

**PROCEEDINGS OF THE FOURTEENTH ANNUAL  
HIGHWAY GEOLOGY SYMPOSIUM**

**Held**

**March 22, 1963**

**at the**

**A. & M. College of Texas**



**A. & M. College of Texas  
College Station, Texas**

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the

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## ACKNOWLEDGEMENT

Appreciation is expressed to the many persons who attended the sessions and to those who aided with arrangements and the program. Welcoming statements were made by T. S. Huff, Chief Engineer of Highway Design, Texas Highway Department, and Fred J. Benson, Dean of Engineering, A. & M. College of Texas. Presiding officials for the sessions were W. T. Parrott, Highway Geologist, Virginia Department of Highways; Charles J. Keese, Executive Officer, Texas Transportation Institute; Peter T. Flawn, Director, Texas Bureau of Economic Geology; T. S. Huff; and S. A. Lynch.

It is hoped the technical papers published in these proceedings will have useful information for the readers.

S. A. Lynch  
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# APPLICATIONS OF AGRICULTURAL SOIL SURVEYS TO HIGHWAY GEOLOGY

By ADRIAN PELZNER  
Supervisory Highway Research Engineer  
Physical Research Division  
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## Introduction

Until about the beginning of horseless-carriage days, the location of highways in the United States was easily accomplished. The highway builder merely improved existing coach trails. The principal function of the coach trail was to connect centers of population. Little thought was given to the ultimate destination of the traveler. The main job of the road was to get the traveler to a town by nightfall so that he could eat, rest and continue his trip in the morning. Thus, latter day motorists, riding on improved coach trails, are often required to travel in a southerly direction for many miles to reach a destination which may have been due west of their starting point.

Locating a highway facility today can be a bewildering complex assignment. The location engineer must not only choose an alinement that will provide the most service for the most people, but he must also consider many other factors. Some of the other factors he has to consider are:

1. Vertical and horizontal sight distances.
2. Cost of right-of-way.
3. Economic losses and benefits.
4. Balance of earthworks.
5. Cost of construction.
6. Surface and subsurface soil and rock conditions.

This paper is primarily concerned with the soil and rock condition factor in connection with highway route locations.

## Soil and Rock Conditions

The various state highway departments and other agencies concerned with highway route location are giving much consideration to soil engineering and highway geology. These two disciplines augment and supplement each other. To merely consider only the engineering properties of soils, and ignore the geological agents of transformation, transportation and deposition, often has caused engineering disasters. When the location engineer has been provided with a geological report for several different highway alinements, he can intelligently evaluate the soil and rock condition factor. For example, if he knows that a soil deposit is eolian, such as sand dunes, it will follow that the soil material will be uniform in size at any one location and the particles will be cohesionless or nonplastic. Thus, armed with this knowledge he can (1) be provided with

preliminary information on the engineering properties of the soil deposit and the degree of variation of these properties both vertically and horizontally and (2) plan the type of subsurface exploration that is required. Therefore, it is quite apparent that, in connection with the location of highways, a knowledge of the geology of the area is fundamental to the study of engineering behavior of soils.

### Sources of Information

A highway geologist when acquiring knowledge of the geology of an area through which a highway is to pass should walk the area, make field observations and take samples for laboratory study. However, prior to any of these steps he will study the geological literature of the area. Fortunately, in this country there is available much information concerning surface and subsurface conditions. Some of these sources of information are:

1. Topographic maps - United States Geological Survey.
2. Geological maps and reports - State Geological Survey and United States Geological Survey.
3. Master's and Doctor's theses - Universities.
4. Files of agencies concerned with construction - state highway departments, Departments of public works, etc.
5. Aerial photographs - United States Geological Survey, United States Department of Agriculture, etc.
6. Soil survey bulletins - United States Department of Agriculture.

The soil survey bulletins are listed last since the remainder of this paper will be concerned with them. They are by no means the least important source of information.

