

Commonwealth of Kentucky  
Department of Highways

KENTUCKY SOILS: THEIR ORIGIN, DISTRIBUTION  
AND ENGINEERING PROPERTIES

by

R. C. Deen  
Research Engineer

A Report Presented at the Kentucky Highway Conference,  
University of Kentucky, Lexington, March 29, 1956.

Highway Materials Research Laboratory  
Lexington, Kentucky  
March, 1956

## KENTUCKY SOILS: THEIR ORIGIN, DISTRIBUTION AND ENGINEERING PROPERTIES

### Soil Derivation

Soil is the product of the action of climate and living organisms upon parent materials, as conditioned by local relief. The length of time over which these forces are operative is of great importance in determining the properties of the final soil product. Altogether, there are five principal factors in soil formation: 1.) climate, 2.) biological activity, 3.) nature of the parent material, 4.) topography, and 5.) time.

The major differences in the soils of Kentucky result chiefly from differences in 1.) the rocks from which the parent materials were derived and 2.) the topographic position of the materials.

Topography controls, to a great extent, the depth as well as the nature of the soil. Erosion is greatly influenced by the slope of the ground surface, and this also affects the proportion of rain water that will seep into and through the soil to that which will run off on the surface.

The percolation of water through soil removes soluble matter and fine particles from the surface layer, the "A" horizon. The upper portion of this horizon is also the zone of accumulation of organic matter. The soluble matter and fine particles are carried to and deposited at a lower depth, the subsoil layer or "B" horizon. The underlying undifferentiated parent material is designated the "C" horizon. A vertical section through the different horizons - considered together as integral parts of a natural unit - is called the soil profile (see Fig. 1).

Soil differences depend not only upon the nature of the rock from which the parent materials were weathered, but also upon whether these materials have remained in their original positions or have been moved and redeposited, and if the latter, by what agency. When the parent material has not been moved, the soils are known as residual. These soils consist primarily of the insoluble residue of rock material after the soluble material has been removed by leaching and erosion. Residual soils are widely distributed throughout Kentucky, and were derived from sandstone, shale, and limestone rocks, either singly or in various combinations. Where the parent material has been moved and deposited by water, the soils are known as alluvial; where the moving and deposition is by wind, as aeolian; and by moving ice sheets, as glacial.

Most of the upland soils of Kentucky have been formed from residual materials. Bottomland soils, which are extensive in many parts of the state, were derived from alluvial materials. A fine wind-blown material known as loess covers a considerable portion of the Jackson Purchase area; and a small area along the Ohio River from Oldham County to Bracken County has been affected by glaciation.

#### Central Kentucky Physiography

The physiography of central Kentucky (see Fig. 2), which is a reflection of geologic features of the area, is largely controlled by the Cincinnati Anticline, a broad arch that stretches north and south through the central portion of the state, reaching a peak in Jessamine County. To the west the strata dip into the broad syncline of the Western Coalfield.

