

FOUNDATION SECTION



TWENTIETH  
ANNUAL  
HIGHWAY  
GEOLOGY  
SYMPOSIUM

Proceedings of a Symposium  
held at the  
University of Illinois, Urbana-Champaign  
April 17-19, 1969

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### I. SOILS OF ILLINOIS AND THEIR ENGINEERING CHARACTERISTICS

T. H. Thornburn\* and T. K. Liu\*\*

Highway engineering design and construction problems in the state of Illinois are almost all related either directly or indirectly to deposits of the Pleistocene. Although the extent of deposits of the Nebraskan stage is not well delineated, Kansan drift has been identified over a large portion of the state. The Illinoian drift covered earlier deposits throughout most of the state, with the exception of extreme southern, western, and northwestern portions. Consequently, except in these areas and along some of the major river valleys, foundation or construction problems dealing with the underlying bedrock are relatively rare. The Illinoian drift is locally thin in the southern and western part of the state, but even here the topography is usually constructional on the drift.

Ice of the Wisconsinan stage covered only about the northeastern one-quarter of the state. Because of the relatively short time of weathering of its deposits compared with those of the

Illinoian stage, there is much more variability in the surficial soils of this region. Even in areas of southern Illinois which the Wisconsinan ice did not reach, most of the surface deposits in the valleys were affected by it. Some of these are lacustrine in nature and appear to be the result of the damming of the Mississippi, Ohio, and Wabash drainageways by outwash or ice blocks from the Wisconsinan glaciers.

Outside of the most recently glaciated area where the older drifts are thin or nonexistent, the surficial soils have been influenced to varying degrees by the thickness of overlying loessial material, again associated primarily with Wisconsinan time. On the field trip some of the problems associated with deep cuts in loess or the underlying bedrock were noted.

This discussion will not attempt to cover the engineering characteristics of all the soils in the state. It is related primarily to the northeastern portions of the state where the research work on highway soils has been concentrated.

Figure 1 is a map prepared more than ten years ago by a compilation of several maps of the Illinois State Geo-

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logical Survey and the University of Illinois Agricultural Experiment Station. (1)\* It needs a few corrections in the light of present knowledge, particularly with respect to the correlation of some of the morainic ridges and the position of the glacial boundaries in western Illinois. It is, however, sufficiently accurate to show the variability in the character and topography of the surface deposits. The contours of loess thickness show the relationship between the loessial deposits and their principal sources, which were the alluviated valleys of the Illinois, Mississippi, and Green Rivers. The loess is thickest immediately adjacent to the source areas and thins toward the south and east. In much of the northeastern part of the state the loess influence is minor. Those areas which apparently were never covered by glacial ice or at least do not contain any significant deposits of till are also indicated. While there are a few morainic systems which can be distinguished within the Illinoian drift region, it is evident that the majority of the moraines are located in the northeastern part of the state, forming more or less concentric rings around the lower end of Lake Michigan. There is an indication, however, that some of the earliest Wisconsinan ridges may have been built by a lobe which originated in the Lake Erie basin and extended across Indiana.

Figure 2, a cross section through

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\*Superscript numbers in parentheses refer to the References at the end of this paper.

the drift which begins near the southwestern corner of the Wisconsinan glaciated area and proceeds about half-way to the Lake Michigan basin, is typical of northeastern Illinois. (2) It shows that the drift thickness throughout most of this area is a minimum of 50 ft and is more than 400 ft over a major bedrock valley. There are some locations in northeastern Illinois where the drift is less than 50 ft thick, but these represent a small fraction of the total area glaciated in Wisconsinan time. In these locations, however, the shallow depth to rock presents special highway engineering problems. It may also be noted that the Wisconsinan drift is often only a thin veneer on the earlier deposits. An indication of the character of the upper drift may be obtained from Figure 3, prepared from a series of borings taken close to Farmer City (see Figure 2). Figure 3 shows 10-12 ft of topsoil and loess over about 10 ft of Wisconsinan till over 4-5 ft of Farmdallian (?) silt over the greenish-gray weathered surface of the Illinoian till. The correspondence to the profile of Figure 2 is quite good. In general, the unconfined compressive strength of the upper till sheet ranges from 2 to 8 tons/sq ft. At the location of Figure 3, the average value was found to be 4.5 tons/sq ft. In many respects the characteristics of the Illinoian till are similar. At the reported location its unconfined compressive strength ranged from 2 to 10 tons/sq ft with an average value of 4.5 tons/sq ft.

Figure 4 is a recently-published generalized map of the soils of Illinois prepared by the University of Illinois

Agricultural Experiment Station. (3) It will be noted that the major subdivisions are "dark colored soils," "light colored soils," and "dark and light colored soils." The dark colored soils are those developed under prairie vegetation; the light are those developed under forests. The mixed forest and prairie are designated as "dark and light." The "L" and "O" areas correspond to the very thick loessial deposits along the major drainage ways. The "A" area represents the regions of predominantly thick loess. Areas "B" and "C" and the "D," "E," "F," and "Q" series represent areas in which the loess is thinning to the east and the southeast, and correspond to the contours shown in Figure 1. It will be noted that none of these areas appears in the extreme northeastern corner of the state where areas designated "G," "H," "I," "J," "K," and "S," "T," "U," and "V" indicate soils developed primarily from glacial drift. These are the areas where the loessial influence is so minor that it affects at most only the surface horizon.