### Soil Survey Bulletins

In many ways a well written, modern soil survey bulletin gives the highway geologist the most information concerning surface and subsurface conditions for the least investment of time, money and effort. The soils that are described in the bulletins are classified into the pedological system. Consequently, the soils engineer or highway geologist who uses the soil survey bulletin should know something of pedology. Pedology is the science that deals with soil as a natural body. The pedologist studies the origin and development of a soil, determines its physical and chemical properties, assigns a pedological classification and delineates it on a soil map. A basic principle in pedology is that if the factors of climate, time, topography and parent material are

the same, the soils developed or influenced by these factors will be the same. This principle is particularly significant to the highway geologist because the soil throughout a mapped soil unit has similar engineering properties and therefore its engineering behavior can be predicted.

The soil survey bulletins contain sufficient background information on pedology to permit the highway geologist to extract the desired engineering information. Such terms as soil profile, series, type and horizon are defined. The formation, classification and morphology of the soils are described.

Cooperative Program of Soil Conservation Service, Bureau of Public  
Roads and State Highway Departments

The Bureau of Public Roads recognized the value of soil survey information to the highway engineer and geologist and, in 1951, entered into a cooperative agreement with the U. S. Department of Agriculture to perform engineering tests on samples submitted by the Department of Agriculture or other agricultural agencies cooperating with USDA in the National Soil Survey.

The test data are reported in the county soil survey bulletins and serve as a basis for engineering interpretations and estimates. Having the engineering test data, a logical expansion was to prepare an engineering interpretations section for the county soil survey report. Currently, most of these engineering sections are prepared by Soil Conservation Service personnel of the U. S. Department of Agriculture with some assistance from highway engineers. The Bureau of Public Roads assists Soil Conservation Service in editing the engineering section of the report.

There are approximately 3,500 counties in the United States. Although samples are not being submitted for all these counties at the same time it was evident from the beginning of the cooperative program that the Bureau's testing facilities would be severely overtaxed if the Bureau of Public Roads was to perform engineering tests on all the soil samples collected in these county soil surveys. Because of this and other factors the Bureau has encouraged state highway departments to enter into three-way cooperative arrangements with the Soil Conservation Service and the Bureau of Public Roads whereby the state highway department would do the testing and assist in the writing of the engineering sections. This type of arrangement serves the double purpose of giving the state highway department confidence in the reported data and encouraging the State highway department to use the information contained in soil survey bulletins for choosing route locations, planning pre-construction soil surveys and indicating potential construction material sources.

Since the inception of the cooperative program there have been over 10,000 samples taken for engineering tests in 392 counties in 47 states and Puerto Rico. Thirty-four

state highway departments are cooperating in this program. Over 100 soil survey bulletins have been published containing an engineering section, and, as of January 1, 1963, 71 were being processed for publication.

The Texas Highway Department was one of the first state highway departments to enter into cooperative arrangements with Soil Conservation Service and the Bureau of Public Roads. Their participation in the National Soil Survey program dates back to 1957. As of January 1, 1963, the Texas Highway Department has supplied engineering test data and additional information for the engineering sections of 21 county soil survey bulletins. The information contained in one of these bulletins (Lamb County, Texas) is discussed in the following sections.

### Soil Survey Bulletin for Lamb County, Texas

The type of information contained in a modern soil survey bulletin is depicted by the following listing from the Table of Contents of the Lamb County soil survey bulletin:

1. General nature of the county.
2. General soil areas.
3. Description of the soils.
4. Wind erosion and its control.
5. Use and management of the soils.
6. Engineering applications.
7. Formation, classification and morphology of the soils.
8. Additional facts about the county.
9. Glossary.
10. Literature cited.
11. Guide to mapping units, capability units and range sites.

A highway geologist or soils engineer when using the Lamb County bulletin to extract information on soil and rock conditions in the county and in planning a detailed soil survey for a proposed highway alignment would be most interested in the "Engineering Applications" section and the information in the geology section. The geology of the area is one of the items included under the general heading "Additional facts about the county."

