

WELCOME . . .

... to the fifth issue of "The Gregg Geo News". ...to the fifth issue of "The Gregg Geo News". The Geo News is being published to provide current information on the services we offer, equipment & technologies utilized and project experience.

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PROJECT SPOTLIGHT

- DRILLING AND CPT FOR RAILROAD BRIDGE INVESTIGATION -



Photo 1:
CPT rig positioned on low railer

Gregg Drilling recently completed a project requiring a CPT and drilling investigation for railroad bridge replacements.

The project presented unique access challenges but Gregg was able to maneuver the equipment into place on the railroad using self-propelled low-railers (see Photo 1). This allowed a 25 ton cone truck, a limited access hollow stem auger rig, and a mud rotary drill rig to move easily on the railroad lines to the exact locations for drilling and testing.

(Continued on following page)

Robertson's Remarks

- EVALUATION OF 'CYCLIC SOFTENING' IN CLAYS -

by: Dr. Peter K. Robertson



Boulanger and Idriss (2007, ASCE) recently presented an excellent summary for the evaluation of the cyclic softening in silts and clays. They correctly suggest that the first step is to evaluate of the behavioral characteristics of the soil. They suggest that the transition from being more fundamentally like sands to more like clays occurs at around a plasticity index (PI) of 7. Others have suggested slightly higher values of PI to define this transition (e.g. Seed et al, 2003 and Bray and Sancio, 2006). This issue will likely become resolved in the fullness of time as more field data becomes available. I prefer a slightly higher PI criteria to define clay-like behavior ($PI > 12$) since sand-like soils tend to have a lower resistance to cyclic loading than clay-like soils and the simplified methodology requires a certain level of conservatism in its application for low to moderate risk projects or in the screening stages of high risk projects. *(Continued on following page)*

WHAT'S NEW @ GREGG DRILLING

- NEW COMPACT SONIC RIG -



Compact Sonic Probe

To enhance our wide range of drilling equipment we recently added sonic drilling capabilities. The compact sonic probe is a versatile rig that has applications in the environmental, geotechnical and construction industries. This compact tracked rig is able to provide both sonic and rotary drilling methods. Sonic drilling can be used in the following applications:

- Environmental drilling and sampling
- Well installation
- Injection of remediation compounds
- Geotechnical drilling and sampling

For more about sonic drilling visit <http://www.greggdrilling.com/Sonicdrilling.html>

Robertson's Remarks continued...

The resistance to cyclic loading for silts and clays is essentially controlled by the undrained strength ratio of the clay-like soil. It is clear that if an earthquake applies a cyclic stress ratio ($CSR = t_{cy}/\sigma'_{vc}$) that is close to the undrained strength ratio of the soil (s_u/σ'_{vc}), large deformations are likely. The amount of deformations will likely depend on the size and duration of cyclic loading and the plasticity of the soil. Boulanger and Idriss suggest a value of $CRR_{M=7.5} = 0.8 s_u/\sigma'_{vc}$ to define the limit when deformations are likely to become large.

In clay-like soils the CPT is also commonly used to obtain estimates of both undrained shear strength (s_u) and consolidation stress history (OCR) profiles. The CPT has the advantage of providing continuous, reliable profiles of tip resistance in a highly cost effective manner. The undrained shear strength of clay-like soils can be estimated from the CPT using the following equation: $s_u = (q_t - \sigma_{vc}) / N_{kt}$

Where: s_u is the peak undrained shear strength; q_t is the corrected total cone resistance; σ_{vc} is the total overburden stress, and; N_{kt} is the empirical cone factor, which typically varies from 10 to 20 depending on the appropriate undrained shear strength required. (Continued on following page)

Project Spotlight continued...

Holes were cut through the low-railers to allow for the cone and drilling equipment to pass directly through (see Photo 2). Initially, the drill rigs were used to set casing through the gravels of the rail line so that the cone could be pushed to characterize the soil. In total, 25 CPT locations were tested to a maximum depth of 120 feet. A few borings were also conducted with the mud rotary drill rig to collect samples and verify the soil conditions. The main concern was discovering the depth of bedrock so that bridge piles could be designed to the correct length.

While drilling, gravels were encountered causing a loss of drilling fluid circulation. Gregg's knowledgeable operators quickly installed casing and were able to complete the sampling to bedrock.

Photo 2: Close-up of cone through low-railer



Robertson's Remarks continued...