On a larger scale map of northeast Illinois the variations in parent material can be shown in more detail. (4) Six different textures of drift (mostly tills) have been mapped by the agronomists preparing soil surveys in this area. These vary from loamy gravel till and outwash (Parent Material No. 1 in Reference 4) to clay till and lacustrine sediments (Parent Material No. 6). The texture designation used is in accordance with the standard triangular diagram of the U. S. Department of Agriculture.

As part of a cooperative research project with the Illinois Division of Highways and the U. S. Bureau of Public Roads, the validity of agricultural soil maps using the parent material classification was tested from the standpoint of physical properties pertinent to engineering. Three counties in northeastern Illinois were selected for study: DeWitt, Livingston, and Will. All had relatively up-to-date county agricultural soil reports and maps which were used as a basis for selecting sites at which samples could be taken. Using the published soil map, the sampling sites were selected in the office. A field check was made only to determine whether or not the profile corresponded reasonably well with that described in the soil report. This was necessary since even recent soil maps cannot indicate all the minor inclusions of slightly varying soil types which occur within a mappable unit. Samples were taken at each site from each of the major horizons encountered within 5 to 6 ft of the surface. These samples were then subjected in the laboratory to grain-size analyses, Atterberg limit tests, and moisture-density relations tests. Since the "C" horizon samples generally represented the parent materials, it was possible, by combining data from those soil types mapped on the same parent material, to obtain a rather precise statistical indication of the variability in the major drift units.

The data presented in the following figures were taken from a published engineering soil report for Livingston County. (5) In that county, the following parent material areas were delineated:

No. 3, loam till; No. 4, silty clay loam till; No. 5, silty clay till; No. 6, clay till; No. 7, water- and/or wind-deposited sandy loams and sands; No. 8, medium and moderately fine-textured outwash; and No. 9, mixed bottomland terrace and bluff wash materials. In the western part of the county the loess is thick enough that it was also possible to obtain samples of some soils developed on relatively unweathered loessial material.

Average grain-size data on each of the parent material groups is plotted in Figure 5. The numbers in parentheses indicate the number of samples tested in each group. It is apparent that on the average there are distinct differences in the characteristics of each of the groups. Curves for loess and sandy windblown soils (No. 7) show textural characteristics which can be obtained only through sorting by wind action. Parent Material Nos. 9 and 8, recent alluvium and medium to moderately fine-textured outwash, respectively, are obviously coarser than the materials constituting the four textural classifications of till. A comparison of the tills shows that the percent of fines increases progressively from loam till through silty clay loam till, and silty clay till to clay till.

In Figure 6 the average plasticity values are plotted on a plasticity chart divided according to the AASHTO classification system. Parent Material Nos. 3, 4, 5, and 6 increase progressively up the chart. A similar pattern is shown in Figure 7, a plot of the average moisture-density relations for each of the eight different parent

materials. As one would expect, the highest values of maximum dry density were obtained with the granular materials. The loam till and the loess showed almost identical results and the other maximum dry density values decreased progressively from the No. 4 through No. 6 materials.

Statistical data for each parent material were summarized, as partly shown for Parent Material No. 3 in the table on p. 5. In addition, statistical data were also obtained as indicated at the bottom of Table 1 in terms of the estimate of range of 85 percent probability. It was felt that this range was more meaningful from the engineering standpoint than one, two, or three standard deviations. It will be noted that even at 85 percent probability there is a fairly wide range of values for each of the three properties. One might therefore question whether there is any value to the differentiation of the various parent materials from the engineering standpoint. In order to test this hypothesis, each parent material was compared with each one of the others with respect to a number of different physical properties (see Figure 8). Where the symbol of a particular property appears in the comparison box relating two different materials, there was a statistically significant difference between the two materials with respect to this property: The single asterisk represents significance at the 10 percent level and the double asterisk, significance at the 5 percent level. Statistically significant differences were obtained in every case, with the exception of Parent Material Nos. 8 and 9

## STATISTICAL EVALUATION OF PARENT MATERIAL NO. 3, LIVINGSTON COUNTY.

## LOAM TILL

## Statistical Data

Index Property	No. of Samples	Mean	Standard Deviation	Coefficient of Variation
Liquid Limit, percent	39	34.5	6.8	19.8
Max. Dry Density, lbs per cu ft	40	110.8	5.7	5.1
Optimum Water Content, percent	40	16.3	3.0	18.2

Estimate of Range, 85 Percent Probability

Liquid Limit, percent	25-44
Max. Dry Density, lbs per cu ft	102-119
Optimum Water Content, percent	12-21

and Parent Material Nos. 5 and 6. Parent Material Nos. 7 and 9 show statistical differences only with respect to the textural characteristics of the material passing the No. 10 and No. 40 sieve. On the basis of this analysis it was felt that without a doubt the field separations made by the agricultural soil survey are significant from the standpoint of engineering. The highway engineer should be familiar with these differences and be prepared to alter his design and construction methods accordingly.

Using the information obtained from the test data, joined with a knowledge of the other characteristics of the soil profiles developed on the various parent materials, it is possible to present the engineer with certain quali-

tative design and construction information. This can be utilized especially during the preliminary planning stage for a highway facility to be located in any part of the state where soil conditions are similar to those already examined. Items which were normally considered are

- (a) design and construction information,
- (b) alignment problems,
- (c) water table position,
- (d) frost action susceptibility,
- (e) seepage problems,
- (f) excavation problems,
- (g) stability of cut slopes,
- (h) compaction characteristics,
- (i) erosion of slopes,
- (j) source of borrow,
- (k) source of granular material,

