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# Maximising geotechnical data and characterisation of critical units through targeted field work

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## Abstract

*Identification and investigation of weak geological units and structures is an important component of a slope design. Such units and structures are highly prone to weathering and typically exhibit lower shear strength than the surrounding rock mass. These units are inherently problematic to obtain quality geotechnical data from due to their fragile nature and often limited frequency. It is therefore essential that a data collection campaign is designed and implemented with the view of collecting maximum quality and representative data from these units. Samples with minimised disturbance from diamond drill core provide a valuable insight into the in situ ground conditions of these units. This method of data collection requires good quality drilling and early identification of weaker units to maximise recovery. Careful handling, correct sampling and transport procedures to enhance preservation of the core until geotechnical laboratory test work can be undertaken are equally essential. It should be ensured that samples are preserved in their in situ conditions prior to arrival at the testing laboratory. Consideration needs to be given to communication between all personnel, early identification of critical weak units, timing of logging and sampling and sample transportation and storage. This paper aims to provide a methodology for sampling of such materials, building on the knowledge of the current standards and best practice benchmarked with other industries. The ultimate result is the ability to collect and preserve a higher quantity and quality of samples of weak material critical to slope stability. With increased sampling from weaker units, it is possible to rely more on results of laboratory testing and reduce reliance on empirical methods for shear strength characterisation. This provides increased confidence in the geotechnical model and ultimately slope design.*

## 1 Introduction

Depletion of near surface ore is encouraging mining companies to design and excavate larger and deeper open pit mines. This has resulted in the need for greater slope heights, and with ever increasing economic pressure to reduce mining costs, the boundaries of slope design are being stretched to reduce strip ratio. The optimisation of slope angles requires a thorough understanding of the risks and uncertainties associated with the geotechnical model.

Any design has its limitations in that it is only as strong as its weakest component. If confidence in the data is low, uncertainties will arise in the geotechnical model. The design will therefore account for this uncertainty with conservatism. The key controlling parameters within a slope design are the strength of the rock mass and the orientation and nature of the structures within the rock mass. Where weaker horizons are present they can significantly reduce the overall strength of the rock mass within the slope.

Failure of slopes within an active mining environment can have severe negative implications with regard to health and safety, production and ultimately mine life. A failure, regardless of size, has the potential to damage equipment, harm or have fatal consequences to personnel working in an open pit. Identification of areas with an elevated risk of failure, and the communication of geotechnical hazard identification and slope failure procedures throughout the workforce, can reduce the consequence of instabilities. If the location and magnitude of a failure results in the sterilisation of a working or future working face, production will be impacted and significant clean-up costs are likely to be incurred.

With the above considered, if weak units are known to be present, it is essential that during the investigative phase of a geotechnical design process, such units are characterised accurately as reasonably practical, so that their effects on slope stability can be quantified. Herein lies the difficulty, as it is problematic to obtain quality geotechnical data from weak critical units due to their fragile nature. It is therefore essential that a data collection campaign is designed and implemented with the view of collecting maximum quality data that is representative of these units.

This paper aims to provide a procedure for the logging and sampling of such materials, building on the knowledge of the current standards and best practice, benchmarked against other industries. The ultimate result is the ability to collect and better preserve a higher quantity and quality of samples of weak material critical to slope stability. With increased successful sampling from weaker units, confirmatory laboratory testing can support data collected from the field, increasing confidence in the interpreted material properties and facilitating a more robust slope design.

The authors' experience of sampling weak units is from the Pilbara region of Western Australia, where shale bands are interbedded with more competent Banded Iron Formations (BIF). Their work involved rig side geotechnical core logging, sampling and field testing to characterise the materials that were encountered and to assist with the geotechnical design of a proposed open pit.

# 2 Engineering implications of weak geological units

Weak materials can arise from a number of geological processes; diagenesis, metamorphism and deformation and subsequent weathering and alteration. Hydrogeological conditions also influence the engineering properties of geological units.

