Title: Models for the Cyclic Resistance of Silts and Evaluation of Cyclic Failure during Subduction Zone Earthquakes

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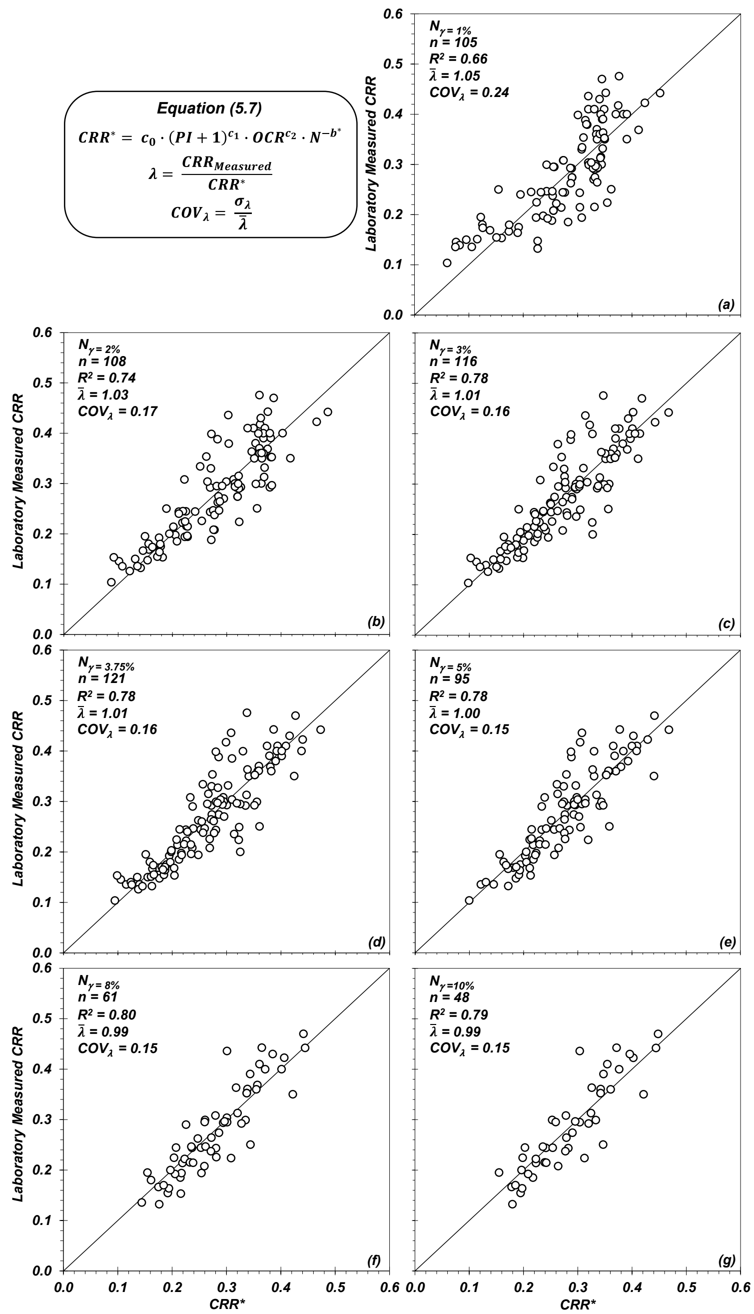
Motivation: Transitional nonplastic and low-plasticity silts present distinct challenges for the estimation of cyclic resistance, as no shear wave velocity-based method is available, and standard and cone penetration resistance may be significantly affected by partial drainage during penetration. Whereas the cyclic resistance of moderate to high plasticity silts are well approximated using existing simplified methods, the cyclic resistance of some nonplastic silts, and low plasticity silts in general, can be significantly over- or under-predicted depending on the methodologies available. Although many such soils can be sampled in an intact state, specimens prepared from samples can be dramatically affected by sample disturbance, leading to potentially erroneous cyclic laboratory estimates of cyclic strength. Thus, an alternative means to estimate the cyclic resistance of transitional silts in the absence of high-quality samples could serve to provide a provisional basis for cyclic strength estimates.

Objectives: This study aims to provide statistical models to estimate the relationship between the cyclic resistance ratio, *CRR*, and the number of equivalent cycles, *N*, for a range of shear strain amplitudes, and the number of equivalent loading cycles and magnitude scaling factors for use in cyclic failure assessments of transitional silt soils in subduction zone earthquakes.

Methodology: First, a database of cyclic loading test data is assembled, evaluated, and used to assess statistical trends in the curvature of the *CRR-N* relationship described by the exponent *b* in the power law describing cyclic resistance. Then the database is used to assess functional forms which can be trained to estimate the cyclic resistance ratio and cyclic strength ratio for cyclic shear strain failure criteria ranging from 1 to 10%. The ground motion records within the NGA Subduction Project are implemented to examine the role of subduction zone earthquake characteristics on the number of equivalent loading cycles for a wide range of soils with exponents *b* ranging from 0.05 (moderate plasticity silt and clay) to 0.35 (dense sand) and corresponding magnitude scaling factors for use with the Simplified method of cyclic failure assessment.

Results: This work culminated in a plasticity index-dependent function which can be used to estimate the exponent *b* in the power law describing cyclic resistance and to estimate the number of equivalent loading cycles anticipated for subduction zone earthquakes. Models to estimate the CRR and cyclic strength ratio are developed and to provide reasonable estimates of resistance for a given number of loading cycles and cyclic shear strain failure criteria ranging from 1 to 10%, within certain stated limitations. Models are presented to estimate the number of equivalent loading cycles associated with subduction zone earthquakes with moment magnitudes ranging from 6 to 9.12, which indicate that the number of loading cycles for a given magnitude subduction zone earthquake is larger than those previously computed considering crustal motions. In contrast, the corresponding magnitude scaling factors for use with the Simplified Method span a smaller range as a result of the ground motion characteristics.



Conclusions: The models developed in this study may be used by practitioners and researchers to estimate cyclic resistance of intact non-plastic and plastic silt soils and corresponding factor of safety against cyclic failure for a range in cyclic shear strain failure criteria, to plan cyclic laboratory testing programs, and to calibrate models for use in site response and nonlinear deformation analyses in the absence of site-specific cyclic test data.

Keywords: silts, cyclic failure, cyclic softening, liquefaction, cyclic resistance, subduction zone earthquakes