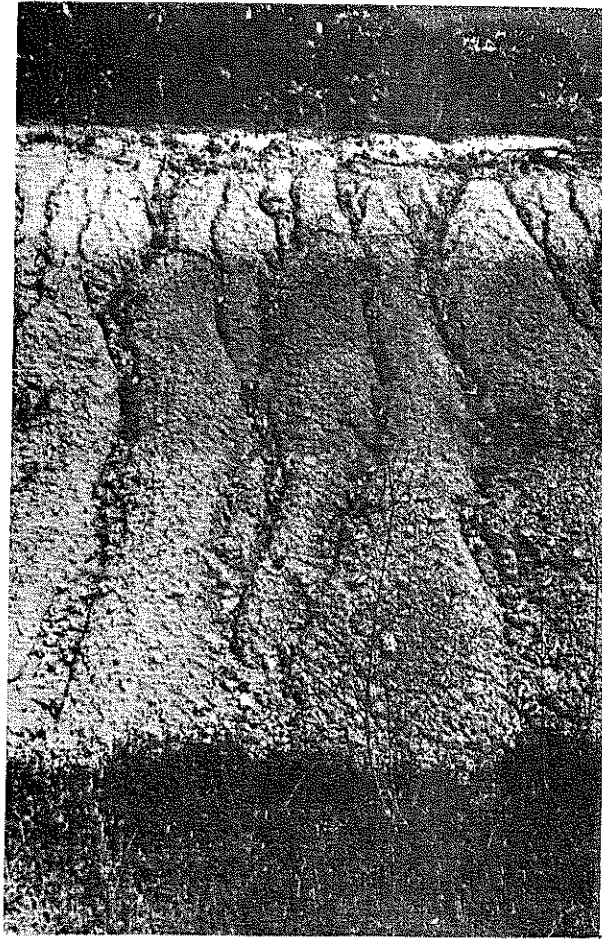


Fig. 1. The Soil Profile. (From Purdue University Experiment Station Bulletin No. 87)

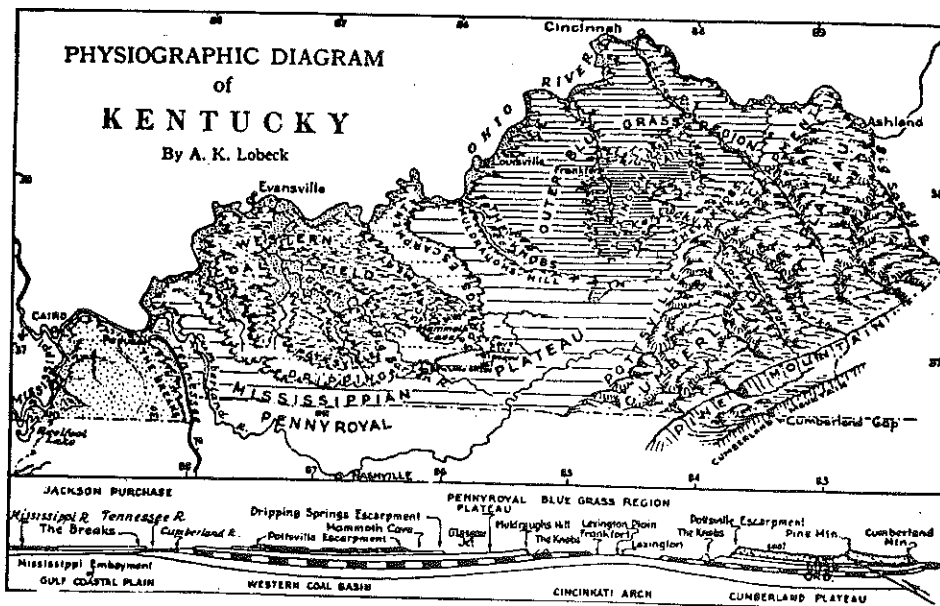


Fig. 2. Physiographic Diagram of Kentucky.

The dips of the strata on the flanks of the Cincinnati Arch are quite gentle and can not be detected by the eye. This arching, however, has been sufficient to allow erosion to be active, exposing on the surface of the dome the oldest formations in the state. Proceeding outward from the Jessamine Dome, the younger formations are exposed in a concentric arrangement.

To the west of the Tennessee River lies an area that was not raised above sea level until late geologic time. This area, the Jackson Purchase, was at one time at the head of an embayment of the Gulf of Mexico, and received deposits of sand, gravel and clay.

The Inner Blue Grass region, or Lexington Plain, includes most of Fayette, Scott, Woodford, Jessamine, and Mercer Counties. This is a lowland with a gently rolling upland terrain. Rivers in the area have entrenched themselves to depths of 400 to 500 feet. Except for major streams, much of the drainage is through subterranean solution channels. And, since many of the constituents of limestones are soluble, solution channels, as well as caves and sinkholes, are not uncommon.

