

## APPLICATION OF ELECTRICAL RESISTIVITY SURVEY TO ENHANCE THE RESOLUTION OF SUBSURFACE INTERPRETATION

In engineering design practice, subsurface conditions are commonly characterized primarily from borehole investigation data. Boreholes may, for example, be spaced at approximately 200 m intervals, and the resulting data are often treated as representative of the ground conditions between adjacent boreholes (typically at the midpoint). This approach is generally adequate in areas where subsurface stratigraphy exhibits limited spatial variability. However, where soil stratification varies significantly, a higher borehole density is required to improve the resolution of the data used for design.

Nevertheless, borehole locations may coincide with, or straddle, anomalous zones, which can lead to biased interpretation of the overall subsurface conditions. For instance, borehole logs from a Chao Phraya Riverbank protection revetment project at Moo 10, Ban Pom Subdistrict, Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province (Figure 1) indicate a soft clay layer overlying a very dense sand layer. The very dense sand was encountered at approximately +83.00 to +85.00, underlain by hardpan. Moreover, the depths at which the very dense sand layer was identified are similar in both boreholes, suggesting—based on the borehole data alone—that the subsurface stratigraphy within the project area is laterally continuous.

Following construction, damage was observed along certain segments of the revetment. An electrical resistivity survey was therefore conducted to support the investigation of potential causes. Two survey lines were established to cover both an apparently undamaged section (AYBP01) and a damaged section (AYBP02), as shown in Figure 2. The damaged zone is located between chainages 0+035 and 0+085 (Figure 3).

The resistivity model for survey line AYBP01 (Figure 4) indicates a relatively continuous layered subsurface structure, in which the upper layer exhibits lower resistivity than the underlying layer. Using an approximate threshold of 15.8 Ohm·m, the interpreted boundary occurs at an elevation of about +80.00 to +86.00. When considered together with the borehole data, the low-resistivity zone is likely

representative of soft to medium stiff clay, whereas the high-resistivity zone is likely representative of very dense sand.

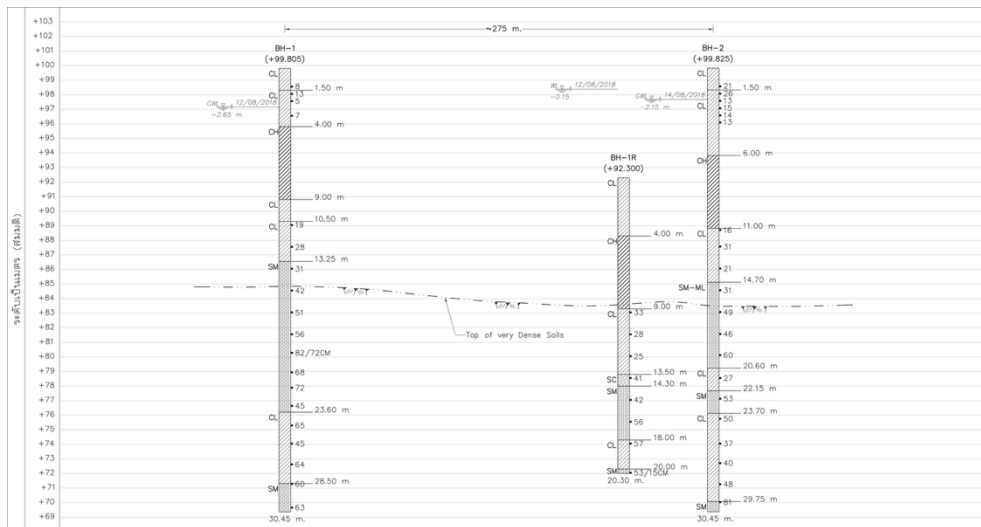


Figure 1 Geological cross-section derived from onshore boreholes for the Chao Phraya Riverbank protection revetment project at Moo 10, Ban Pom Subdistrict, Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province.



Figure 2 Plan view of the Chao Phraya Riverbank protection revetment project at Moo 10, Ban Pom Subdistrict, Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province, showing site conditions, boreholes (red circles), flow direction (blue line), and electrical resistivity survey lines (diamond symbols).

