COOPERATIVE SOIL MAPPING PROJECTS
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LAFAYETTE INDIANA

by

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Technical Paper

COOPERATIVE SOIL MAPPING PROJECTS IN INDIANA

TO: K. B. Woods, Director January 25, 1961
Joint Highway Research Project

FROM: H. L. Michael, Assistant Director File No: 1-5-2
Joint Highway Research Project Project No: C-36-51B

Attached is a technical paper titled "Cooperative Soil Mapping Projects in Indiana" by R. D. Miles and W. T. Spencer. This paper was presented at the Annual Meeting of the Highway Research Board in January 1961.

The material presented in the paper has been previously submitted to the Advisory Board in more detailed form. It was prepared in the attached summary form for publication and dissemination.

The technical paper is presented to the Board for the record and for approval for publication by the Highway Research Board.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Secretary

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Joint Highway Research Project

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Purdue University
Lafayette, Indiana

January 25, 1961

REPORT

REPORT TO THE BOARD OF DIRECTORS

REPORT OF THE BOARD OF DIRECTORS
ON THE
ANNUAL MEETING OF THE
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COOPERATIVE SOIL MAPPING PROJECTS IN INDIANA

by

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SYNOPSIS

The Soils Section of the State Highway Department of Indiana uses agricultural soil maps, surficial and bedrock geology maps, aerial photographs and published literature to assist them in preliminary engineering studies of soil along a proposed highway. In cooperation with the Joint Highway Research Project, special soil strip maps have been prepared, several county engineering soil maps have been and are being compiled, and special publications on utilization of agricultural soil maps by soils engineers have been developed.

A cooperative project between these highway agencies, the Bureau of Public Roads and the Soil Conservation Service has been initiated to develop and compile data on soil profiles within the various counties. These data will be used in an engineering section of the agricultural soil survey report, and will be used as supplementary data to the engineering soils maps.

This paper is a discussion of the applicability of the strip maps and area soil maps to highway planning and the development of field exploration programs in Indiana. The methods of map presentation are discussed.

INTRODUCTION

The Soils Section of the State Highway Department of Indiana, in making recommendations for the design of a proposed highway, bases its decision on the analysis of soils information obtained by indirect and direct methods of exploration. The direct methods of soil sampling and laboratory analysis are standard and need not be discussed. They furnish criteria on engineering soil types and physical properties on which design recommendations are based.

The indirect methods, whereby actual contact is not made with the soil, involves the utilization of:

1. published agricultural soil survey reports,
2. aerial photography, or
3. combinations of the two with additional information obtained from geological publications and maps.

To assist the engineer in evaluating these data contained in the published reports and portrayed upon aerial photographs, cooperative soil mapping projects were developed at Purdue University by the Joint Highway Research Project.

These cooperative projects evolved from an early attempt to utilize published agricultural soil survey reports. This study resulted in the publication of a soils manual on "The Formation, Distribution, and Engineering Characteristics of Soils," Bulletin 87, Purdue University. This manual with the variables of parent material, topography and soil profile development is used in conjunction with aerial photographs to make preliminary engineering soils maps. These preliminary engineering soils maps may be prepared for entire counties or for individual highway sections in the form of strip soils maps.

A new cooperative soil mapping project was established in July 1960. This new project involves the development of an engineering section in the Agricultural Soil Survey Report. The cooperating agencies are the Bureau of Public Roads, the Soil Conservation Service, the State Highway Department, and the Joint Highway Research Project. The engineering section will be based on soil test data of the important pedological soils in a county.

It is the purpose of this paper to discuss the applicability of the various types of maps to highway engineering and the development of field exploration programs.

County Agricultural Soil Survey Reports

County Agricultural Soil Survey reports and maps prepared under the soils mapping program of the Department of Agriculture have been published in Indiana since about 1900. The early reports and maps developed prior to about 1925 are of little value to the engineer except as a reconnaissance type soil survey. Current soil mapping techniques have shown that care must be exercised in evaluating the pedological soil types shown in these early reports.

The reports and maps published since about 1925 are suitable for interpretation into engineering terms and to locate soil problem areas. The soil mapping scheme used presently by the Soil Conservation Service was essentially standardized about that time. Figure 1 shows those county soil surveys presently being used in preliminary soil studies for highway engineering purposes.