The level uplands have developed deep residual soils derived from limestone. Physical tests show that such soils are relatively plastic, yet these are very well drained because the bedrock allows the water to escape through cracks, joints, and solution channels and because the soils develop a fragmentary structure. However, when this natural soil structure is destroyed in earthwork operations for engineering purposes, the soils become plastic and react in much the same way as other clay-like materials.

The area encircling the Lexington Plain is known as the Outer Blue Grass, including the Eden Hill Country. The comparatively impervious and easily eroded shale has produced a rough, hilly country (see Fig. 3). The soils of the Eden Hills have been formed by the decomposition of limestones and shales. The valleys are narrow and winding, entered by numerous streams which require many culverts and bridges. The soil is highly plastic and provides poor pavement support at normal moisture contents, while cut slopes frequently produce landslides and are a major engineering problem.

Proceeding outward from the Jessamine Dome, the soils of the Outer Blue Grass become more similar to those of the Inner Blue Grass. The upper horizons are more suited as subgrade material than the Eden Shales, although the parent material is very similar to that of the Eden. It is fortunate that the gently rolling nature of the terrain (see Fig. 4) requires lighter cuts, so that little of the undesirable clay finds its way into the subgrade.

Surrounding the Blue Grass is a narrow belt of land known as the Knobs area, characterized by the conical knobs (See Fig. 4) that are the erosional remnants of former uplands to the south and west. This is a narrow shale area encircling the limestone country of the Blue Grass, with the Mississippian Plateaus to its west and south, and the Cumberland Plateau of the Eastern Mountain area to the east. It is a region of rough topography but with the major stream beds flat and wide.

The Mississippian Plateaus form a broad belt to the west and south of the Blue Grass, encircling the Western Coal Field. This belt is a rolling upland plain formed from limestone, with small local relief

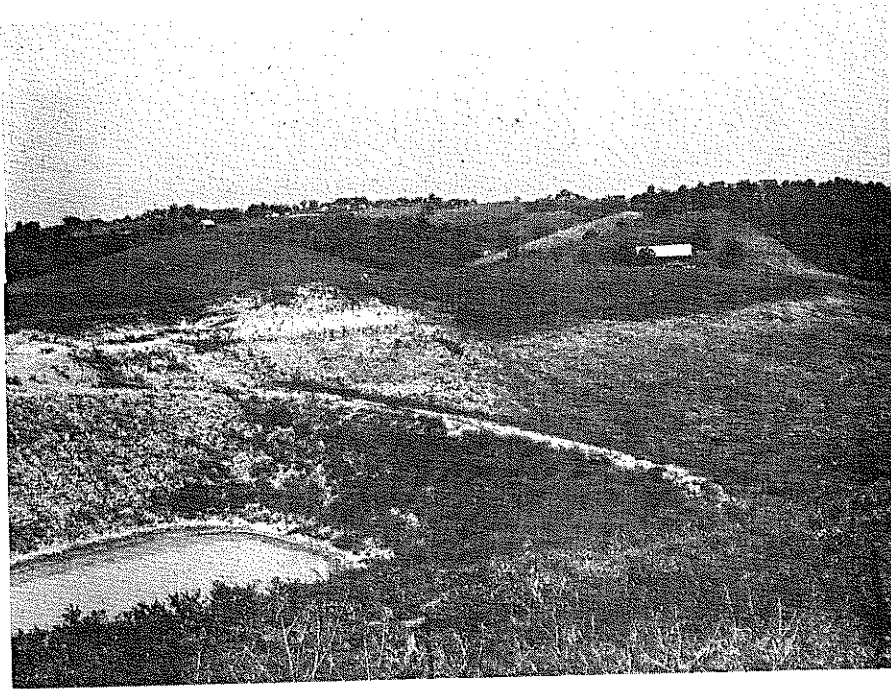


Fig. 3. Topography of the Eden Hill Country.

