Developing a Standard for the PS Logger®

The PS Logger® sonic probe, since its inception in the 1970's, has seen ever increasing adoption for geotechnical investigations, with the exponential growth in Offshore Wind Farm (OWF) development being a primary driver. As with many technologies in this field the development of a standard follows behind its widespread use, such that there is currently no standard for the PS Logger®.

To address this, Robertson Geo have recently submitted a paper to the 7th International Conference on Geotechnical and Geophysical Site Characterization in Barcelona (ISC7) entitled "Towards the development of a standard for the PS suspension logger". Herein follows a brief resume of the salient points and scope of this paper.

Why the PS Logger® is Increasingly Adopted

The PS Logger® probe measures compressional (P) wave velocity and shear (S) wave velocity from a single borehole using a standard wireline logging setup. Unlike other sonic probes the PS Logger® can measure S wave velocity across the spectrum of formations from the hardest of rocks to unconsolidated sediments. From the resulting velocities small strain moduli can be easily derived with G_{max} being of particular relevance for OWF turbine foundation design, given the complex nature of the forces acting on the structure. Other in situ measurements routinely collected offshore include the Cone Penetration Test (CPT), the Seismic Cone Penetration Test (SCPT) and the Standard Penetration Test (SPT). PS Logger® data is a natural complement to these methods as it can provide strength parameter data through hard rocks where CPT cannot

penetrate, with data quality generally improving with depth. For OWF ground investigations the operational simplicity of the PS Logger® is key as the source is integral with the probe avoiding the need for operationally challenging seabed sources. By mounting the winch on the rooster box, for heave compensated drillships, excellent depth registration can be easily maintained.

Current Standards Relating to Soil Strength Determination Methods

The most relevant standards organisation applicable for soil strength determination is ASTM International (formerly the American Society for Testing and Materials). Other professional bodies involved include ISO (international Standards Organisation), BSI (British Standards Institution), AGS (Association of Geotechnical and Geoenvironmental Specialists), and OSIG (Offshore Site Investigation and Geotechnics Committee). Any standards produced by these bodies are technically voluntary until specified in a contract.

There are many laboratory based methods for measuring the strength of core samples with some specific tests being covered by applicable standards including ISO, ASTM and BSI.

For in-situ testing there are some general standards which apply to the PS Logger® such as ASTM D5753-18 (Standard Guide for Planning and Conducting Geotechnical Borehole Geophysical Logging) and BS7022:1988 (Guide for geophysical logging of boreholes for hydrogeological purposes). Both of these covers acoustic velocity logging but are very generic in nature with no details of PS Logging methodology. CPT and SPT methods are well served by ASTM standards such as ASTM D5778-20 and ASTM D1586M-18 respectively. SCPT is less well covered by applicable standards but is referenced in ASTM D5778-20 and ASTM D7400M-19.

Why is a Standard Important?

A relevant standard can form a bridge between client requirements and the purveyor of the service, detailing what the client requires and what is expected from the service provider. Conversely the lack of a standard leaves the specification of requirements and deliverables in the hands of individual clients, manufacturers and contractors with predictably variable results.

Proposed Framework for a Standard for the PS Logger®

Section	Sub-Section	Content
General Information		Scope, overview of method, principle of measurement, significance and use, terminology, units, significant digits, symbology, referenced documents.
Borehole Specifications	General	Separation between boreholes, open versus cased boreholes, necessity for fluid filled boreholes. Suggested drilling method.
	Geometry	Depth limits, borehole diameter, depth point, probe geometry.
	Grouting and Casing	Casing material requirements (PVC), importance of proper installation and grouting, best practice for grouting procedure, grout density specifications. Explanation of problems caused by improper grouting/casing.
Apparatus	Overview	Schematic of the PS logger®, showing all probe sections and components.
	Energy Source	Specification of dipole source: uni-axial force applied indirectly via borehole fluid, exciting flexural borehole mode. Recommended operating frequency range for avoiding dispersion corrections. Description of typical solenoid-operated hammer, merit of capacity to record measurements 180° out of phase.
	Receivers	Two receiver stations for measurement of difference in seismic arrival times, hydrophones and geophones for measurement of compressional and flexural waves, respectively.
	Acoustic Filter Tubes	Explanation of role of acoustic filter tubes, material and geometry specifications.
	Additional	Telemetry, recording system, winch and software.
Test Method	Calibration	Conformance, free pipe test
	Planning	Guidelines for planning a borehole run, starting at the deepest measurement location. Required information including datum level, typical depth interval. Liaison with other practitioners, potentially unstable subsurface conditions, logging in sections, guidelines for planning multiple runs.
	Test Instructions	Selection of appropriate test parameters by initial borehole testing, including sample rates, gains and filters. Detailed instructions of all aspects of the test procedure. Safety considerations.
	Offshore Considerations	Heave compensation, rooster box based operations, borehole instability, external noise factors.
Data Interpretation	Guidelines	Schematics of typical waveforms, compressional and flexural arrivals, picking methods.
	Deliverables	List of standard deliverables

Client contractor understanding is aided by a relevant standard and this simplifies and standardises the specification process on contracts. Both standard and survey specific parameters required from the client by the contractor are better defined upfront by application of a standard. Borehole and operational matters that need to be addressed are also more easily specified by reference to a standard. Details of deliverables and their timescales can also be covered by a standard.

Scope and Content for a PS Logger® Standard

The PS Logger® is now routine deployed in both offshore and onshore ground investigations and any relevant standard must cover both environments. Operations pertaining to the Oil and Gas industry are considered out of scope as this industry is already highly developed with its own methodologies and specific safety concerns. The above framework for a PS Logger® standard is loosely based on similar ASTM standard formats.

Discussion and Conclusions

As can be seen in the above table, which is not exhaustive, there are many important factors that need to be considered when engaging with a PS Logger® service, especially for offshore deployment. Over time, Robertson Geo, as manufacturer of the PS Logger® and the world's largest purveyor of PS Logger® services, have successfully dealt with all the factors involved thus providing reliable and safe operations while achieving the highest possible data quality. For less experienced organisations having all the necessary specifications and methodologies encapsulated in a standard would undoubtably be of benefit, by providing a framework whereby consistency and better data quality could be achieved.