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OVERWATER DEPTH INSPECTION ON A SUBMERGED PILE BENT

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Introduction

- Current foundations condition is crucial for engineers to evaluate their stability.
- Missing or unknown foundation information could impede the earthquake or flood resistant capacity assessment.
- Materials deterioration, scour, or severe cracking could undermine the foundation capacity.

Near-Surface Depth Inspection

Phase I- Electrical Resistivity Tomography

(a).Selecting a proper electrode spacing and layout length around bridge site
(b).Laying out 10 or more electrode probes along the designate probing line
(c).Selecting appropriate inspection modes
(d).Removing irregular points and displaying the apparent resistivity profile
(e).Identifying soil layers, foundations, and underground structures from images

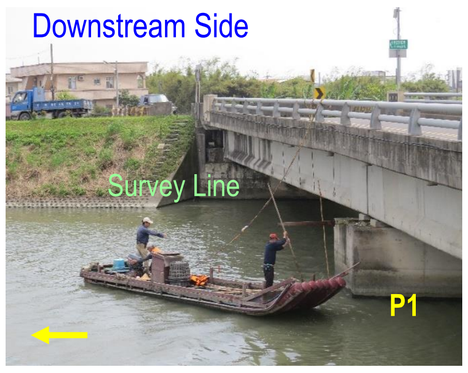
Phase II- Ultra-Seismic Inspection

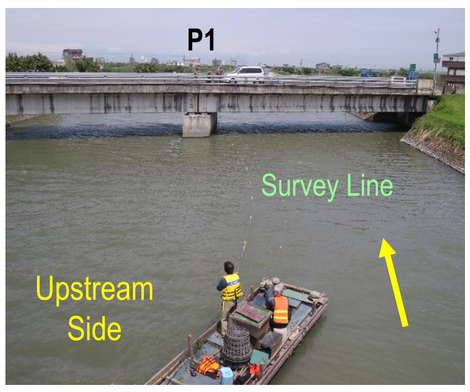
(a).Aligning receivers in an equidistant linear fashion on one side of an exposed foundation
(b).Generating seismic waves on surface using a hammer
(c).Identifying the reflection waves generated at the interface between foundations and surrounding strata (sands/clays/rocks).
(d).Finding interfaces of the foundation and soil

Investigation Case

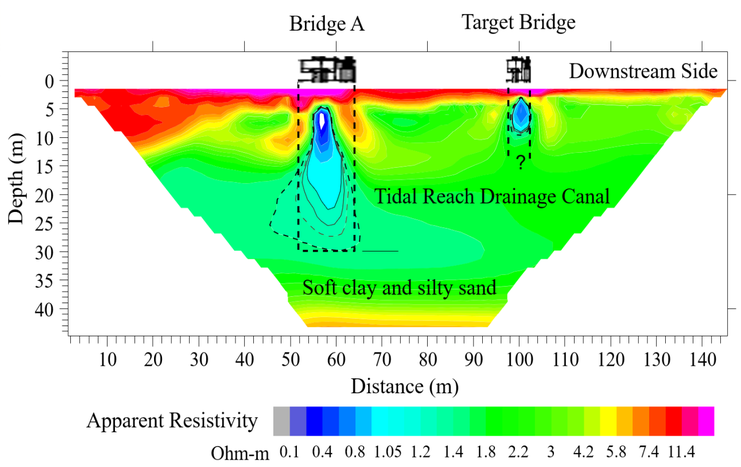
In order to accelerate the bridge construction speed, pile bents (i.e., partially embedded concrete piles) were used for crossing over the drainage canal full of soft clay and silty sand. The pile bents were composed of two cast-in-place piles (drilled shafts) with a diameter of 1.5 m and a length of 31.8 m. The exposure height beyond the riverbed was designated as 1.8 m below the pier cap bottom at its design phase. The varying tidal level significantly traced back to the upstream, caused the riverbed variation, and also led to the water table approaching the pier cap bottom at its highest tidal level.