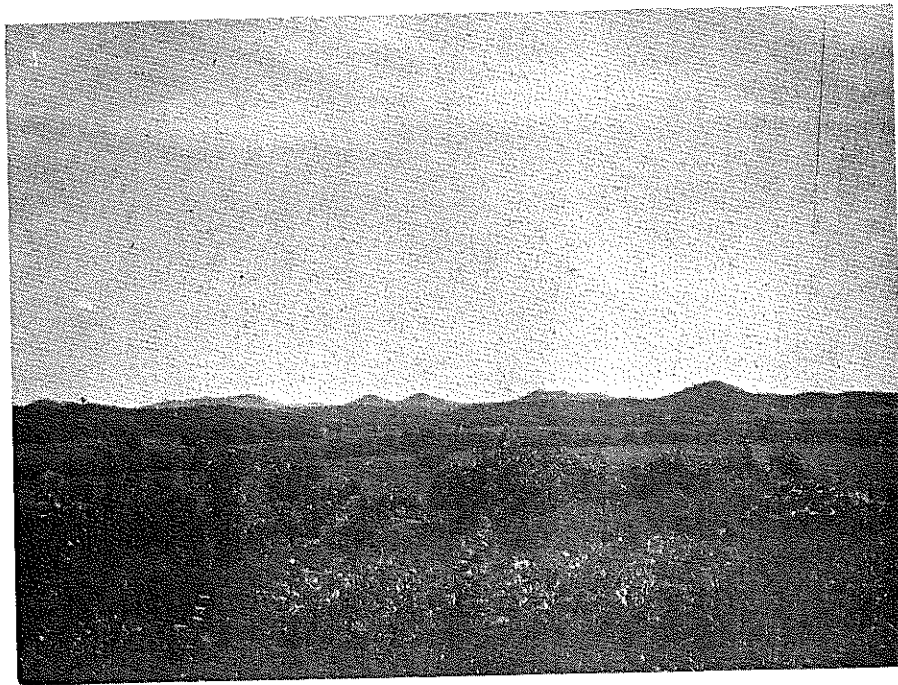


Fig. 4. The gently rolling terrain of the Outer Blue Grass is shown in the foreground. In the background are the conical knobs that encircle the Blue Grass Region.

(see Fig. 5). Except for the larger rivers, the drainage is underground. The gently rolling topography and lack of surface drainage favor the development of thick, residual soils, similar to those of the Blue Grass area. These soils are usually good in Highway construction. In deep cuts, however, a great deal of plastic, unstable clay is frequently encountered.

The region centered around Madisonville is the Western Coal Field, a topographic as well as a structural basin. The country is a dissected plateau with rolling hills and moderately wide valleys. An outstanding feature of this region, as well as of the Jackson Purchase, is the broad alluvial bottoms of the larger rivers. The soils of this area, formed by the weathering of sandstones and shales, are similar to those of the Eastern Coal Field.

The Eastern Coal Field, a region characterized by a rough topography with narrow ridges and deep, narrow valleys, includes all of the states east of the Pottsville Escarpment. Flat lands are at a minimum; but locally, in areas of shale outcrop, numerous bottomlands have developed. Massive sandstones have given rise to local upland floats.

The soils derived from these sandstones and shales are usually quite good subgrade material. Because of the rugged terrain, the deep cuts and high fills required in highway construction consist predominantly of sandstones and shales (see Fig. 6). The bedrock in this area thus becomes of great engineering significance.