The degradation of material strengths is often a product of either weathering, rock type and its composition and or geological conditions. Clay minerals are the most common products of chemical weathering and are present in almost all sedimentary rocks. The depositional environment of clay minerals will govern the lateral extent and thickness of the beds formed. During diagenesis, sediments will become compacted and free water will be expelled; mudrocks and shales will form. Individual clay minerals are composed of flat sheets. The resulting defect plane shear strengths are a reflection of the degree of induration (bonding and cementation) and the subsequent rebound history of the unit (Cripps and Taylor, 1981). In folded environments, undulation of defect planes (e.g. bedding) can influence the strength of both the defect plane and rock mass.

Weathered rocks are often open textured, weakly bonded and or micro-fractured. The behaviour of weathered rocks is often sensitive to disturbance during sampling, changes in temperature and moisture content. On exposure and wetting many types of soil-like material will disintegrate (slake) while for other materials the loss in suction forces may cause a significant reduction in strength. Other rocks, particularly mudrocks or residual soils rich in expandable clay minerals, may have significantly as they absorb water (Hencher and McNicholl, 1995). Weaker units can often behave like a soil if the degree of weathering and alteration has decreased the intact strength to that of a soil. Where thicknesses of such material are significant, stability may be influenced by circular failure modes, along with the potential for planar failure along relic discontinuities.

Rock mass strength is a measure of both intact rock strength and discontinuity shear strength. For a horizon in the rock mass to be described as critical for stability, where the slope geometry permits, it must have substantially weaker geomechanical properties than the surrounding rock mass. It therefore becomes a preferential plane of weakness along which slope failure may occur. The presence of a significant structure in an isotropic rock mass, such as a weak shear or fault zone, will allow ingress of water which can accelerate weathering. This results in a marginal zone around the structure with a clay-rich composition due to greater degrees of weathering than the surrounding rock mass. If preferential weathering of weaker units occurs beneath more competent beds, undermining of the overlying material can lead to unravelling, blockfall or toppling instability if the slope and discontinuity geometry permits.

A bedded stratigraphy, such as BIF, often comprise of strong competent silica-rich beds and softer shale or clay-rich beds. The Hamersley Group in the Pilbara region of Western Australia is an example of such stratigraphy. Here, BIF's are present with shale bands at discrete horizons. These beds of shale can vary in thickness between the centimetre scale to the metre scale. In this example, the BIF is the competent non−shale unit, with weaker clay-rich shale bands present between beds.

# 3 Challenges of investigation

Geotechnical data for open pit studies is often obtained from rock core by diamond drilling techniques. Drilling, logging and sampling of weak and highly weathered material can be problematic due to its fragile nature. Good recovery of intact drill core of weak units, especially when intercalated with more competent materials can be difficult to achieve.

There is potential for drill core to lose or gain moisture upon exposure to the surface environment following drilling. A change in moisture content can affect the strength, increasing the susceptibility to slaking and degradation. The time between exposure and data capture can influence rate of degradation of the drill core. Incorrect handling techniques can accelerate mechanical damage to the drill core. During transport, drill core samples can also fracture reducing the strength properties of the material. Prolonged storage can cause drill core to degrade over time if not adequately protected from the elements.

The following international standards have been developed for geotechnical site investigations and the preservation and transportation of both rock and soil samples:

- American Society for Testing and Materials (ASTM):
  - D5079 - 08 (ATSM, 2008) – standard practice for preserving and transporting rock core samples

    *"If engineering properties are to be determined for the core, it must be handled and preserved in such a way that the measured properties are not significantly influenced by mechanical damage, changes in chemistry, and environmental conditions of moisture and temperature, from the time that the core is recovered from the core drill until testing is performed."*

    This standard covers the preservation, transportation, storage, cataloguing, retrieval and post-test disposition of rock core samples obtained for testing purposes and geologic study.
  - D4220 - 95(2007) (ATSM, 2007) – standard practices for preserving and transporting soil samples

    This standard covers procedures for preserving soil samples immediately after they are obtained in the field and accompanying procedures for transporting and handling the samples. The standard lists four levels of sample protection: routine care, special care, critical care and soil like care.
- Australian Standard:
  - AS 1726-1993 (Standards Australia, 1993) – geotechnical site investigations

    'This standard sets out minimum requirements for a geotechnical site investigation, as a component of the engineering design, construction, commissioning and operating of civil engineering and building works.'