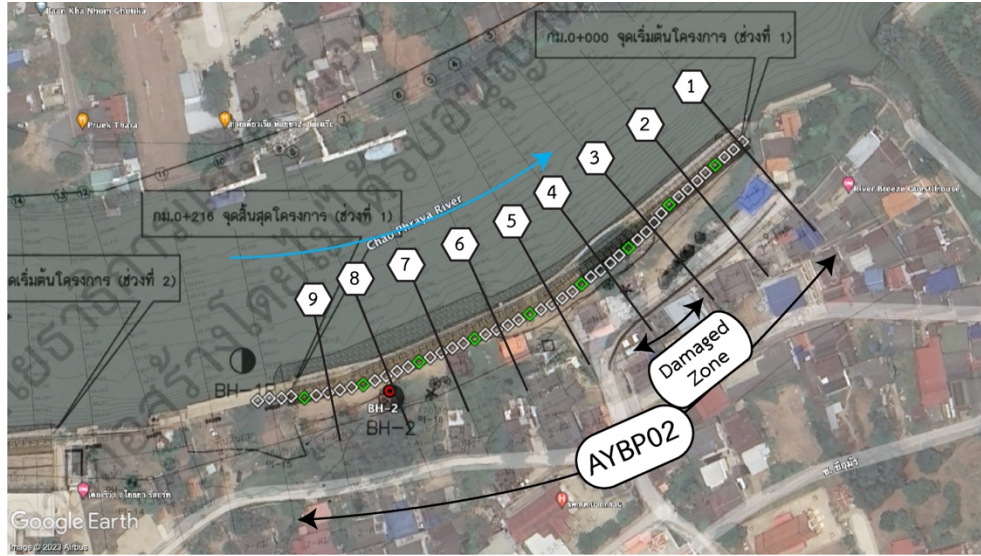


Figure 3 Plan view of the Chao Phraya Riverbank protection revetment project at Moo 10, Ban Pom Subdistrict, Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province, during Construction Phase 1 where settlement-related problems were observed, including site conditions, boreholes (red circles), flow direction (blue line), and electrical resistivity survey line AYBP02 (diamond symbols).

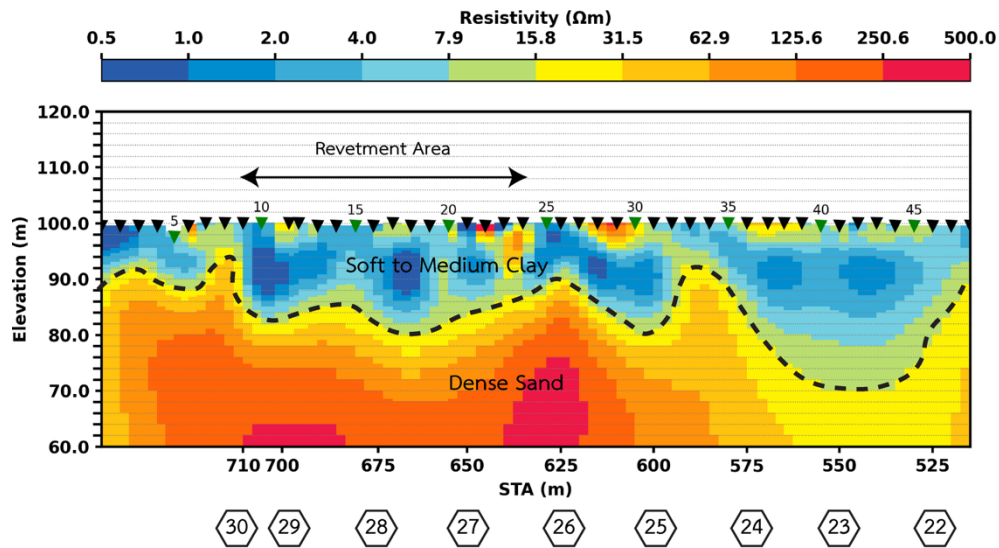


Figure 4 Electrical resistivity model along survey line AYBP01, where no revetment failure was observed.

In contrast, the resistivity model for survey line AYBP02 (Figure 5) differs markedly from AYBP01 and is not consistent with borehole BH-2. Specifically, the AYBP02 model does not exhibit a continuous layered structure and yields substantially higher resistivity than would be expected for the soil types encountered at comparable depths. For example, at the depth interval where CH soil was identified, the measured resistivity is approximately 125 Ohm-m, which is unusually high relative to typical geotechnical interpretations.

When the survey-line location is evaluated in conjunction with the revetment configuration and construction components, it is possible that a zone of water-bearing sand fill compacted to high density is present beneath the line. Accordingly, the high-resistivity zone may represent sand fill placed during construction.

