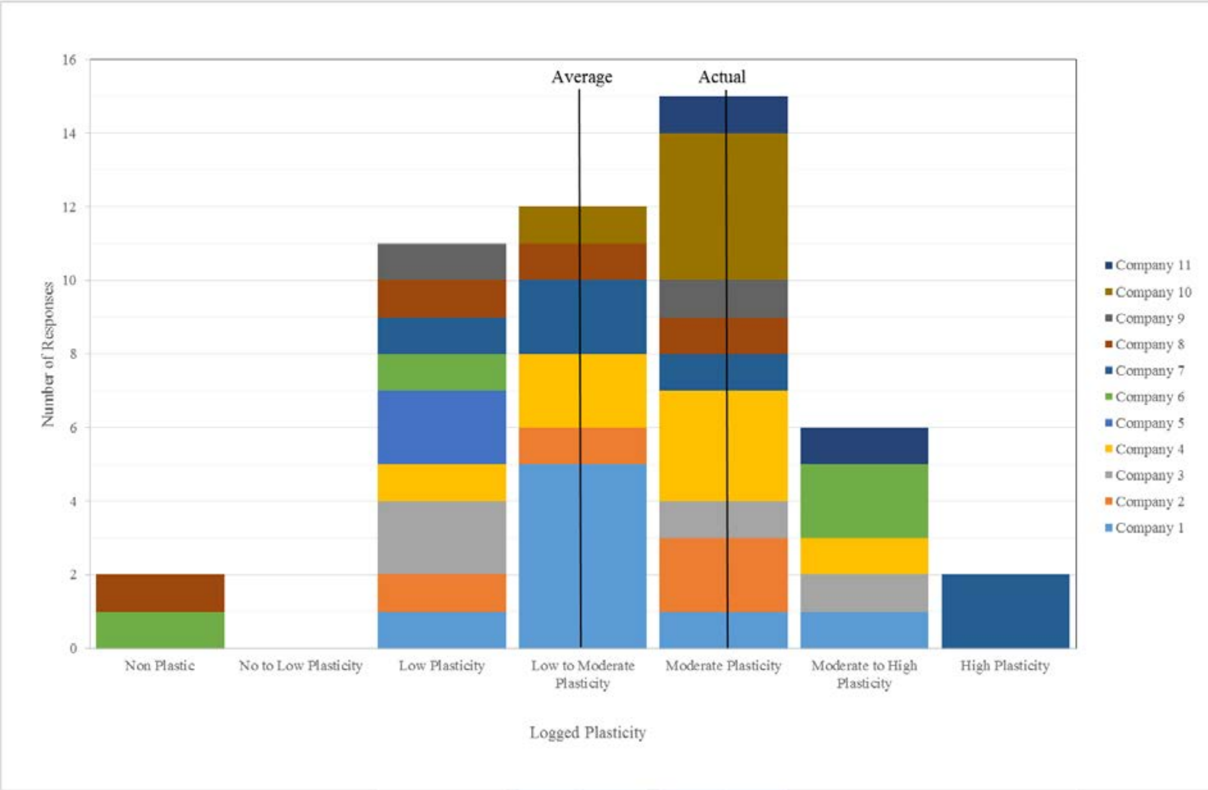

Figure 1: Sample 1 Plasticity Logging

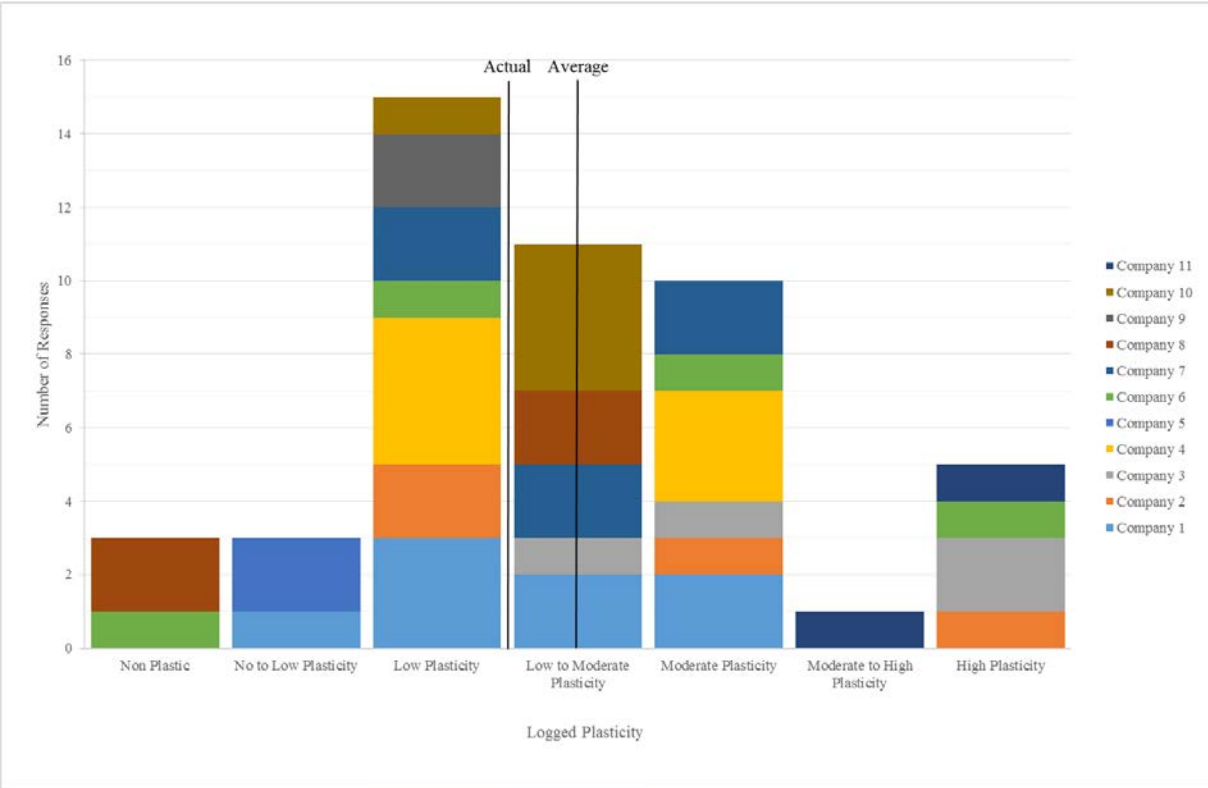

Figure 2: Sample 2 Plasticity Logging

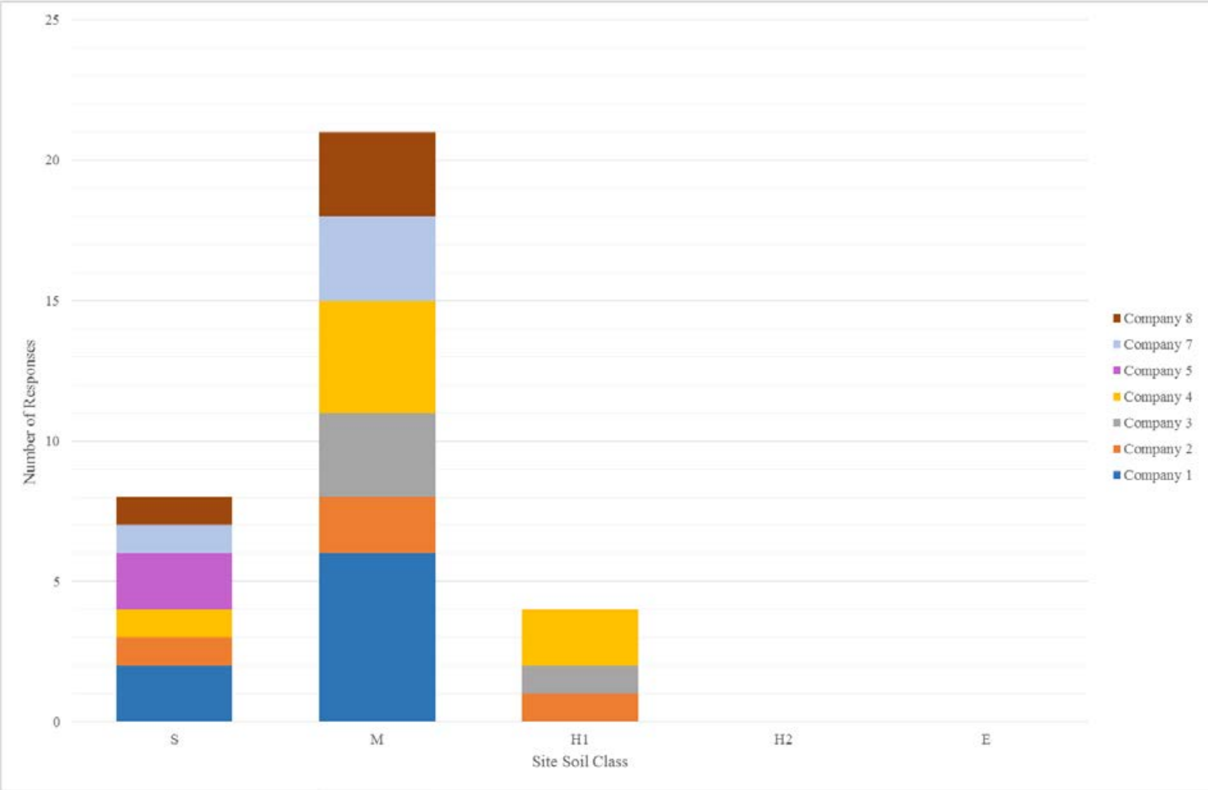

Figure 3: Sample 1 AS 2870 Classification

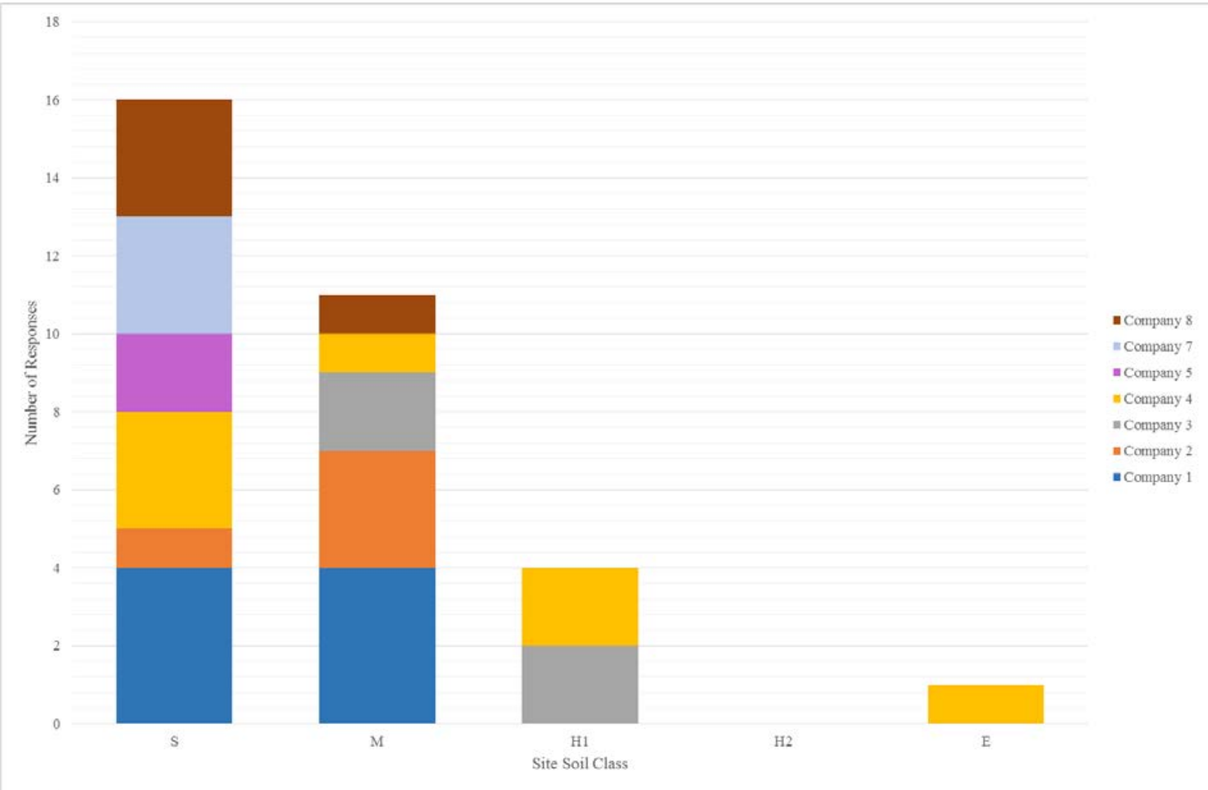

Figure 4: Sample 2 AS 2870 Classification

The average response for sample 1 was low to moderate plasticity with a standard deviation of 1.3 classifications. The average site soil class classification was class M, moderate expansivity.

The average response for sample 2 was low to moderate plasticity with a standard deviation of the responses calculated to be 1.5 classes. The average site soil class classification was class M, moderate expansivity.

Site soil class classification was not undertaken by companies 6, 9, 10, and 11 as they were not familiar with this standard.

The processed results show a large variance in the extremes in the logged plasticity for both samples. Both samples were logged as having plasticity ranging from non-plastic to highly plastic; 8% and 17% of the respondents returned results at the extremes for samples 1 and 2, respectively. The average response for sample 1 was one category lower than the laboratory determined result (actual); which is close to one standard deviation lower than the actual. The average response for sample 2 was closer than sample 1 actual, however, the variation in the responses was greater.