    'The applications of this standard include the assessment of natural or filled ground, new construction, maintenance of existing facilities, the evaluation of post construction performance and the assessment of failure.'

    The standard does not specify sampling methods.

- International Society for Rock Mechanics (ISRM, 1978):

  Suggested methods for the quantitative description of discontinuities in rock masses best practice guidelines providing standardised classification of rock mass properties.

To be able to obtain the best representation of the in situ ground conditions, minimal disturbance to the cored material is required. This can be achieved with thorough planning and good drilling techniques followed by the careful handling, logging, sampling, transport, storage and preservation of drill core. The following sections detail a case study outlining a practical approach that builds on the current standards and their applicability to critical units.

# 4 Case study

The following case study describes methodologies that can be applied to investigations in any weak rock mass.

## 4.1 Project management

For any project to be successful the aims and objectives of the project should be defined at the outset. This is not limited to the logistical, managerial or financial aspects of the project, but also the technical issues. Good communication of the technical aims between all parties is paramount for the successful execution of the programme; all personnel involved should have a thorough understanding of what data is required and the importance of the integrity of the data. The quality of a project can depend on time and budget constraints. The budget should allow for minor delays with drilling; drilling through weak ground is often slow in order to achieve the highest quality of core possible. Drilling contracts should be focused to bring emphasis from quantity of drill core to technical quality (e.g. recovery of intact core). Drilling on a day rate can assist with this. While there may be a balance point between reasonable expenditure and the point of diminishing returns, where possible, data integrity should not be sacrificed to save time and money.

## 4.2 Drillhole design

The initial drillhole design can influence the success of the data collection. Ideally a detailed geological and structural model (based on previous RC and diamond drilling) should be provided by the client. Existing geotechnical data from previous drilling should be also be reviewed and assessed to allow critical units to be identified. When targeting critical units, drillholes are to be angled sufficiently to allow core orientation and be aimed to drill perpendicular to the primary fabric (e.g. bedding). A small minority of drillholes should be aimed to drill parallel to bedding to investigate the presence of structures orientated orthogonal to bedding. Note that drilling down-dip of bedding can often result in drilling difficulties in strongly bedded units and can result in the core being severely damaged. Consideration should be given but not limited to: topography, lithology, geological structures such as folds, jointing and faulting, weathering, groundwater and surface water, to best target drillholes to maximise the data collection. Best practice guidelines presented in Chapter 2 of 'Guidelines for Open Pit Slope Design' (Read et al., 2009) should be followed.

## 4.3 Personnel

A number of personnel over many disciplines, with varied skills and experience will be involved in a drilling programme. All personnel are to be suitably qualified or experienced for their respective roles. Communication between all involved personnel is essential for a productive and efficient programme. Daily meetings between field crew should take place to ensure all parties are informed of any issues and information is distributed accordingly. A summary of the various staff and a typical overview of their roles is presented in Table 1.

