REVIEW OF GEOTECHNICAL INVESTIGATIONS OF LOESS IN NORTH AMERICA

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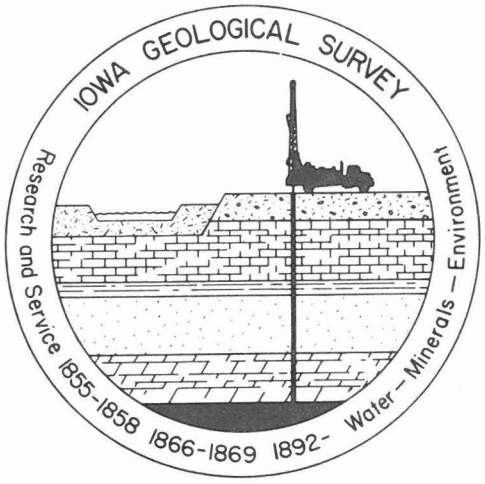

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FOREWARD

This paper, in slightly modified form was compiled as part of the North American Committee Report to the INQUA (International Quaternary Association) Subcommission on Loess; Dr. R. V. Ruhe, Indiana University, North American chairman. Loess is an important engineering material in Iowa. Consequently, this paper is being reproduced for limited distribution.

Review of Geotechnical Investigations of Loess in North America[1]

by

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Loess deposits mantle wide areas of North America, particularly the United States (see Thorp and Smith, 1952). (In Iowa, loess soils form about 38% of the land surface, and range in thickness to well over 60 feet along the Missouri River.) The inherently unique but somewhat overgeneralized geotechnical characteristics typically associated with loess include the ability to maintain near-vertical slopes both naturally and in roadcuts, low density, sudden collapse of structure upon saturation, relatively high permeability, and severe erosion potential. The past forty years have seen substantial research devoted to investigating these problems, and other factors influencing

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engineering properties and behavior of loessial soils *in situ*. The widespread distribution and thickness of loess have led to a second emphasis in geotechnical research, where loess is regarded as a construction material, to be treated, or stabilized, or otherwise dealt with for use in roads, embankments, etc.

Figure 1 shows a histogram summarizing the number of publications dealing with geotechnical properties of North American loess by 5-year intervals, through early 1979. The plot produces an interesting distribution, which is near-Gaussian in appearance, with the lowest 5-year total occurring in the last interval, 1975-1979. We believe that the decrease in publications in recent years may not reflect a decline in interest so much as a pause for reflection and reassessment of the problems. Certainly not all of the problems are solved.

The bibliography which follows includes all the publications known to the authors which deal with geotechnical properties of North American loess deposits. The references have also been annotated to indicate the type of studies or data compiled in each publication. The references presented in the bibliography have been divided by subject matter into two sections; (1) characization and (2) performance. Characterization deals with identification of particulate composition and associated properties, e.g. -- specific gravity, Atterberg limits, particle size, density, shear strength, etc. Performance includes case histories of foundations and embankments utilizing natural deposits and/or remolded loess. Property variations between undisturbed and reworked loess occur as a result of the alteration of natural structure. When loess is reworked by slope processes, it is