The actual plasticity classification for sample 1 (moderate plasticity) was classified by 31% of respondents and 69% of responses were within one classification of the actual value. As such, 31% of responses were more than one classification from the actual result, where the most populous response was low plasticity contributing to 22% of the total. 52% of responses were lower than the actual result whereas 17% were higher than the actual.

The actual plasticity classification for sample 2 (low and low to moderate plasticity) was classified by 58% of respondents. 13% of responses were lower than the actual plasticity in contrast to 33% that were higher than actual.

4 DISCUSSION

4.1 PLASTICITY

The results for plasticity logging showed a large variance in responses for both samples. This could be due to a number of factors including definition of the plasticity classes, sample condition, differences between field based logging and the laboratory testing method, and personal and internal company bias. For sample 1 the plasticity was generally underestimated whereas it was generally overestimated for sample 2.

The standard deviation in responses for both samples is greater than 1.0 which indicates a lack of logging consistency. This indicates that the majority of responses would be spread across two to three plasticity categories. From this the likelihood that two geotechnical professionals would have differing opinions on the plasticity of a sample is high. This has the potential to materially affect recommendations that are based on the logged plasticity.

Individual uncertainty was shown through variable results within a company. Company 6, for example, returned results ranging from non-plastic to highly plastic for sample 2, which indicates that companies with high variability in their results may benefit from further exposure to this type of procedure.

The average standard deviation within companies was 1.0 and 0.9 classifications for samples 1 and 2 respectively. This variation is lower than that of the entire study where standard deviations of 1.3 and 1.5 classifications were calculated for samples 1 and 2 respectively. This indicates that there may be specific bias on a company by company basis. This was expected as most internal training is undertaken by in house senior staff deemed to have the most experience, and perceived to log correctly consistently. As such, all staff trained within a company adopt the logging tendencies of those that trained them. Also, company to company variability could be influenced by the scale of jobs undertaken by the company. Large scale jobs individually require a large amount of investigation typically across limited geological units and site sizes. In conjunction with the large time investment required for these jobs, geotechnical professionals assigned to these jobs may not receive the variety of samples to log as those who typically undertake a large quantity of small developments.

The condition of the samples is believed to have influenced the variability of the results. Sample 2, in particular, was over-saturated during the sample preparation and was above the soils liquid limit. Participants who logged plasticity as the classification at current moisture content would incorrectly classify this material as non-plastic as at the received moisture content the material does not display plastic characteristics. This is not a correct methodology of determining plasticity as this is defined as the range of moisture contents in which the soil displays plastic behaviour. Similarly, many respondents classified Sample 2 as highly plastic, potentially due to the moisture content being greater than the liquid limit. Potentially these respondents accounted for the excess moisture content (above liquid limit) in their plasticity classification. This excess moisture should not be accounted for in the determination of plasticity as, theoretically, soil does not show plastic characteristics at moisture contents greater than liquid limit. Sample 1 was also pumiceous in minerology, which potentially caused some difficulty in logging.