**Table 1 Responsibilities and requirements of personnel involved in drilling programmes**

| Role | Responsibilities | Requirements |
|---|---|---|
| Project Manager | Oversee all aspects of the programme.<br>Conduct audits of geotechnical logging data to ensure consistency between personnel. | Ensure all personnel are aware of their objectives and are working within budget and on schedule. |
| Drilling Crew | Extracting drill core from the ground.<br>Provide feedback on ground conditions during drilling. | Employ suitable techniques for recovering weak material.<br>Good communication between geologists and geotechnical engineers. |
| Geotechnical Engineer/Engineering Geologist | Conduct geotechnical logging and sampling.<br>Conduct field testing.<br>Core photography.<br>Provide drill rig supervision and feedback.<br>Assist with drill core transportation and sample preservation and storage.<br>Schedule samples for laboratory testing and arrange for their rapid dispatch from site. | To be present at drill rig during shift to oversee drilling and core orientation and liaise with drilling crew.<br>Logging and sampling is to be undertaken following all relevant and current standards. |
| Field Technician | Core transportation and storage. | Transport core with extreme care.<br>Ensure core trays are securely fastened and stubs or core are not loose in the trays. |
| Field Geologist | Conduct geological logging and sampling.<br>Daily drill rig inspections. | Good communication between drilling crew and geotechnical engineers. |
| Senior Geologist | Conduct audits of geological logging data. | Good communication between field geologists, geotechnical engineers and drilling crew. |
| Transportation Company | Transport core samples with extreme care and in a timely manner. | Good communication with geotechnical engineer.<br>Ensure samples arrive at destination in same condition as dispatched. |
| Laboratory Staff | Conduct laboratory test work. | Inform project manager of condition of samples upon arrival at the laboratory.<br>Employ suitable core handling techniques. |
| Stakeholder | Finance geotechnical investigation. | Have an understanding of the long–term investment of the project.<br>Understand that data integrity should not be sacrificed to cut costs. |

## 4.4 Core logging

Geotechnical core logging is to be conducted to published current standards, which may be specified by the client (e.g. ISRM). A brief summary of the data collected is given below:

- Rock mass data:
    - lithology
    - degree of weathering and alteration
    - estimated intact rock strength
    - Rock Quality Designation (RQD); and
    - fracture frequency.
- Structural defect data:
    - defect type
    - defect orientation (alpha and beta)
    - orientation reliability
    - defect profile and roughness characteristics; and
    - defect infill type and width.

This data allows the characterisation of the rock mass using empirical methods, such as Bieniawski's Rock Mass Rating (Bieniawski, 1989), Laubscher's Mining Rock Mass Rating (Laubscher, 1990) and Hoek and Brown's Geological Strength Index (Hoek et al., 1995).

In the authors' experience, further steps are required when collecting data from critical units. The following points are made to maximise geotechnical data from such units. They are not intended as an alternative to the standards, but as a method of applying them.

- Rig side logging will assist with full-time supervision of the drilling, in particular the core orientation techniques and marking of the core should be overseen. The careful handling and immediate logging of the core can be observed; extraction of core from the splits is especially critical.
- Triple tube drilling is highly recommended. The geotechnical logging is to be undertaken whilst the core remains in the split (where triple tube drilling is used). This ensures minimal disturbance to the core allowing for a more representative RQD measurement and fracture count. The core is then to be transferred to an appropriate sized core tray and photographed. Samples of drill core identified for geomechanical testing are to be taken at this stage and immediately packaged and sealed ready for transportation. Where the sample is highly susceptible to damages, it should be sampled and photographed immediately from the split.
- Where possible, Optical Televiewer (OTV) and Acoustic Televiewer (ATV) data should be captured upon completion of the drillhole. This should provide a high confidence data set for orientable structures.
- Logging should be performed under shelter from the elements. Drilling locations are often in exposed locations and for logging to take place at the rig side will require some form of temporary tent, shade sail, or gazebo to be erected. This will prevent the core from being exposed to intense UV and light, causing the sample to dry out and deteriorate, or conversely, prevent any precipitation increasing the moisture content. Where there is a backlog of core prior to logging, it is to be stored under shelter or suitably covered. The use of damp towels should be considered as a cover for the core trays. All samples packaged for laboratory testing are to be stored with adequate protection from the elements also.