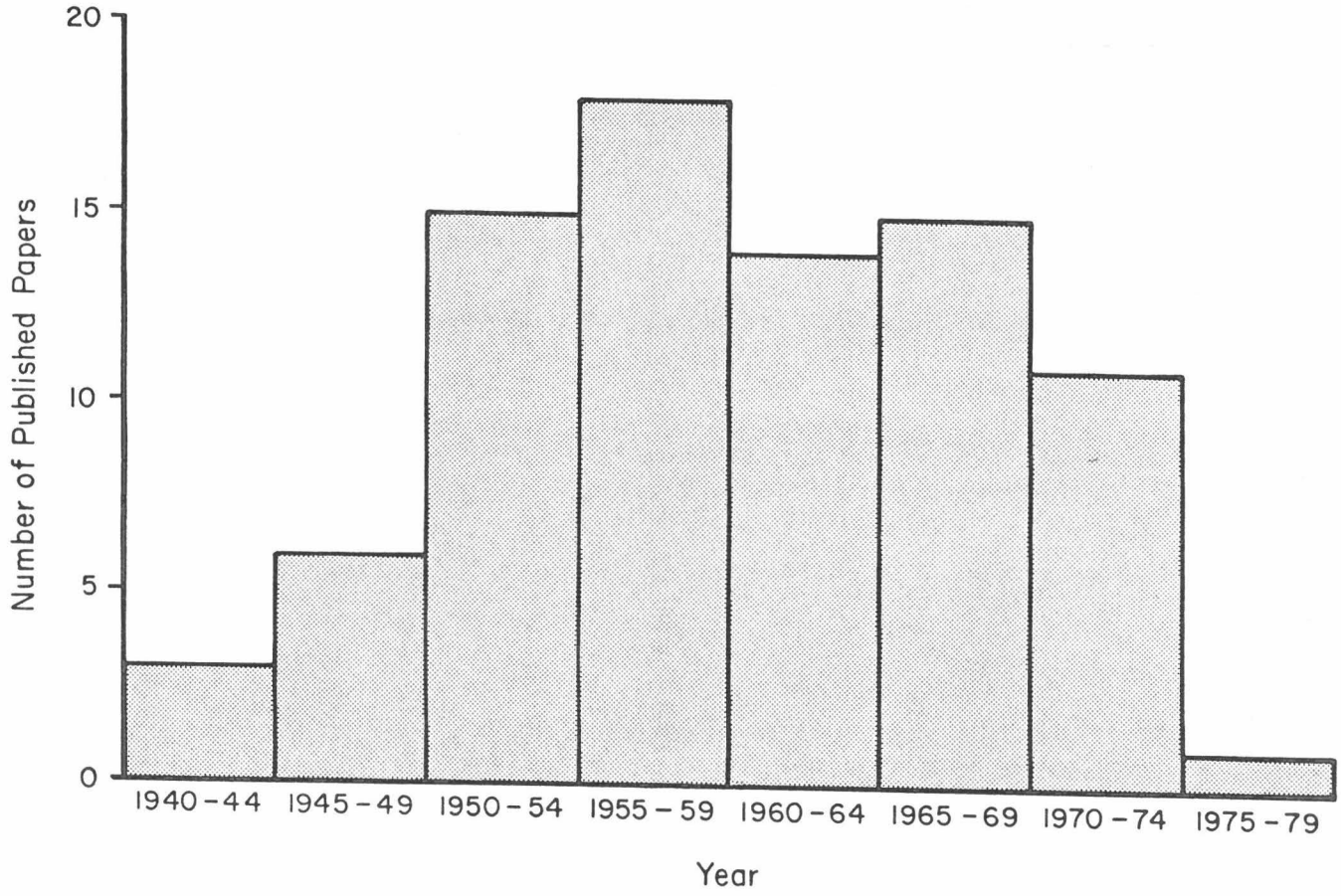

Figure 1. Number of publications dealing with geotechnical properties of North American loess.

effectively an alluvial or colluvial material, and studies of these materials have not been included. Only a few unpublished theses are recorded in the bibliography. They have been included only where the data has not appeared in a published paper and the information would otherwise be inaccessible.

DISCUSSION

Although extensive research has been conducted dealing with certain geotechnical problems in loess, the gaps in our knowledge, and in our applied approach to loess problems, are numerous as well. For example, among the classic geotechnical properties of loess, the potential for sudden collapse or rapid consolidation upon saturation has the greatest notoriety. Cases of excessive settlement of building foundations have been reported in the U.S. leaving the general impression that collapse is imminent in all loess deposits, when this is not the case. The authors have observed instances where the opposite has occurred -- heave and "stretching" of single family dwellings from the swelling of expandable clay minerals present in the loess. In general, the amount of clay present is the controlling factor governing swell (Hallberg, 1978), and may be related to the systematics of loess deposition and development of a soil profile.

Perhaps even more hazardous than collapse from a geotechnical design standpoint is the widespread natural occurrence of isolated zones of semi-liquid loess, within an otherwise coherent sequence. These zones occur where the in situ moisture-content approximates, and often is above, the liquid limit. This material has tentatively been termed "Loess Mush" (Hallberg, et al., 1978), which

is descriptive of its natural consistency. The possibility of shear failure and/or excessive settlement of foundations placed on this material are obvious hazards to be considered. Although research is continuing in this area, it appears that this phenomenon may be attributed to capillary saturation above perched water tables. The extent of the mush is then also a function of overburden stress, i.e. -- density and thickness of the loess deposit. It is interesting to note that in Europe this phenomena has been recognized (Stefanoff and Ivanov, 1971); however it has gone unmentioned in the North American literature.

Perhaps no other geologic deposit exhibits such well-defined, systematic property variations as loess, primarily because it has been dispersed and transported by the wind. The variations in thickness and particle size distribution with increasing distance from a source have been extensively documented, and can be quantified with a high degree of precision. (A review is presented by Ruhe [1973], and those references will not be included in this paper except where other pertinent engineering properties are discussed. The reader is urged to consult specific references cited by Ruhe for a background of geologic and pedologic investigations of loess.) More recently, a mathematical explanation rather than simply an empirical description of the systematic loess thickness relationship has been attempted (Handy, 1976) and this general approach appears to have an application in exploring properties such as particle size distribution as well. Most of the geotechnical properties of loess are controlled or affected by the thickness and particle size distribution of the deposit. Further documentation of the relationship of geotechnical

properties with the systematic changes in these variables would certainly be useful.

The effect of sampling procedures on engineering properties, as shown in other parts of the world (Milovic 1971) needs further investigation. In light of more advanced techniques in both laboratory and in situ testing methods, the use of certain standard tests for loess soils may be inadequate (Varga 1965).

The state of the science of geotechnical engineering requires continual updating, to make the application of research a reality. Even though the knowledge acquired over the past decade has increased our understanding and appreciation of loess soils, current practices leave a variety of areas open for important and productive research.

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a. Composition-chemical, mineralogical, textural
b. Moisture density relations-in situ, remolded
c. Consistency - Atterberg limits
d. Shear strength
e. Compressibility - consolidation, collapse
f. Permeability
g. Stabilization - chemical, mechanical
h. Slope stability
i. Settlement observations
j. Field testing - pile loadtest, plate bearing

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