ANALYTICAL EVALUATION OF
STRESS-STRAIN TEST DATA

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Abstract
An analytical model for deducing the actual stress-strain properties from laboratory test results is discussed. As an illustration, an elastic bilinear material is used for unconfined cylindrical compression test conditions, as simulated with a finite element analysis. The results obtained are applicable for assisting in evaluating measured strength and stiffness properties of some clay soils, concrete test cylinders, concrete cores, and rock cores.

The quantitative results of this study can be used for interpreting measured stress-strain data for unconfined compression test conditions. The error in measured results is shown to be influenced by Poisson's ratio, length-to-diameter ratio of the specimen, end condition, and ratio of inelastic modulus to initial elastic modulus. Curves for adjusting the measured results to the theoretical results are presented.

Nomenclature

\( D \) specimen diameter
\( E_i \) initial elastic stiffness modulus
\( E_y \) elastic stiffness modulus beyond the yield stress, plastic or inelastic modulus
\( L \) specimen length
\( \varepsilon \) axial strain
\( \varepsilon_{av} \) average strain
\( \varepsilon_g \) gage length strain
\( \varepsilon_y \) yield strain
\( \mu \) Poisson's ratio
\( \sigma \) compressive stress
\( \sigma_{av} \) average stress
\( \sigma_t \) theoretical compressive stress
\( \sigma_y \) yield stress
\( \sigma_{ym} \) measured stress at the yield strain
§ 1. Introduction

Material properties are quantified on the basis of laboratory test results. Because of constraints imposed by the testing method, the test results require careful and judicial interpretation for deducing accurate quantitative material properties from the test data. For example, friction which develops between the specimen and end platens during a compression test, results in a stress and strain distribution within the specimen that differs from the uniform or average conditions assumed in the analysis of the data.

The accuracy of the interpretation of test data can have far-reaching consequences. Thus, the validity of an analysis to evaluate the reliability and performance of a structure, depends, among other factors, on the accuracy of the material properties used for input the analysis. If the input data are in error, the evaluation of the structural performance and reliability will be in error no matter how precise the analysis model. Clearly, the influence of laboratory test conditions on measured properties must be understood if functional, reliable, and economical structures are to be designed optimally.

The effect of test constraints can often be circumvented by using a portion (designated the "gage length") of the specimen, which excludes the end regions adjacent to the holding or load transfer devices (see Fig. 1). The average stress $\sigma_{av}$ is taken as the applied load divided by the area of cross-section of the specimen. The gage strain $\varepsilon_g$ is defined as the ratio of the change in the gage length to the gage length. The change in the total length divided by the total