- Where 24 hour drilling is carried out, logging and rig supervision should provide full coverage. If full coverage cannot be provided, then the core is to be stored as outlined above.
- It is highly recommended that all data is captured electronically on to a ruggedised laptop. This will allow for back-ups of data, facilitate data validation, remote auditing and prevents later manual entry of data, reducing the risk of human error.
- Geotechnical field staff are to be familiar with the materials expected to be encountered in the programme. They should be aware which materials are most susceptible to mechanical damage and changes in environmental conditions, so they can prioritise the logging and sampling of these materials. They are to be aware of sampling requirements in terms of minimum sample sizes and project specific requirements and understand the necessity for quality sample preservation.
- Regular audits by a senior geotechnical engineer are to be undertaken. These audits would include an assessment of the sampling preservation techniques undertaken by the field staff. The quantity and quality of samples would be reviewed against the sampling requirements specified at the commencement of the project. The field crew should submit (electronic) copies of the logging data with core photographs for auditing on a regular basis to enable feedback to be reported back in a timely manner. Site audits should also take place periodically (preferentially on a shift handover day so that all logging personnel are present) where lengths of core are laid out and any queries by any party can be clarified. Site geologists should also be present.

## 4.5 Sample collection and testing

Laboratory test work on samples of core is an important source of data to confirm and compare with data obtained in the field. Test work is to be undertaken in controlled conditions to the appropriate standards at a suitably accredited laboratory. Laboratories certified to conduct test work are often located a significant distance from the location of the drillhole. To ensure that the samples remain as close to the in situ conditions as possible, sample preservation during transportation is essential. The core must be handled in such a way that properties measured by laboratory testing are not significantly influenced by mechanical damage, changes in chemistry and environmental conditions such as temperature and moisture, from the time the core is recovered, until the test work is undertaken.

It is the sampling of these critical units that has historically proven most problematic during many drilling programmes. Due to the fragile nature of the core and the intrusive nature of diamond drilling, the core specimen is prone to mechanical breakage more readily than other units. The below points provide additional considerations to be taken into account with the standard practice guidance for ‘critical care’ sample protection.

- Sampling is to be performed immediately after the core has been logged and photographed, particularly for clay-rich or shale materials. The core is to be stored with suitable shelter up to and during this process.
- The core should not have been removed from the split prior to sampling.
- Close-up photographs of each sample, containing a scale and colour bar are to be taken before handling.
- The core is to be transferred to a PVC split of the same size as the core, where it is then wrapped in gladwrap and foil (wax can also be used). The second half of the split can be used to cover the sample and fastened by tape. This is to be labelled with all the required information for the sample to be clearly identified at a later stage. Bubble wrap is recommended to be used to further protect the sample.
- Once sealed as per the relevant standard and encased in PVC splits, the sample is to be placed in a suitable container or core box that provides cushioning and thermal insulation.

- While the samples remains in the field (until the end of the shift for example), it should be kept under shelter; an insulated storage box (e.g. cool box) can be used. At the end of the shift, the samples should be relocated to a temperature controlled environment (e.g. an air-conditioned office where the temperature is constant). For example, samples taken during contaminated land investigations, where preservation of the (often volatile) contaminant chemicals is necessary, refrigerated containers have been mobilised to site for the sole use of sample storage. This is highly recommended for samples sensitive to changes in environmental conditions, e.g. clay-rich or shale material.
- From the time the sample is drilled and exposed, it will begin to deteriorate. Samples will undergo stress relief due to changes in stress conditions. It is therefore essential that samples are frequently dispatched and submitted for laboratory testing. This may result in added expense for the client, however this is required for sample integrity.
- Samples will spend most time in storage and transportation. As transportation is frequently out of the control of the field crew, it is essential for the sample preparation and storage to be adequate for the distance and time it will take to arrive at the laboratory. Consideration should be given to the method of transport suited to best minimise the disturbance to the samples (e.g. air suspension on vehicles). Alternatively, air freight may be a more appropriate method for greater distances.
- Samples should be safely secured and driving techniques, route and speed are to be adapted to minimise disturbance for the samples.
- Upon arrival at the laboratory, samples are to be inspected and photographed prior to testing. This will allow for comparison to the field sample photographs to assess for degradation.

Field tests are to be undertaken at regular intervals throughout each drillhole. A Point Load Test (PLT) machine should be available for axial and diametric testing of the core at the rig side. This will ensure that the in situ conditions of the rock are captured in the field and can be compared with laboratory data.