The Jackson Purchase is that part of Kentucky lying in the Gulf Embayment, a coastal plain region. It is an undulating plain with very little local relief. The area has been covered and the soils are greatly



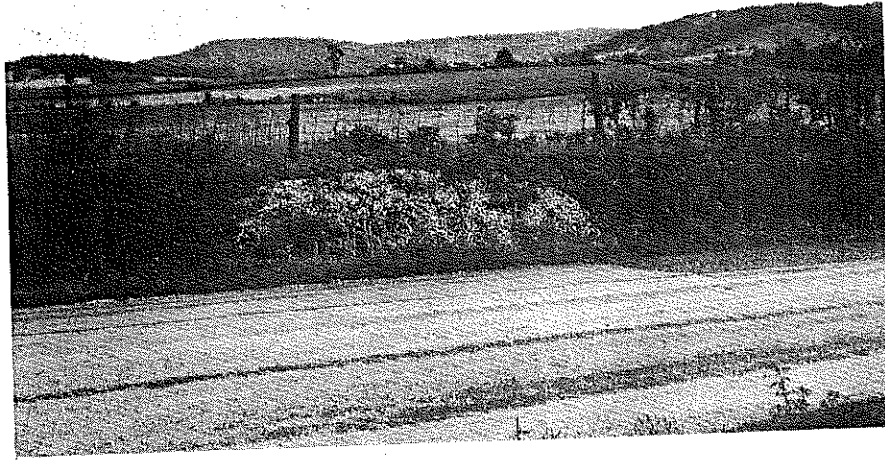


Fig. 5. In the foreground is the gently rolling terrain of the Mississippian Plateaus. The Pottsville Escarpment rises in the background to the Cumberland Plateau of Eastern Kentucky.

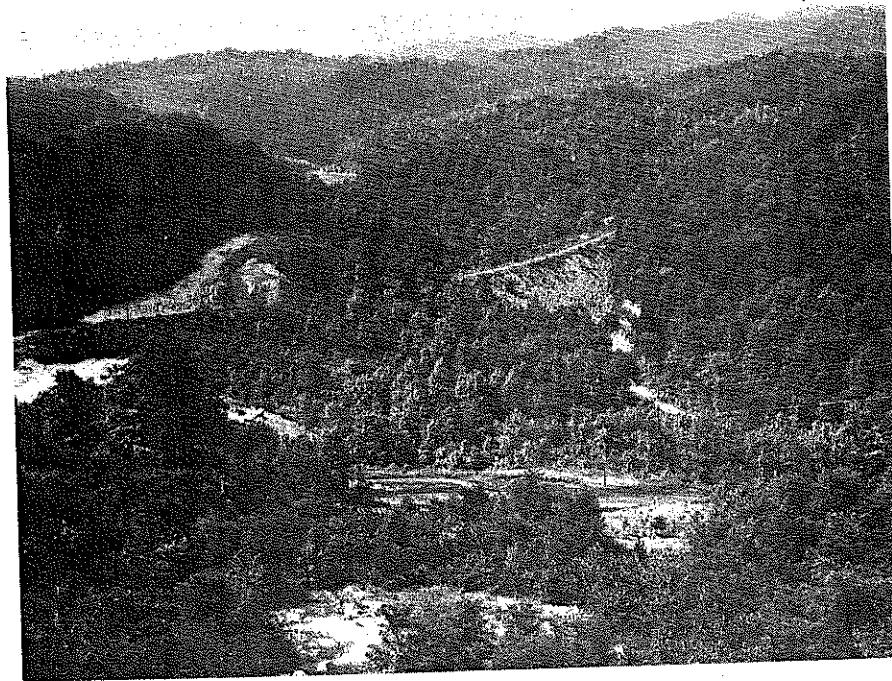


Fig. 6. The rugged terrain of the Eastern Coal Field, showing the deep cuts and high fills required in highway construction.

influenced by the wind-blown loess, which overlays all older materials. Floodplains of large extent have formed along the Mississippi, Ohio, and Tennessee Rivers.

### Engineering Problems of Soils

Soils in the state are greatly varied and the problems encountered in the use of them are numerous. The most logical solution of a soil problem is to "go around" or to choose a more favorable site. Unfortunately, this solution is generally not feasible; consequently, the soil engineer's job is to suggest economical remedies and corrective treatments for the soil and the problem concerned.