Electrical Resistivity Tomography

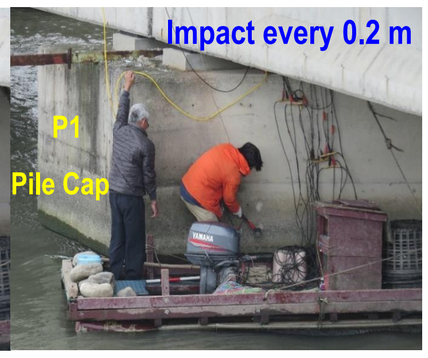




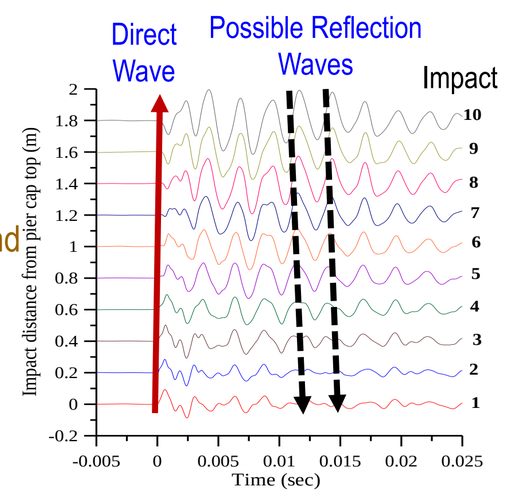
Utilizing SYSCAL Pro, Switch Pro, termination strip, and electrode probes to display the electronic potential field on the target bridge. Low resistivity closed contours are right at pile bent locations. The bridge depth was identified as 10 m (<<designated length, 31.8 m). Repeated scour and deposits weakened the interface among saline water, soft soils, and piles bents. The resistivity effect on the deeper pile bent was masked with salt-content materials at the shallow canal.



Ultra-Seismic Inspection

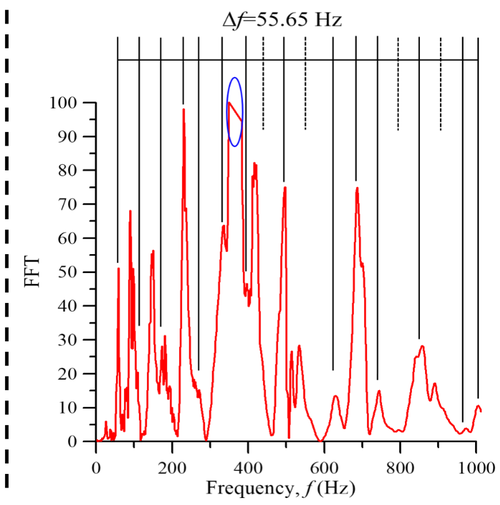


The ultra-seismic waveform (**lapsed-time analysis**) shows that the pile bent length, 25.51~34.52 m. The precision of a plot-based approach is affected by overlapping echoes, waveform identification, inconsistent responses, and installation quality.



The 1-D **frequency analysis** provides a relatively reliable length estimate (34.44 m; 2.5% error) by using the average frequency span between two adjacent resonant frequencies.

$$L = C_{bar} / (2\Delta f)$$



Discussions & Conclusions

1. A high salinity in riverbed soils and water weakens the overwater electrical resistivity tomography ability.
2. The modified ultra-seismic inspection technique provides more flexible installation for evaluating the condition of completely-submerged pile bent foundations.
3. The conventional lapsed-time waveform image analysis has a wider range of length prediction values. The determination of unknown pile bent lengths is highly dependent upon investigator's experience & judgement.
4. Based on the one-dimensional wave theory, the frequency analysis provides a relatively reliable length estimate by using the average frequency span between two adjacent resonant frequencies.
5. The entire set of investigations demonstrates the conclusiveness in determining the foundation depths when the results from testing methods are corroborated with appropriate analysis modes.

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