# 5 Results

The authors undertook a geotechnical data collection programme in the Pilbara region of Western Australia. During this investigation, it was noted that currently published standards for preserving rock and soil samples did not provide adequate detail for obtaining data on critical units. The methodologies outlined in Section 4 were employed to compliment the standards, with the intention to enhance the quality of the data being collected.

To investigate the success of the procedures outlined above, a data set from the same stratigraphic unit from a previous investigation (data set A) was analysed and compared with the more recent data set (data set B). Data set A was undertaken where drilling practices were not supervised and the additional procedures stated in this paper were not carried out. Data set B was collected implementing the procedures outlined in Section 4.

It should be noted that:

- Only field and laboratory PLT data is presented to allow for an assessment between the conditions of samples in the field at the time of the logging and when they arrive at the laboratory. Other tests (such as direct shear) were performed however only at the laboratory. This prevents an assessment of the degradation of the samples from the field to the laboratory.
- There is a varied number of field and laboratory samples for each data set.
- Field PLT results were limited to the capacity of the field apparatus.
- The laboratory PLT data has potential for sampling bias towards more competent units as length of core for laboratory sample is greater than required in the field.

Figures 1 and 2 present the results of field and laboratory PLT data for each data set.

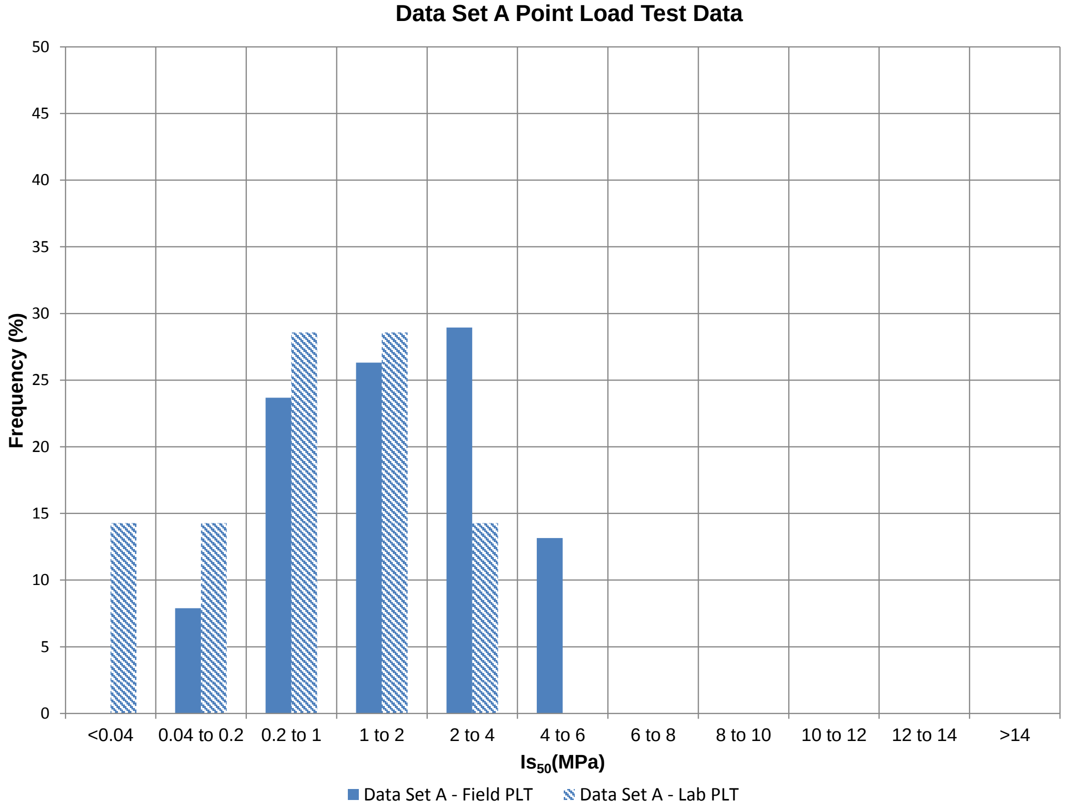


**Figure 1 Data set A PLT results (without additional procedures)**

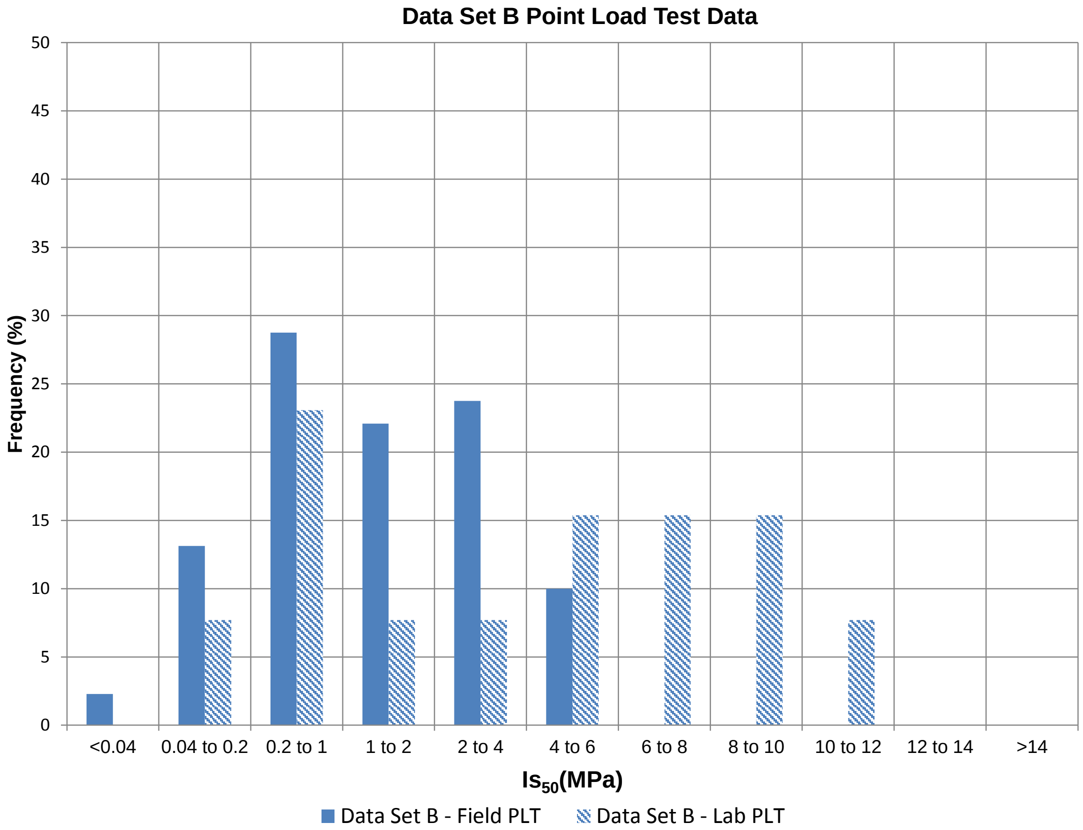


**Figure 2 Data set B PLT results (with additional procedures)**

Figures 1 and 2 show that the field data exhibits similar distributions for both data sets. The mean laboratory result from the distribution shown on the graph for data set A is less than the field data. This suggests that samples have degraded between sample collection in the field and testing at the laboratory. Data set B however, shows an increase in the mean value of the laboratory data, relative to the field data. This could suggest that the original in situ conditions of the samples have been preserved and little to no degradation has occurred during transportation.

Table 2 shows that the laboratory sample frequency per metre for data set A is less than that for data set B. Whilst the geological conditions between the two sets remain similar; the final number of valid tests undertaken at the lab, is a higher frequency per metres drilled for data set B (e.g. a successful laboratory sample was collected every 31.40 m). This is considered to be due the improvements in sample preservation and consequently a higher frequency of quality samples has been taken.