Normalized CPT parameters are used to identify Soil Behavior Type (SBT), where the normalized CPT parameters in clay-like fine-grained soils are:

Normalized cone resistance, $Q = (q_t - \sigma_{vc}) / \sigma'_{vc}$
 Normalized Friction Ratio, $F = 100 f_s / (q_t - \sigma_{vc})$ in percent (%)

It can be shown that for insensitive clay-like fine-grained soils the undrained shear strength ratio can be estimated using the following simplified equation and CPT results: $s_u / \sigma'_{vc} = f_s / \sigma'_{vc} = (F \cdot Q) / 100$

For sensitive clays the sleeve friction, f_s is essentially the remolded shear strength of the clay. Hence, the above equation produces the remolded undrained strength ratio. Hence, it is possible to identify contours of undrained shear strength ratio in insensitive, clay-like fine-grained soils on the Normalized Soil Behavior Type (SBTn) chart suggested by Robertson (1990). These undrained shear strength ratio contours can be reduced by the recommended factor of 0.8 to produce contours of Cyclic Resistance Ratio ($CRR_{M=7.5}$) for clay-like fine-grained soils on the Robertson (1990) Soil Behavior Type chart, as shown in Figure 1. Robertson and Wride (1998) suggested that the approximate boundary between sand-like and clay-like behavior could be estimated using the Soil Behavior Type Index, I_c , and that the boundary was approximately $I_c = 2.6$, as shown on Figure 1. Zhang et al, 2001, recently updated the normalization of cone resistance for application to liquefaction assessment to allow for a variable stress exponent in different soils. The updated approach for normalized cone resistance (Q) is recommended for Figure 1.

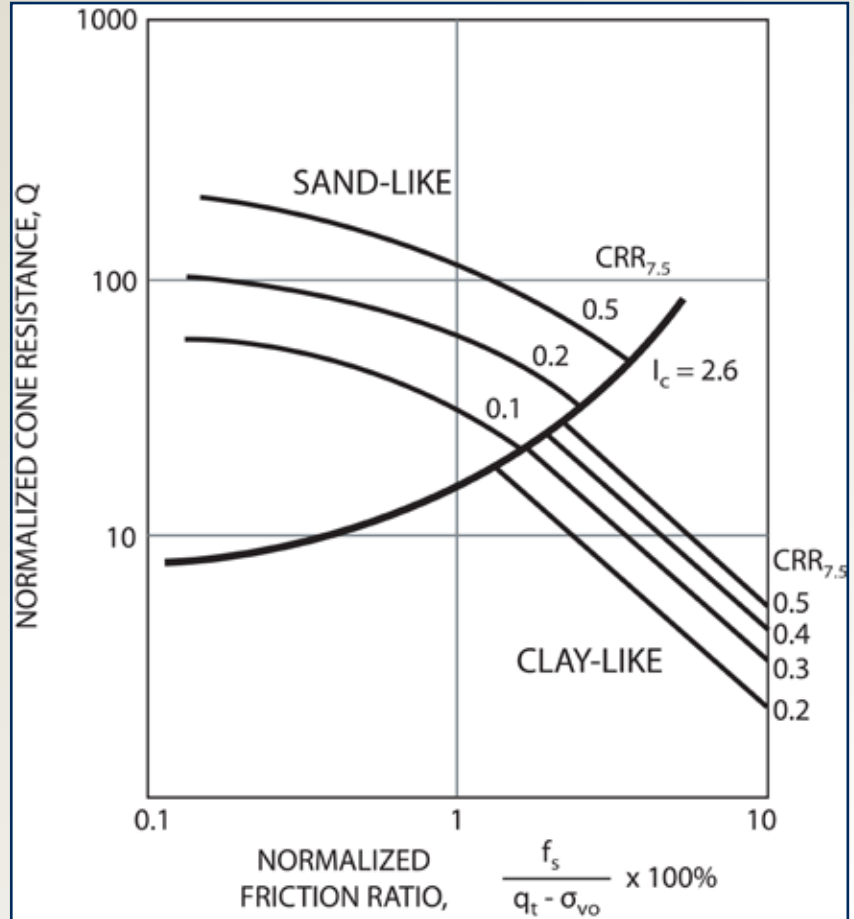


Figure 1

Also included in Figure 1 are the contours for $CRR_{M=7.5}$ for sand-like soils derived using the method described by Robertson and Wride (1998). Robertson and Wride (1998) and Youd et al (2001) suggested that when $I_c > 2.6$, samples should be obtained and Atterberg Limits determined to evaluate whether the soils were more clay-like or sand-like.

Figure 1 illustrates that when the Robertson and Wride (1998) approach for sand-like soils is extended into the clay-like region (i.e. $I_c > 2.6$) the approach produces generally conservative estimates of cyclic resistance ratio compared to the clay-like response suggested by Boulanger and Idriss (2007).

Contact Peter with any questions or comments regarding "Robertson's Remarks" at: probertson@greggdrilling.com. Visit www.cpt-robertson.com/links.html for previous issues of "Robertson's Remarks".

Did you know Gregg Drilling & Testing, Inc. is incorporated in Mexico and we have carried out numerous site investigation projects both on-shore and off-shore at international locations including:

- Mexico
- Central America
- Caribbean
- Japan
- Diego Garcia



B-80 drill rig during a site investigation in the Sea of Cortez

International work poses a unique set of risks and logistical challenges. Gregg's staff has the knowledge and experience to ensure these projects go smoothly. We have a thorough understanding of customs procedures in many locales and have cultivated a network of international resources to identify and mitigate potential problems before they impact project performance.

For more information on our international capabilities please contact Tim Boyd at tboyd@greggdrilling.com.