The definition of soil plasticity classes are not clearly defined in terms of the plasticity index. Typically the Casagrande (1948) plasticity chart is used to classify and support on-site classifications where it is not uncommon for these to differ. For example, laboratory results for the samples used in this study are placed within classes CH and ML for samples 1 and 2 respectively. A common misconception is that the L and H in the classifications represent low and high plasticity, however, Casagrande (1948) and ASTM D2487 use L and H in reference to liquid limit. Additionally, the applicability of the Casagrande chart in classifying soils on the Auckland region is uncertain. A paper exploring this titled 'The Casagrande plasticity chart: does it help or hinder the NZGS soil classification process' (Hind, 2017) shows that although soils within the Auckland region are predominantly silt-dominated, the results plot on the Casagrande chart above the A-line and would be classified as high plasticity clays. This makes confirmation of in-field plasticity classifications by laboratory testing very difficult. A detailed study into plasticity classification and plasticity index with a New Zealand context would be beneficial to assist comparison between laboratory results and logged plasticity. From this, a plasticity chart could be formulated to provide guidance on plasticity classification.

This uncertainty in plasticity classification with respect to plasticity index causes an additional point in subjectivity as each individual and company is required to define their own classification ranges. This effect becomes evident when comparing the results from companies 1, 4 and 10. These data sets have a relatively low variability and show the overall classification tendencies of the companies. Company 1 generally underestimated plasticity with an average logged plasticity of low to moderate. Comparing this to Company 10, which have a logged plasticity of moderate, could suggest there is some uncertainty as to where the plasticity divisions are situated in relation to plasticity index. In this example, Company 1's plasticity divisions correspond to higher logged plasticity indexes than are assumed in this study (e.g. Company 1's low-moderate boundary could correspond to the moderate plasticity boundary).

The Atterberg limits tested by the laboratory are undertaken in accordance with NZS 4402:1986 tests 2.2, 2.3 and 2.4. Where significant portions of material greater than 425μm are present within the sample, preparation according to this standard requires sieving to remove oversized particles. Testing is then undertaken on the sieved sample. The laboratory tested sample therefore differs to that logged in the field. Theoretically the liquid limit on the laboratory tested sample would increase and the plastic limit would decrease. This would inflate the plasticity index and hence plasticity classification. The magnitude of this effect is not known and a future study could be undertaken to quantify this.

4.2 SITE SOIL CLASS

The classification of site soil class according to AS 2870:2011 showed some variability across both samples; however; to a lesser degree than the plasticity classification as shown by the lower standard deviations for both samples. The variation of this classification does not reflect the variation in plasticity logging. The median response for both 1 and 2 was site soil class M, although the most common response for sample 2 was class S. The site classes determined through laboratory results were M-H and M for samples 1 and 2 respectively and as such results indicate that typically, as an industry, we slightly underestimate soil reactivity. This underestimation could mean that foundations are under designed for soil expansivity.

Similarly to the plasticity classification, the average standard deviation within companies is less than that of the overall sample. This suggests that there is a company bias in the determination of the site soil class. This is understandable as the site determination of soil class is similar to that of plasticity and training is provided by the more experienced staff members.

This result may be skewed by the reduced sample size, as companies situated outside of Auckland are not commonly requested to provide recommendations as per AS 2870. There is also a possibility that some of the participants were not aware of this standard, however, attempted this classification regardless. Additionally, the origin of the samples were not given to the participants and were assumed to be of Auckland origin (when sample 1 is from Hamilton). This also potentially skewed the results as the minerology of the material was not advised to the participants.

