SECTION I

THEORIES, HYPOTHESIS, CONSIDERATIONS OF A GENERAL CHARACTER.

SUB-SECTION Ib

GEOLOGY AND SOIL MECHANICS.

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SOIL MECHANICS AND GEOLOGY

(A contribution for discussion)

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A. AIM.

This article was a consequence of the observation, that in the invitation bulletin to the second International Congress on Soil Mechanics in Rotterdam in 1948, the word Geology was never used inspite of the papers mention of practical and theoretical problems of soil mechanics. This gave the impression that Soil Mechanics are today more or less independant of Geology. Therefore we have both tried to illustrate the subjects treated by Soil Mechanics and by Geology. This study leads us to the conclusion that not only the point of view of Soil Mechanics, but also that of Geology are, or should be, considered in the majority of problems concerning practical Soil- and Foundation engineering.

B. DEFINITION AND DEVELOPMENT.

If we mentioned the word Geology in the introduction, it was in its more general meaning of geological, as used in anglo-saxon countries. These geological sciences (General Geology, Geomorphology, Tectonics, Paleontology, Petrography and Mineralogy) study the effects of forces on the formation of the earth's crust, the early history of the earth, and investigate the materials composing the outer layer of the earth (Niggli, 1924). Both purely descriptive methods, partly with measurements, and, in recent, years, also experiments and model tests were employed to this effect.

The application of geological knowledge to technical problems is considered in Economic Geology, which studies the composition of raw materials (mining, oil, etc.) and also in Engineering Ceology which engage in problems of Civil Engineering. In the following paper, we shall unite these two branches under the term of Geology, which shall therefore include the geological as well as the petrographical-mineralogical science.

Within Civil Engineering, Soil Mechanics has developed since 1920 to an independant branch of Foundation Engineering. Terzaghi gave, in his "Theoretical Soil Mechanics" in 1942, the following definition of this science:

"Soil mechanics is the application of the laws of mechanics and hydraulics to engineering problems dealing with sediments and other unconsolidated accumulations of solid particles produced by the mechanical and chemical desintegration of rocks, regardless of wether or not they contain an admixture of organic constituents".

Apart from the theoretical Soil Mechanics, there exists a large field of the practical side, which forms an integral part of Civil-Engineering. Especially the above mentioned definition of Soil Mechanics omits the reciprocal influence existing between Engineering Geology and the practical application of Soil Mechanics. The history of this science, as the following lines will show, prooves that its development and application was, and still is, only possible when a close cooperation exists between Engineering Geology and the Civil-Engineering sciences.

Prior to 1925, two tendencies were easily distinguishable in Soil Mechanics: one purely theoretical (Coulomb, Rankine, Boussinesq), the other experimental and practical. At the same time Engineering Geology developed; it treated principally landslides (Alb. Heim) and hydrological questions, and , less frequently, mainly with the aid of engineers, foundations were examined. The collected facta were only empirical described, and beeing hardly numerically investigated, the conclusions were based on personal experience. Already a first classification of the different soil types, based on experiments, was undertaken, especially by the geologists, for the use of material testing, foundation and agricultural technology. 1), 2) 3).

The publication of a paper by the Swedish Geotechnical Commission in 1922 and of the "Erdbaumechanik" by Terzaghi in 1925, show a turning point in the evolution of the Soil Mechanics. Since then the interest in this sciences has become more intense, whereby the following tendencies can be distinguished:

1) On the one hand a large development of the theoretical basic principles of Soil Mechanics 4), 5), 6), 7), 8), 9).
2) On the other hand, parallel to the former,
   a) a better classification of soil types, based on a physical research of the soil, 10), 11), inpart with special consideration of the petrographical-mineralogical and colloid-chemical knowledge of fine-grained loose sediments 12), 13), 14).
   b) a better comprehension of soil processes, 15), 16), 17), 18) 10), 19).

These newly won aspects permit today the full use of practical experience and allows it to be applied from one case to another on the grounds of a comparison of geological and physical soil characteristics 20), 21), 22), 23), 24).

This historical summary shows, that in explaining the alteration of soil, as well as in the application of practical experience to geologicaly similar deposits, the geological sciences have contributed considerably to the development of Foundation Engineering.

C. PROCEDURE OF THE INVESTIGATION.

The historical survey has shown that besides Mathematics, Physics, Hydraulics and Soil Mechanics, Geology is one of the auxiliary sciences of Foundation Engineering. The intentional or unintentional consideration of geological methods in each phase of a practical application in Foundation Engineering will be briefly explained in the following:

a) Preparatory phase.

The general ideas of a new project are developped by the engineer. Soil Mechanics offer the theoretical principles for the solution; the Geology, with its general and local knowledge of the material enables however a primary judgement of the building ground.

b) Research phase.

Field investigation. The next investigation is that of the building ground, by way of test-borings, in order to recognise the geological series, to take samples and to make field experiments. The application of geological experience and procedure permit a systematical disposition of the test-borings, the correct correlation of identical beds from one borehole to another; characterising the encountered rock as moraine or solid ground, it decides whether the borings should be continued or not, interprets the observations in their right sequence, judges the genesis (lake deposits, glacier formation) and the evolution of each geological stratum (e.g. former burdening with glacier).