Probably the most important soil consideration, particularly in terms of pavement construction, is that of supporting power. When it is realized that soil supports, ultimately, virtually every engineering structure, its importance is forcibly brought to the front.

Numerous problems arise concerning the relationship between the subgrade and the pavement performance. Frost heave, for example, has received special attention in recent years, and is now known to vary with the type of soil encountered. Pumping of joints and cracks in concrete pavements is also associated with soil type. If a soil is known to be subject to frost heave or pumping, corrective measures should be taken during construction to reduce the probability of their occurrence.

With a knowledge of the engineering characteristics of soils, and the occurrence and distribution of these soils, estimates of excavation and conditions can often be made with accuracy. The suitability of

foundation materials, including those at dam sites, can also be determined. The possible locations of construction materials can be selected if information is available concerning the properties and areal distribution of soils.

Landslides in highway work are generally limited to bedrock conditions where deep cuts and side-hill fills are required. The most dangerous geologic formation from this standpoint is the outcrop in the Eden Hill Country of North Central Kentucky. In many cases the cut is not deep enough for the roadway to be located entirely on bedrock and the weight of the required side-hill fill is often great enough to cause slipping. The removal of material from the toe of a slope in a side-hill cut is often sufficient to cause slides to develop above the Highway (see Fig. 7).

With the deeper cuts and higher fills required in present day highway construction erosion problems have increased. Different soils have different erosion characteristics and thus require different treatments. Since drainage, both internal and surface, reflects soil properties, different soils will require different treatments to control water conditions.

#### Mapping and Classification of Soils

The need for soils information for use in the location, design, construction, and maintenance of engineering structures is generally accepted. Field and laboratory methods used to gather such information are many and varied -- and oftentimes too expensive to use for preliminary reconnaissance surveys. There is, therefore, a need for the development and use of shortcut methods.

The agricultural soils scientists have developed a classification and mapping system that they can use to predict soil properties which concern agricultural productivity. Many areas have been mapped by such methods, and many more are being mapped. These maps and surveys contain a wealth of information that would be highly useful to the soil engineer. They are not, however, reported in terms familiar to him; consequently, this source of invaluable soils information remains largely unused by engineers.

Each type of soil, as classified and mapped by the pedologist, has characteristics that will be practically the same wherever that soil type is encountered. Since this condition of similarity holds true for the engineering characteristics of a soil, the agricultural soil surveys and maps can be used for preliminary engineering reconnaissance investigations. If a given soil is found to have practically identical engineering test constants (see Fig. 8) wherever it has been mapped, whether in Fayette County or Mercer County, or even in Tennessee; the information already on record can then be used, eliminating a large amount of the routine testing now considered necessary.

There is now in progress at the Highway Materials Research Laboratory a project designed to give engineering significance, in terms familiar to the engineer, to the agricultural classifications. It is hoped that each soil in the state will eventually be represented by a sheet similar to that shown in Fig. 8 in a kind of "dictionary of soils". The "definition" of the soil would include characteristics that can be observed in the field, such as depths and colors, as well as engineering test constants.