### Geology Section

The geology section reviews the geologic history of the area starting with the formation of the Permian Red Beds from marine sediments deposited from a shallow inland

sea. The High Plains rose above the level of this sea and streams flowing over the exposed Permian Red Beds eroded fine-textured materials and redeposited them in flood plains. These materials formed the Triassic Red Beds. The area was again inundated and sand, clay and limestone were deposited over most of the area forming Cretaceous deposits. These were later mostly eroded away after the Rocky Mountain uplift.

As the Rocky Mountains eroded, gravelly, coarse material was deposited in alluvial fans. The finer materials were transported and spread farther to the east. The Ogalalla formation developed from these deposits of outwash. The text describes the deposition of the Ogalalla formation as the outstanding geologic event in the history of Lamb County since it is the main source of irrigation water in the county.

The materials from which the soils of the county developed were deposited during the Pliocene epoch and were later reworked, mostly by wind, in the Pleistocene epoch. This wind shifted and sorted the surface materials.

Although the geologic history, as described in the bulletin, is rather brief, it certainly helps the user of the report to understand the nature of the geologic agents that have been at work in the county. Certainly the information contained in the engineering applications section can be better understood when the geologic history of the area is comprehended.

### Engineering Applications Section

The principal subsections of the Engineering Applications Section of the Lamb County report will be described in some detail.

#### Engineering Classification Systems

The engineering classification systems that are used in the soil survey bulletin are based on the gradation and plasticity a soil material possesses. In general, if a soil is non-plastic or very slightly plastic and is coarse textured it is best suited for engineering purposes.

In the unified classification system, used by the U. S. Corps of Engineers, Bureau of Reclamation and other engineering agencies, pairs of letters are used to designate the soil groups. The first letter of the symbols used in this report are S, M, and C standing for sand, silt and clay, respectively, while the second letter of the symbols are P, L, and H meaning poorly graded, low and high plasticity, respectively.

In the AASHO system, a method standardized by the American Association of State Highway Officials, the soil materials are classified from A-1, gravelly soils of high bearing capacity, to A-7, clay soils of low bearing capacity when wet.

#### Soil Test Data and Engineering Properties of the Soils

Twenty-one soil series have been mapped in this county. The areal extent of five of these series comprise approximately 65 percent of Lamb County. Five soil types have been selected as examples from the table in the bulletin that shows the estimates of properties that are significant to engineering of all the soils that are mapped in the county. Portions of this table of estimated properties are shown in Table 1. The data given in the "Percentage passing sieve" column are estimates which are based on actual test data, when available, or test data for similar soils from other counties. The shrink-swell potential of a soil, reported in the last column, is the property of the soil material to change volume when subjected to changes in moisture. A soil that is rated high in shrink-swell potential is of significance to engineers since it can cause severe damage to the engineering structures built on it.

The Amarillo comprises 45 percent of the land area of the county. Other than its being erodible, it does not have properties that would cause engineering problems.

The information of significance concerning the Arvana soil is the presence of rocklike caliche at a shallow depth, as indicated in the description column. The text advises that the soils in Lamb County do not provide a source of sand or gravel and that bedrock is not likely to be encountered. Therefore, the Arvana and a few other soils in the county are very significant in that they indicate local areas of potential aggregate supply.

The Brownfield is similar to the Amarillo in that it does not have properties that would cause engineering problems other than its erodibility.

The information in the description column for the Randall along with the estimated classifications of A-7-6 and CL warn the engineer and geologist concerned with highway location of potential trouble. They should certainly avoid locating a highway in the Randall if at all possible.

The information concerning the eolian nature of the Tivoli is of particular significance to location engineers and geologists. Deep shifting sand dunes present design, construction and maintenance problems. This soil should also be avoided whenever possible.

The soil survey bulletin for Lamb County also contains a table of test data prepared by the Bureau of Public Roads from test reports supplied by the Texas Highway Department. This table is of interest since it reports actual test data for some of the