**Table 2 Summary of PLT data**

| Data Set | Laboratory Sample Frequency (per metre) | Source | Mean $Is_{50}$ (MPa) | Standard Deviation (MPa) |
|---|---|---|---|---|
| A | 42.86 | Field PLT | 1.99 | 1.58 |
| | | Lab PLT | 0.97 | 0.86 |
| B | 31.40 | Field PLT | 1.65 | 1.54 |
| | | Lab PLT | 4.53 | 3.57 |

The standard deviation for both sets of field data is similar, suggests the two drilling programmes were undertaken in similar geological units. A greater standard deviation for the laboratory data relative to the field data for set B is considered to be due to successful sampling of an increased range of material types and strengths. This was not achieved with data set A.

Upon arrival of the samples at the laboratory, photographs were taken and compared with the photographs taken in the field. This was to assess if any degradation had occurred during transport and the suitability of the sample for testing. Laboratory photographs were not available for comparison for data set A; however it was observed in the photographs for data set B that there were very few samples unsuitable for testing.

The results suggest that the procedures have been successful in increasing the sampling rate and preserving the in situ conditions, resulting in a greater frequency of valid laboratory data. However, due to the limitations of the two data sets, the results are not conclusive. The application of the procedures is still thought likely to produce superior results compared to the current standards.

# 6 Conclusions

This paper provides procedures for core logging and sampling which should be used in conjunction with the current published standards. Implementation of these procedures should result in the ability to collect and preserve a higher quantity and quality of samples of weak material. It is anticipated that the procedures that led to the increased number of valid PLT laboratory tests in Section 5, will also increase the number of valid results for other test work, such as direct shear tests. The application of the procedures described in this paper can be applied to investigations in any weak rock mass.

A summary of the additional considerations complementary to the current existing standards is provided in Table 3.

**Table 3 Summary of additional considerations**

| Issue | Standard | Additional Considerations |
|---|---|---|
| Project Management | D5079-08 (ATSM, 2008)<br>This person shall be qualified and technically competent in the management of rock core. | Understanding of the technical issues.<br>Good communication.<br>Proactive engagement with field personnel.<br>Drillers should be contracted on a day rate. |
| Drillhole Design | Industry best practice guidelines, i.e. Read et al., 2009. | Consideration given to geographic and geological conditions.<br>Drilling down-dip may encounter difficulties. |
| Personnel | D5079-08 (ATSM, 2008)<br>This person shall be qualified and technically competent in the management of rock core. | All personnel to have a thorough understanding of the objectives of the programme and suitable experience.<br>Daily meetings to communicate any issues. |
| Core Logging | D5079-08 (ATSM, 2008)<br>If engineering properties are to be determined for the core, it must be handled and preserved in such a way that the measured properties are not significantly influenced by mechanical damage, changes in chemistry, and environmental conditions of moisture and temperature, from the time that the core is recovered from the core drill until testing is performed. | Rig side logging.<br>Logging is to be undertaken while the core remains in the split.<br>Core photography is also to be done while the core remains in the split.<br>Logging should be undertaken under shelter from the elements.<br>All samples packaged for laboratory testing are to be stored under shelter.<br>Data is to be captured electronically in the field.<br>Regular audits by a senior geotechnical engineer are to be undertaken. |
| Sample Collection and Testing | D4220-95(2007) (ATSM, 2007)<br>Procedures for preserving soil samples immediately after they are obtained in the field and accompanying procedures for transporting and handling the samples. | Sampling is to be performed immediately after the core has been logged and photographed, particularly for clay-rich or shale material.<br>Where material is highly susceptible to damage, sampling and photography should be undertaken from the split.<br>Samples should be wrapped as per the standards and guidelines mentioned above.<br>The core and all samples are to be stored under suitable shelter from the elements.<br>At the end of the shift, the samples should be relocated to a temperature controlled environment.<br>Frequent dispatch of samples from site to the laboratory.<br>Consideration should be given to the storage and method of transport suited to best minimise the disturbance to the samples. |

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