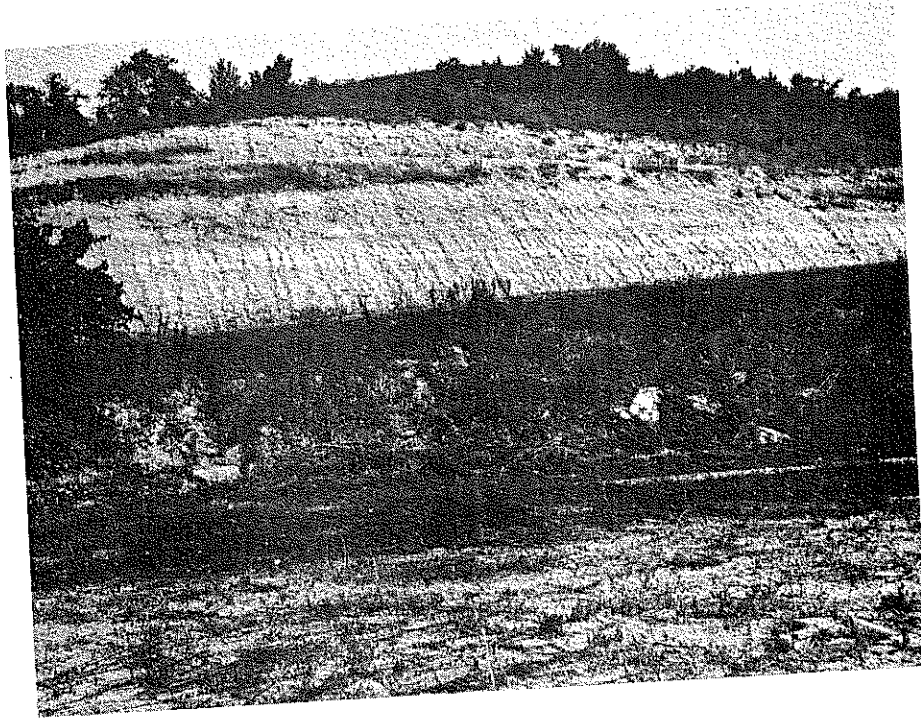


Fig. 7. A Slide in the Eden Hill Country.

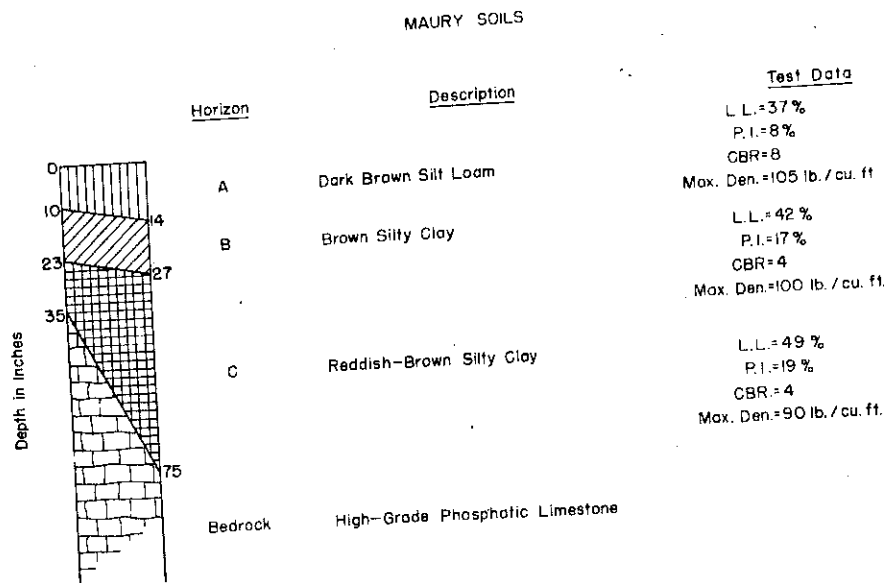


Fig. 8. A Page From a "Dictionary of Soils".

Such an accumulation of soils data would permit the preliminary soils work for an engineering project to be accomplished without the engineer ever leaving the office. Reasonably accurate estimates of the engineering properties and problems associated with the soils can be made before design or construction work is begun.

It was announced recently that the \$7,000,000 topographic mapping program of Kentucky had been completed. Kentucky is now the first state to be covered by a single-scale, topographic map. On the other hand, this state is greatly lacking in pedological maps and surveys. Only 20 of Kentucky's 120 counties have been soil surveyed, and only five of the soil maps are considered to be within modern standards. Kentucky needs an effort, such as that used in the topographic mapping, directed toward pedological soil surveys. Since making the pedological survey and map is a logical and economical point at which to start the engineering soil surveys, the engineers of Kentucky will be at a great disadvantage until much more soil mapping progresses to a much greater degree of completion.