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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 nas 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

training in those geological fields which had specific applicability to his own line of endeavor. Thus, upon recognition of the importance of geology, the use of a specialist in such fields as structural, petrographic, or stratigraphical geology became quite common practice.

It soon was apparent to the civil engineer that there was a distinct gap or lack of information between the data supplied him by the geologist on the various soil strata and the ability of his design engineers to utilize these data so that known laws of applied mechanics in computing stresses in the various soil strata under given systems of forces could be applied. The missing link was a knowledge of the behavior of the soil strata when subjected to load and the limiting stress and deformation conditions for failure. About thirty years ago this was strongly emphasized by Dr. Karl Terzaghi and largely through his efforts the young science of soil mechanics has developed. The need for this science in the engineering profession is attested by its rapid growth and adaption over even a wider range of fields than is implied in the term "soil mechanics".

It can be said with considerable truth, confirmed by practice, that soil mechanics is the real and necessary connecting link between the geologist and the civil engineer in soils technology. One man well trained technically and with considerable experience in both geology and engineering, an engineer geologist, might bridge this gap. Few such individuals exist by virtue of their training alone because the high degree of specialization makes it impractical to obtain the necessary background in educational institutions. The soils engineer, by the very nature of his technical training in a field much closer to the "earth science", and by his practical experience, acquires a greater knowledge of geology than does the general type of civil engineer.

A common-sense appraisal of the whole situation indicates that the work of the geologist complements that of the soils engineer, while the work of the soils engineer complements that of the structural design engineer, and so on until the final completion of the job. It takes many types of specialists in the construction of dams and large earth-works and every specialist has his own place in the entire picture. It may be true that due to the simplicity of a proposed structure or to repetition of the same type of structure in the same locality, the geologist, the soils engineer, or the structural design engineer, one or all, will not be needed. However, in general, those organizations charged with the responsibility of building important structures will find it feasible and economical to maintain a complete staff of experts including engineers and geologists.

## GEOLOGICAL AND SOILS ENGINEERING FUNCTIONS

The principal construction items in the Lower Mississippi Valley Division which require close foundation investigation and study consist of the following: levees, earth dams, flood walls, locks, long spillway structures, bridges, trestles, flood-gates, and miscellaneous flood control structures. Bank stability studies for revetment are also required. Levees and revetments are major items and are more extensive in this area than in any other area in the world. Earth dams and large concrete structures for flood control are also major items.

In 1941 the junior author, as consulting geologist, was instructed by the President, Mississippi River Commission, to conduct a geological investigation of the Lower Mississippi Valley. The results of this investigation showed that the region is one that provides an excellent opportunity for the geologist to study natural processes and to establish the relationships between sedimentary materials and the environments in which they were laid down. From such studies the geologist can supply the soils engineer with usable information necessary for complete interpretations of specific data derived from soil investigations and testing.

The alluvial lands are flat lying plains with only slight surface irregularities, yet they comprise a large number of depositional environments, each with its characteristic sedimentary deposit. Near the surface within the meander belts of the rivers the soil profiles can be quite heterogeneous. River accretions, with alternate sand ridges and silt and clay-filled sloughs, tend toward very irregular topstratum conditions. Cut-off river channels forming ox-bow lakes, gradually fill with a type of sediment determined by nature of cut-off; some fill with clay and silt and form a very thick topstratum. The widespread flood-basins are underlain by thick back swamp deposits, generally with uniform characteristics but locally containing slough or old lake areas back-filled with fine-grained soil materials in a softer state. The alluvial lands of the coastal marshes are less heterogeneous in their composition, being composed largely of organic clays with sand and shell lentils and local peat layers. Ancient sedimentary deposits, far more consolidated than the alluvium, form the marginal uplands and alluvial valley floor. The eastern wall of the Mississippi Alluvial Valley is masked by a blanket of loose to well-consolidated, loess, or loess-like soil, which rests upon thick sand and gravel deposits. These strata are of variable geologic formation and differ widely in their general physical characteristics and thus require special investigation and study for most projects.

