Introduction to Symposium on Reliability of Geotechnical Instrumentation

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ABSTRACT

Background on the development of concepts of reliability of geotechnical instrumentation is presented. Emphasis is placed on learning from successful experiences as well as unsuccessful experiences or failures. Definitions of reliability are given, but uniform methods of characterizing reliability for geotechnical instrumentation remain to be developed.

Recent efforts of TRB Committee A2K01, Soil and Rock Instrumentation, have included exchanging information on actual instrumentation experience. Often a case history focused on the positive results of a field monitoring program. The negative experiences, the failures, were often not reported. Uncertain liabilities or ongoing litigation kept the facts from being disclosed. Perhaps just as often, unwillingness of the professional worker to share an unpleasant experience kept many failures from being reported. Thus, it was often noted that mistakes were repeated. Neither instrumentation suppliers nor users were learning as much as they should have been from the past experience of others.

Instrumentation failures were for a time the topic of active Committee discussion. Some members believed that practitioners should be able to learn a great deal from the study of failures, in the same way that much has been learned from structure foundation or earth slope failures. Further thinking, however, suggested that a still broader approach should be taken to understanding past instrumentation experience. Why instrumentation did not work, as well as why it did work so well in some cases, was of interest. Reliability of geotechnical instrumentation was then recognized as the broader concept that was appropriate for exploration.

So far there has not been a compact expression to characterize reliability in the context of geotechnical instrumentation. On the basis of Webster's Ninth New Collegiate Dictionary (Merriam-Webster, 1983), the following can be stated:

> Reliability: The quality or state of being reliable (a noun).
> Reliable: Suitable or fit to be relied on (an adjective).
> Rely: To have confidence based on experience (a verb).

The Dictionary of Scientific and Technical Terms (McGraw-Hill, 1974) gives the following:

> reliability: (engineering) The probability that a component part, equipment, or system will satisfactorily perform its intended function under given circumstances, such as environmental conditions, limitations as to operating time, and frequency and thoroughness of maintenance for a specified period of time. (Statistics) 1. The amount of credence placed in a result. 2. The precision of a measurement, as measured by the variance of repeated measurements of the same object.

As can be seen from its definition, reliability can be a broad topic. Perhaps the most telling word is "experience" in the definition of "rely." It means that reliability cannot be created on paper. Instead, reliability of an instrument has to be tested by actual use in the field.

Most practitioners in geotechnical instrumentation agree that there are no mathematical models that characterize reliability. Current work on instrumentation for nuclear waste repositories will no doubt require probabilistic approaches to ensure adequately designed systems. Probabilistic characterization of soil procedures has an active following, but its application to everyday use is beyond the state of the practice of geotechnical instrumentation. Most practitioners in the transportation industry probably do not want to know if something is "90 percent" or "99.9 percent" reliable. Most workers are not able to appreciate something that sounds so much like a technological cliché. Perhaps in the future more rigorous concepts of determining reliability will be used. For now, however, simpler, more subjective tests of reliability must be used.

Subjective evaluations of reliability are typical. In NCHRP Synthesis 89, Geotechnical Instrumentation for Monitoring Field Performance, John Dunnicliff uses the terms "Very Good," "Good," and "Fair." An occasional "Poor" is noted. Often what makes one device good has no application to another. Therefore, it is difficult to make sweeping generalizations about what constitutes reliability.

One of the most difficult aspects of understanding reliability is that it necessarily involves human factors as well as physical factors associated with the instrument hardware and its installed environment. Statistics may be able to characterize reliability in an abstract sense. However, what is of most interest to this Symposium is the "why or why not" physical details behind the reliability of geotechnical instrumentation.

The approach to getting a measure of reliability for this Symposium was to address the following questions:

- How was the correctness of the instrument readings established?
- What was the quality of performance of personnel who installed and maintained the instruments and took the data readings?

• What was the durability of the instrument in the installed environment?
• Did the instrument do the job intended and, if not, why not?
• What were the lessons learned from the instrumentation experience?

This Symposium, then, attempts to address reliability on the basis of the experience of others. Topic reporters gathered information on reliability in the following categories of instrumentation:

• Pore pressure,
• Earth pressure,
• Load and strain in structures, and
• Deformation.

The first three categories are reported at this Symposium. Case histories include all categories. As will be seen from the papers, each reporter's approach to characterizing reliability was somewhat different. This reflects real human considerations and the diverse nature of the topic.

This Symposium is to be a focal point for exchanging information, learning, and improving future work. It is expected that future sessions can be held that will encompass deformation measurements and other geotechnical instrumentation experience. It is hoped that future presentations will report on experiences with well-planned and executed instrumentation programs with well-defined and realistic objectives of reliability.

Reliability of Pore Pressure Measurement

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ABSTRACT

The importance of reliable pore pressure measurements and their influence on design and construction are discussed. Methods of obtaining high-quality data are related to five major items: (a) system design, (b) instrument design, (c) installation details, (d) operator knowledge, and (e) engineering interpretation methodology. Suggestions for addressing these factors are given. It is concluded that attention to detail in all phases by a responsible engineer is necessary to obtain reliable data.

Engineers have been attempting to determine the state of stress in soil by measuring excess pore water pressure for many years. The results reportedly ranged from good to unacceptable. In an effort to improve results, sophisticated electronic instruments have been developed that measure pressures as small as 1/100 psi. Results have not improved (1).

Improved reliability must, therefore, address two variables: (a) the instrument performing properly and (b) the soil system performing as predicted.

The major items that contribute to successful (or reliable) pore pressure measurements are

• System design,
• Instrument design,
• Installation details,
• Operator knowledge, and
• Engineering interpretation methodology.

Reliable pore pressure measurements can only be obtained by planning equally for all of these factors.

IMPORTANCE OF RELIABILITY

Pore pressure measurements are taken to allow the engineer to accurately predict the state of stress in the soil and to make appropriate engineering decisions. Reliable pore pressure measurements allow the engineer to use specialized cost-saving construction procedures with little risk. Undetected undependable measurements may lead the engineer into taking risks the results of which are costly or disastrous, or both.

The engineer must have a means of evaluating the reliability of all parts of the decision-making system. Some ways of ensuring reliable data for decision making are discussed in this paper.

SYSTEM DESIGN

A high-quality design must be done to allow determination of the type of instrument, location of instrument, frequency of readings, and other key features needed to ensure success of the system.

Design factors that need further discussion are

• Soil profile,
• Geotechnical model chosen for analyses,
• Vertical and horizontal soil parameters,
• Expected loading, and
• Groundwater.