Taking into account the test-borings, further experiences and other results dating from the neighbourhood, a careful and intelligent extrapolation may present a very objective picture of the subsoil. At this preliminary stage, many investigations are finished without a more exact laboratory examination. Success depends on the individual geological experience and a good understanding of the processes at work in the soil, but of course will unknown approximation.

Laboratory examination. The determination of the samples in the laboratory continues the work of a more geological nature mentioned in the field examination. Besides the description of composition, colour, degree of weathering of the separate samples, further investigation entails the correlation of the samples with sections through strata and boreholes. This geological examination determines the colloid-chemical and petrographical composition of the material (effect of humus and carbonate content, that of certain ions and eventually that of clay minerals.).

c) Synthesic phase.

The geological data, together with the characteristica collected in the field and laboratory, form the basis for the technical reckoning, which demand the purely mathematical and physical deduction from the engineer.

These calculations necessitate a generalisation and idealisation of the natural phenomena. The theoretical findings cannot be always applied to the concrete example without a careful comparison of the idealised conditions and of the real situation considered, taking into account the detailed geological circumstances.

D. Practical use and consequences.

We have tried to answer the question mentioned in the introduction, as to the complete independance of Soil Mechanics from Geology; we have tried to show that geological procedure forms an integral part of many phases of practical Foundation Engineering and that it has made a considerable contribution to the scientific side of Soil Mechanics. It was our intention to draw attention to the fact, that a detailed description of underlaying stratas and the physical situation, as well as the practical application of the theoretical calculation, both demand a geological examination.

We intentionally avoided the terms of engineer and geologist in the proceeding paragraphs, because we did not wish to decide which of them, in practice, introduces or uses geological methods. It has been shown that a geological solution can be applied to a concrete problem through the cooperation of different Institutes (Geological Department of a University or Geological Survey Department and Laboratory for Soil Mechanics) or persons (geologist and civil-engineer) or also by an engineer who is acquainted with and has experience in Geology and Soil Mechanics.

Here we should like to mention the fact, that, in Zürich, on the suggestion of Professors Niggli and Meyer-Peter, a permanent geologist has been employed at the Laboratory for Soil Mechanics since its foundation in 1935. The help of the geology has been much appreciated in Soil Mechanics, especially in our geologically complicated land. From our experience, we should like to suggest that a geologist, with a knowledge of colloid-chemistry and petrography, be on the staff of the larger Laboratories. This is also a means of interesting geologists more in Soil Mechanics than has been the case until now.

Finally, this cooperation or symbiose of Geology and Engineering is not only a question of technical competence in each branch, but also of the individual character, whereby science, as well as a certain measure of intuition and love of responsability are descisive.

Practical Soil Mechanics is a young and adolescent science, where further development can only be assured by continual and varied encouragement. This encouragement may come from the theoretical science of Civil-Engineering, from practical experiences or, last but not least, from the geological and petrographical knowledge of the geologist, but will in all cases be equally and heartily wellcomed.

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RELATION OF SOIL MECHANICS AND GEOLOGY IN FOUNDATION EXPLORATION LOWER MISSISSIPPI VALLEY

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SUMMARY

The practical utilization of developed geological information is being effected by the Mississippi River Commission in the Lower Mississippi Valley Division, Corps of Engineers, Department of the Army. This is brought about by full cooperation between the soil mechanics group and the geologists with the former converting the information and data furnished by the latter into a form which is readily used in design and construction. The effective cooperation of the two allied fields of soil mechanics and geology is brought about by a common-sense and realistic approach to the problem with a clear delineation of the functions of each.

INTRODUCTION

The purpose of this paper is to show that soil engineers and geologists can work together to their mutual advantage, and as a team can provide better and more economical information for final structure design. The scope of this paper is limited to the demonstration of the use and relationship of geology and soil mechanics on work accomplished by the Mississippi River Commission in the Lower Mississippi River Commission in the Lower Mississippi Valley Division. By far, the greater portion of work is confined to the alluvial valley of the Mississippi River and to those of its tributaries.

Most geologists, soil mechanics engineers, and civil engineers have rather fixed ideas concerning the relation between geology and soil mechanics. Originally the feeling between the three groups was quite often very critical of the other' scope of work and its real value. More recently it is believed that they are becoming more cooperative in their attitude one toward the other. It is considered that the gradual development of this cooperative attitude will lead to better and more economical design. It is unfortunate that numerous examples can be cited where the geologist was allowed to play a too important part in the design of a structure all to its detriment. Poor structural design has also occurred in instances where the civil engineer ignored geological features.

For purposes of clarity and simplicity, the term "civil engineer"as used in this paper refers to engineers with regular civil engineering technical training, usually in general over-all charge of the type of work referenced. The term "soils engineer" refers to soil mechanics engineers. A geologist is an individual trained in one or more of the "earth sciences".

The civil engineer receives training in the sciences of chemistry, physics, and mathematics and utilizes them in his work. Quite often he has found that due to the complexity of the work he has had to utilize the services of specialists in these fields to complete the necessary design work. Thus, for example, occurred the development of the structural design engineer. The science of Geology was of equal importance to the civil engineer. However, it was only rarely that the engineer had adequate training in geology because that science covers many specific fields, and only an occasional engineer received background