For the damaged section of the revetment, the resistivity model indicates relatively low resistivity, suggesting the presence of soft soil. In addition, a high-resistivity layer—interpreted in AYBP01 as very dense sand—does not appear to underlie the damaged zone. These observations imply that the failure may be associated with a very dense sand layer occurring at greater depth than inferred from the boreholes, or with pronounced lateral variability such that the boreholes do not adequately capture the true subsurface conditions.

This case study of the Chao Phraya Riverbank protection revetment project at Moo 10, Ban Pom Subdistrict, Phra Nakhon Si Ayutthaya District, Phra Nakhon Si Ayutthaya Province demonstrates that, although the borehole data suggest laterally continuous stratigraphy, the electrical resistivity survey more clearly reveals lateral variability. In other words, if borehole BH-2 had been shifted by only approximately 25 m, the subsurface interpretation could have changed materially, potentially prompting additional boreholes or refinement of the investigation program.

The use of resistivity models as supporting evidence to define the confidence bounds of borehole-based interpretation represents a practical approach for engineering design. Such integration can reduce the risk associated with boreholes being located across highly variable zones and can

mitigate the likelihood of designs that do not reflect actual ground conditions, which may otherwise lead to structural distress during construction or service.

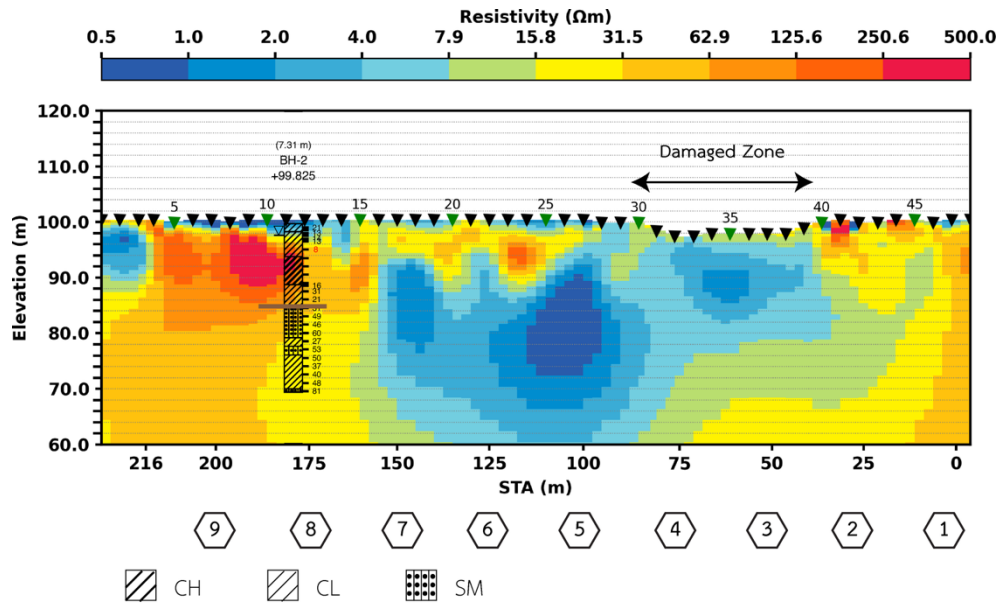


Figure 5 Electrical resistivity model along survey line AYBP02, where revetment failure was observed. The solid brown line indicates the elevation at which the very dense sand layer was encountered.

The second case study was conducted at the Ping Riverbank protection revetment project, Moo 5, Ban Tha Pui, Sam Ngao Subdistrict, Sam Ngao District, Tak Province. Three boreholes were advanced (Figure 6). The investigation indicates that the subsurface profile is predominantly composed of coarse-grained soils, with an interbedded fine-grained layer classified as sandy clay encountered in boreholes PTAK1\_BH-1 and PTAK1\_BH-2, whereas borehole PTAK1\_BH-3/1 did not intercept this fine-grained unit. The stratigraphic sequence observed in PTAK1\_BH-1 and PTAK1\_BH-2 is highly consistent; however, it differs significantly from that in PTAK1\_BH-3/1. In addition, the depth to the very dense sand layer in PTAK1\_BH-2 and PTAK1\_BH-3/1 is comparable and is approximately 1.4 m deeper than that recorded in PTAK1\_BH-1.