In 1941 a Board for utilization of soils data for levees was established by the President of the Mississippi River Commission. The over-all purpose of this Board was to set up a code of methods and procedures to make the maximum practical use of the science of soil mechanics in levee construction. In 1945 a new Board was assembled with its specific purpose being to bring the code up to date by incorporating improved procedures of foundation investigation, testing, design and construction. One item new to the code was the specific inclusion of geological studies and their utilization to the fullest on levee construction. During the last two years this has been extended to all major items of construction requiring extensive field investigations.

In the conduct of field investigations the overlap between geology and soil mechanics is held to a minimum by the clear recognition of the functions which each group is capable of performing and then staying within the proper limitation of scope. It is recognized that the functions of the geological group are: (1) to furnish a general over-all geological picture of the soil profile both horizontally and vertically, (2) to furnish sufficient specific geological detail at locations where required to give direction to more intelligent and economical soil borings, (3) to furnish sufficient geological information to give the engineer a clear insight as to the time se-

quence, method of deposition, structural features, and all other useful data concerning each soils or rock stratum involved in the construction of the contemplated structure, (4) to furnish general information on drainage and ground water conditions, (5) to assist in classifying the soil samples obtained, and (6) to offer advice with respect to the location of additional soil borings which are made for the purpose of obtaining all critical features of the detailed soil profile at the lowest cost. The functions of the soil mechanics group are recognized as (1) selecting the proper type of sampling equipment for obtaining adequate samples as to type and number commensurate with the structure involved, to (a) furnish sufficient information to the geologist so that the geology of the area can be adequately developed, and (b) to obtain the necessary additional samples from which the information for the detailed design of the structure can be obtained; (2) making sufficient borings to thoroughly develop the natural variation in the physical properties of the soil within the different geological soil groupings; (3) scheduling and obtaining the necessary and proper test data on the soil samples so that adequate information is available for all phases of design; and (4) assisting in the design of the structure by determining settlement, bearing capacity, type of foundation, and methods of construction.

The following is typical of exploration, testing, and design for a levee. Field engineers report that at a certain point a caving bank is rapidly encroaching on a main line levee, and that a setback is required. They will roughly determine the levee setback alignment. Instructions are issued to the geological unit to develop the detailed geology of the area and the soil mechanics exploration unit moves on the job to accomplish the boring work needed by the geologist to develop the geology of the area and by the soils engineer to develop the natural variations in physical properties within geologically similar classifications. On the basis of the geological information developed and data regarding the variable physical properties within the geological grouping, a more accurate alignment of the levee is made. If a clay plug is found to run roughly parallel with the levee, the latter may be shifted so that the clay plug acts as a cutoff under the riverside too. Wide and deep sloughs filled with soft blue mud are avoided or are crossed as nearly as possible at right angles. Natural levees are utilized where possible as the foundation for the artificial levee, since they are at a higher elevation and more stable. An attempt is made to avoid crevasse deposits of sand. The geologist is responsible for the drafting of a complete report of his findings with recommendations. On completion of the final investigational work and laboratory studies by the soils engineer the levee alignment may be further shifted to meet certain basic requirements of the soils study not demonstrated by the more general geological survey.

After the levee design is completed, should a general conference appear necessary, the geologist and soils engineer are invited to attend to answer questions which might arise concerning the geological or soil mechanics features, respectively, of the site.

The above example is typical of levees; other examples could be quoted concerning lock, earth dam and hydraulic structure foundations. As previously indicated, no difficulty in cooperation between the soils and geological groups exists on any of the varied types of work in the Lower Mississippi Valley. This is made possible by a common-sense and realistic approach to the problem in that each group recognizes its limitations. Of particular importance is the frank over-the-table discussion which precedes the actual undertaking of a job. One particularly gratifying feature is that the soils engineer and geologist are recognized to have equivalent stature with all other specialist engineering groups. This promotes a healthy respect between groups and as a result cooperation of effort is generally good.

As set up at the present time, the geological group is headed by the junior author and stationed at Baton Rouge, La. Organizationally, it operates as a part of the Soils Division, Waterways Experiment Station. In the not too distant future it is expected that a competent geological survey of the entire Valley will be completed. When this work is accomplished, it is the intent to move the geological section to the Waterways Experiment Station where it will continue to make all necessary geological studies.

## CONCLUSIONS

It is believed that the geological and soil mechanics work as accomplished by the Mississippi River Commission in the Lower Mississippi Valley represents an approach to the ideal cooperation of these two allied fields resulting in full utilization of both in design.

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