4.3 PROFICIENCY TESTING

Proficiency testing enables the assessment of variability in test methods that require judgement without access to quantitative metrics. When used, it can provide a check/test of the consistency by which companies internally undertake non-quantitative assessments and the consistency/inconsistency across the industry as a whole. Periodic proficiency testing can assist with the identification and correction of assessment habits/trends within companies and across the industry and has the potential to add more consistency industry-wide.

Whilst quantitative field and laboratory testing provides the primary basis for most analysis, and recommendations, qualitative assessments, such as soil and rock descriptors, relative composition, plasticity, and moisture content, provide valuable information that is used in making these decisions and recommendations. The author is aware that there have been disputes and litigation where the basis of the claims has been the reliance on qualitative assessments recorded on borehole and test pit logs and referenced in reports. In this regard, proficiency testing can provide a valuable quality assurance process and a means of assisting risk management for companies.

In addition, this proficiency testing has potential benefit to the client, as it can provide increased confidence in the quality of the results. Although the exact performance of each company involved in a proficiency testing programmes is kept anonymous, the assumption is that improvement is desired by all participants to achieve consistency. This added assurance grants increased confidence when reviewing logged information from other consultants. Increased confidence of qualitatively assessed properties has the potential to decrease the amount of field investigation required on sites where investigation has already been undertaken.

The variability in the results from the study suggest that proficiency testing undertaken by a governing or technical body (such as NZGS) on an annual basis would be beneficial to increase consistency across the industry. The study results suggest that for the soil characteristic of plasticity chosen for the study, proficiency testing would be of value. Similarly, it could be applied to other qualitatively assessed soil characteristics. The role of the proficiency test operator could also be expanded to define and enforce performance criteria and non-conformances.

Feedback from the study participants indicated some changes could be made for future proficiency tests. The samples used could be more common to those typically logged in the Auckland region (such as East Coast Bays). This would show a more true indication of a participant's opinion on logged plasticity through the increased experience with this material. Additionally, it would be beneficial to undertake hydrometer testing on the logged soil samples to determine the soil gradation and to give context to the Atterberg limit tests.

5 CONCLUSION

Forty eight participants, from eleven offices, across seven companies participated in a soil plasticity logging proficiency test undertaken in accordance with ISO/IEC 17043:2010. Two samples were prepared to be logged by each participant for plasticity (with guidance from NZGS) and site soil class classified as per AS 2870:2011. The soil samples were also sent to a laboratory for Atterberg limit and linear shrinkage testing to assist in classifying plasticity and site soil class.

The results were processed into their corresponding plasticity indexes in order to undertake statistical analysis. The results showed a large variability across the study group where both sample 1 and sample 2 received responses in the extreme classifications (non-plastic and highly plastic). The average response for sample 1 was low to moderate plasticity, which was lower than the actual plasticity determined to be moderate and was generally underestimated. Inversely, the average response for sample 2 was low to moderate, which was higher than the actual plasticity index of between low and low to moderate, and was generally overestimated. The data sets were also highly variable where the standard deviation was 1.3 and 1.5 classifications for samples 1 and 2 respectively. Despite this, the site soil class classification was more consistent where the median result for both samples was class M. The site soil class, determined through correlations to laboratory test data, was class M-H and class M for samples 1 and 2 respectively. The logged site soil class is close to the laboratory determined class, however, is slightly lower on average.

The results for plasticity logging showed a large variance between responses for both samples. This could be due to a number of factors including, individual and company bias, definition of the plasticity classes, sample condition, and differences between the laboratory testing method. The logged plasticity classes (low, moderate, high) do not have clear boundaries with respect to plasticity index. Additionally the Casagrande chart does not classify soils in relation to plasticity index, rather liquid limit. It would be beneficial for the future consistency of logged results and laboratory comparisons that a study is undertaken to determine appropriate classifications in relation to plasticity index in a New Zealand context. From this a plasticity chart can be formulated to provide guidance on plasticity classification.

The variability in the results would suggest that proficiency testing undertaken by a governing or technical body (such as NZGS) on an annual basis would be beneficial to increase consistency across the industry. Proficiency testing ultimately leads to increased consistency, both within individual companies and across the industry as a whole. With increased consistency, certainty of the validity of results increases potentially providing enough confidence to provide recommendations utilising logged data from other consultants.

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