Interpretation of the electrical resistivity model (Figure 7) demonstrates a clear correspondence between the depth to the very dense sand layer and local upward deflection of zones exhibiting resistivity values greater than 55 Ohm·m. The anomalous zone is not laterally continuous as a straight, uniform feature; instead, it rises and falls along the survey line. This suggests that the depth to the very

dense sand layer may not vary gradually with distance, as might be inferred from the borehole data alone. The interval warranting particular attention is located near electrodes 34–41, where a body with resistivity in the range of 17–31 Ohm·m is observed at greater depth. Considering the observed trend between resistivity and SPT values, this feature may correspond to soils with SPT values of approximately 15–30 blows/ft.

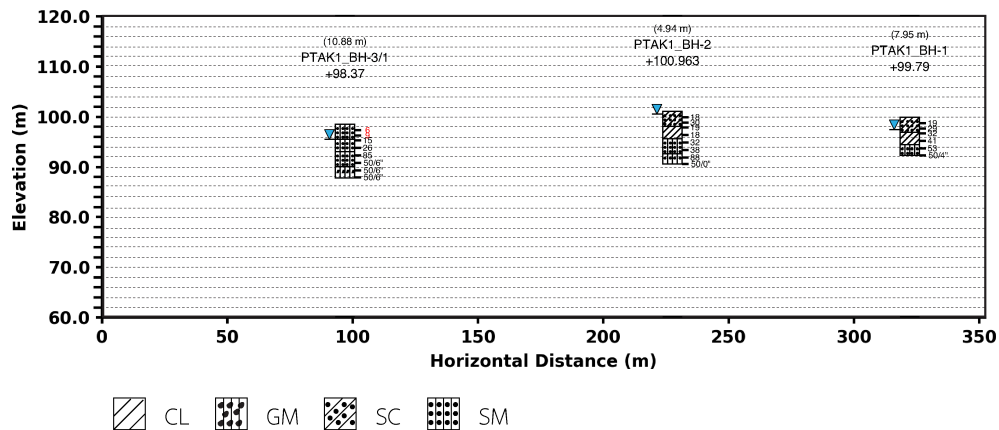


Figure 6 Geological cross-section derived from onshore boreholes for the Ping Riverbank protection revetment project, Moo 5, Ban Tha Pui, Sam Ngao Subdistrict, Sam Ngao District, Tak Province.

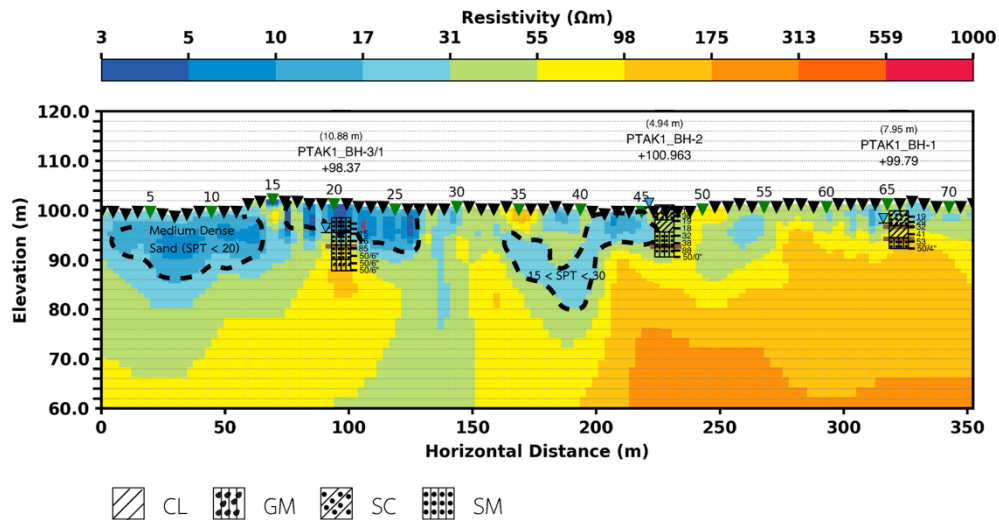


Figure 7 Electrical resistivity model for the Ping Riverbank protection revetment project, Moo 5, Ban Tha Pui, Sam Ngao Subdistrict, Sam Ngao District, Tak Province. The solid brown line indicates the elevation at which the very dense sand layer or hardpan was encountered.

This study indicates that reliance on borehole data alone may be insufficient in areas where subsurface conditions exhibit strong lateral variability. Electrical resistivity surveying can increase the resolution of subsurface characterization and effectively support the identification of anomalous zones. Therefore, integrating geophysical information with borehole data can enhance the reliability of subsurface interpretation, reduce design uncertainty, and support decisions regarding additional site investigation for geotechnical and foundation engineering works.