SYMPOSIUM ON TIME RATES OF LOADING IN SOIL TESTING

INTRODUCTION

By Donald M. Burmister[1]

The influences of time rates of loading are most important aspects in testing soils, about which little is known at present. Information on this subject is scattered through the soil mechanics literature and is not readily accessible. The purposes of this symposium are: (*a*) to delineate the scope and real nature of the phenomena associated with time rates of loading and their influences on test results and on the uses of soil test data; (*b*) to bring together a body of fundamental knowledge and of laboratory and field experiences in a symposium for study and use; (*c*) to stimulate fundamental research both experimental and theoretical on this important subject; and (*d*) to formulate present ideas into a set of fundamental and systematic conceptions and working principles which will accurately describe and adequately explain the real nature and scope of the associated phenomena.

Soil by the very nature of its character and responses is the one engineering material that is most susceptible to and influenced by time rates of loading. The fundamental facts that must be recognized and fully taken into account in all soil investigations are that soils do not respond immediately: (1) to applications of stress in the field and laboratory; (2) to changes in the natural environmental conditions which may be caused by construction of structures; and (3) to any artificial test conditions imposed in laboratory and field testing, which may be materially different from the natural environmental conditions prevailing in a given situation or different from the new conditions to be imposed by the construction of structures.

This characteristic time delay of responses to the influences of imposed conditions not only makes it more difficult to understand completely the natural phenomena, because the complete phenomena cannot be observed at one time, but also makes it more difficult to evaluate the influences of the prevailing natural environmental conditions, of conditions imposed by construction of structures, and of test conditions used in soil testing. The conditioning influences of soil test procedures on soil responses and test results are so important that they must be given major consideration in setting up and in properly conducting soil tests that will significantly and reliably reflect the natural phenomena. Unfortunately the responses of soils and soil test results that may be obtained under conditions materially differing from the natural environmental conditions and from conditions imposed by construction of structures cannot usually be significantly interpreted and reliably translated

[1] Symposium Chairman; Department of Civil Engineering and Engineering Mechanics, Columbia University, New York, N. Y.

into probable actual field performances having representative and direct applications in making reliable predictions for the purposes of design and construction control of foundations and earthworks.

For each type of soil and of stress-strain response there is a characteristic time delay in attaining the full response. The basic problems of testing soils for strength properties and responses are to simulate and to reproduce as closely as possible the time delay conditions prevailing in a natural situation. Furthermore, in order to understand, interpret, and evaluate the apparent diversity of conditions and responses of soils in terms of significant controlling soil characteristics, it becomes essential to identify soils more accurately and completely with regard to these controlling characteristics. The principal objective should be to identify soils with the same preciseness, clarity, and revealing of soil character as has been consistently attained from the beginning in chemical names and formulas. The degree of generalization and approximation and the spread of soil characteristics in present classifications is much too large for classification to be really significant for these essential purposes.

The fundamental Terzaghi theory of consolidation of soils[2] established the nature and importance of the time delay of consolidation of soils under stresses imposed by structures and earthworks and provided the basic equations for estimating the time delay of settlement of structures. Applications of the consolidation theory require the experimental determination by consolidation tests of the coefficient of consolidation, which involves the coefficients of permeability and compressibility of soils. The Coulomb, Rankine, and Terzaghi theories of shearing strength of soils[3] provided equations for estimating the magnitude of shearing strength of soils mobilized under imposed stress conditions. Applications of these shearing strength theories require the experimental determination by shear tests of cohesion and angle of friction of soils. The time rate of increase in shearing strength by consolidation of soils under stress has been taken into account by the consolidation theory.

In the nature of things these theories have been based on idealized and simplified conditions of simple, constant, and definite soil properties. Many of present ideas, concepts, and working principles have grown out of experiences and experimentation. This empirical approach has been based on the concept that soil may be treated as any other structural material, having relatively simple, constant, and definite physical properties and responses. Experiences, research, and and advances in soil mechanics, however, have shown that the phenomena associated with consolidation and shearing of soils is much more complex than originally supposed. Soil properties and responses are not constant and definite quantities but are markedly conditioned and altered by conditions imposed in the natural situation by construction of structures and by artificial conditions imposed in soil tests, and are also markedly strain-rate dependent.

At present there seems to be a tendency to direct research and investigations toward confirming and bolstering up present ideas, concepts, and practices, rather than toward developing new ideas, concepts, and working principles more fundamental. These principles would describe and explain more adequately and reliably the real nature and scope of the phenomena of consolidation and shearing in soils, particularly with regard to the

[2] Karl Terzaghi "Theoretical Soil Mechanics," Chapter XIII, John Wiley & Sons, Inc., New York, N. Y. (1943).

[3] *Ibid*, pp. 7–25.

important influences of time rates of loading. As a consequence, there is an attempt to fit each new advance in soil mechanics into the old scheme of things. This limits the effectiveness and usefulness of new advances by bringing them down to the level of the old scheme.

What is urgently needed in the light of each new advance is to reinterpret observed natural phenomena and test responses and to reassess and to re-evaluate "old ideas and conceptions" in all related aspects of soil mechanics. This requires more comprehension and thoroughness and more engineering imagination in the search for truth. The present scheme of ideas, conceptions, and working principles should be constantly brought up to date and revised upward to meet the level of each new advance by "cutting out the deadwood of the old," which has become no longer significant and realistic.

Eight outstanding papers are presented in this Symposium on Time Rates of Loading in Testing Soils. All of these papers contain essential elements of truth. But in the nature of things, no one paper fully and adequately presents the complete nature and scope of the phenomena associated with time rates of loading in consolidation and shear testing of soils. Naturally, in the present state of understanding and knowledge, there are inconsistencies in interpretations and inadequacies in conceptions. Now that this wealth of information, experiences, and knowledge is available in this symposium, there should be a concerted effort to seek out what is significant and true. The extremes of blind acceptance and of skeptical rejection of "the new" should have no place in this search and in the evaluation of conceptions presented. The basic problems of soil mechanics are thoroughly to test out the old and the new ideas, conceptions, and working principles without bias or preconceived notions, and by concerted and consistent efforts to verify and to establish what is really significant and correct in developing and building up a fundamental and systematic set of ideas, concepts, and working principles which accurately describe and adequately explain the real nature and scope of the phenomena associated with the influences of time rates of loading in testing soils in consolidation and shear.

A most important objective for ASTM Committee D-18, on Soils for Engineering Purposes, in its work of preparing soil test methods and procedures involving aspects of time rates of loading, is to develop and to present a coherent system of "simulated performance" testing of soils, which consistently will yield representative and reliable test results and will be sufficiently convincing to be generally accepted in laboratory and field practices. In addition this system must be sufficiently flexible to permit adjustments and revisions to be readily made, as new advances unfold more completely the full scope and nature of soil phenomena.