Multi-Sensor Core Logging of Shallow Seabed Sediments for Subsea Power Cable Design: A North Sea Case Study

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Accurate characterisation of shallow seabed sediments is a vital step for the design and installation of subsea power cables. Current industry practice is to collect sediment samples with vibrocores and to conduct cone penetration tests (CPTu) at points along the cable route. While CPTU tests give continuous profiles with depth, laboratory testing of sediment samples is required to ground truth the results, particularly in complex geological environments such as the North Sea.

In this study, we review results from an Offshore Wind Farm site investigation in the southern North Sea with a focus on relationships between Multi-Sensor Core Logger (MSCL) data and results of geotechnical index testing. We evaluate data on a range of materials including sand, soft marine clay, over-consolidated clay, peat and gyttja from the Quaternary formations Holocene, Botney Cut, Bolders Bank and Swarte Bank, in addition to structureless chalk of the Cretaceous (Cameron et al. 1992).

We used the MSCL apparatus by Geotek Ltd to measure attenuated gamma density (analogous to bulk density), P-wave velocity, magnetic susceptibility, electrical resistivity and natural gamma on sediment samples at 1-cm intervals. We compare and explore relationships between MSCL data and geotechnical properties including electrical resistivity and thermal conductivity, natural gamma and grain size/clay content, and magnetic susceptibility as an indicator of stratigraphic unit.

The most critical parameter for cable design is thermal conductivity, with lower thermally conductive sediments such as peat posing the highest risk towards overheating cables. Thermal conductivity measurements are typically taken with a needle probe at discrete intervals and are sensitive to sample preparation methods which can alter saturation ratio (Tucker et al. 2023). We propose that an empirical relationship between thermal conductivity and electrical resistivity can be used to derive continuous profiles of thermal conductivity, while other MSCL measurements such as attenuated gamma density and P-wave velocity, provide supporting information on soil type, sample quality and saturation ratio.

In large offshore projects, data from different locations are routinely grouped together into stratigraphic units with similar geotechnical properties to reduce the amount of laboratory testing required. Sediments of the same provenance and mineralogy are reliably correlated with measurements of magnetic susceptibility (e.g., Gehman & Kelly. 2001). In addition, as natural radioactivity is concentrated in silts and clays compared to sands, natural gamma can be used as an indicator of grain size/clay content.

References

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