The interpretation of these maps and reports in Indiana is facilitated by the use of information published in the soils manual on "The Formation, Distribution and Engineering Characteristics of Soils." This manual includes an engineering summary of 146 major pedological soil profiles as mapped in Indiana

FIG. 1
AGRICULTURAL SOIL
SURVEYS 1925-1960

by the agricultural soil scientists. The soil profiles are correlated with engineering test data to include physical soil properties and highway performance data in relation to subgrade, embankment and foundation conditions. The pedological soil names as such are not used in Indiana highway mapping projects; however, they are used for evaluation and comparison of soil textural changes and profile development that might influence design.

The engineering soils manual published in January 1943 was prepared by personnel of the Joint Highway Research Project for the State Highway Department of Indiana. Although it contains only the pedological soil profile information that had been accumulated up to the year of publication, it continues to be of great value in assessing soils on even the most recently published soil survey reports. Numerous new soil series, types, and phases have been added by the Soil Conservation Service since the publication of the manual; therefore, it is necessary to correlate the new soil series and their parent material types with those published in the engineering soils manual. This may be done by reference to the report section of the agricultural soil survey and determining the slope and parent material class for the new soil series and comparing this with a similar series in the engineering soils manual. Valuable information may be obtained by reference to the tentative and adopted soil series descriptions that are published by the National Cooperative Soil Survey, Department of Agriculture.

To further enhance the value of the agricultural soil survey report to the engineer, an engineering section is needed to complement the information presented. To accomplish this, the Joint Highway Research Project, the Bureau of Public Roads, the Soil Conservation Service and the State Highway Department have entered into a cooperative agreement. The purpose of the project is to

provide engineering test data on the important soil series that occur within a county. These engineering test data will assist in developing an engineering section to be included in all future agricultural soil survey reports.

The preparation of the engineering soils section as it is being developed in Indiana is primarily the responsibility of the agricultural engineer, Soil Conservation Service, with advice and review by the highway engineer. The soil samples of the major pedological soil series within a county will be collected by field personnel of the Soil Conservation Service. The samples with complete field notes including location on an aerial photograph will be forwarded to the Joint Highway Research Project for testing.

Engineering tests will be performed by the Joint Highway Research Project on all soil samples from the various soil horizons. The data for the preparation of a table on physical constants will be supplied to the Bureau of Public Roads for transmittal to the Soil Conservation service for inclusion in the report. The summary of the soil test data will include the pedological soil type, soil horizon sampled and depth, parent material type, soil textural description, mechanical analysis, liquid limit, plasticity index, standard density and optimum moisture content, CBR values, and both the AASHO and Unified soil classification. Appropriate explanatory notes will be included in the report section to explain the table and its use. A summary table to explain both the AASHO system of soil classification and the Unified system of soil classification will be included.

As a part of the engineering section of the agricultural soil survey report, information will be presented in tabular form on all the soil series and types mapped within the county. Estimates will be made of the physical properties or

characteristics within the soil profile that may effect the design or the application of treatment measures in civil engineering. Qualitative or quantitative data will be presented on such items as: seasonally high water table; soil permeability; shrink-swell potential; susceptibility to frost action; erosion potential; internal and external drainage conditions; landslide potential; and suitability of soil material as a pavement subgrade, road fill, source of top-dressing, and source of sand and/or gravel; and soil profile features affecting engineering practice to include vertical highway alignment and embankments.

The new agricultural soil survey reports with engineering sections developed by the Soil Conservation Service will contain soil maps prepared on an airphoto base map. The engineering soil test data combined with the land use information shown on the airphoto mosaics will make these maps and reports of inestimable value in preliminary studies of highways or any other civil engineering project.

As engineering test data is accumulated on the major pedological soil series in the State of Indiana, it is contemplated that a new engineering soils manual will be prepared. The general format of the previous engineering soil manual will be followed, but important new pedological soil series and test data will be included. A manual of this type will be of great value to all highway engineers.

County Engineering Soil Surveys

County engineering soil surveys prepared by the use of aerial photographs have been developed for the State Highway Department by the Joint Highway Research Project. These maps serve a need in those counties for which agricultural soil surveys are not available. In some cases, the engineering soils map is prepared for a county that has also been mapped with an agricultural soil survey. Both

the soil survey and the aerial photographs are used to prepare the engineering soils map. This procedure is used in an attempt to expedite the development of the county engineering soils mapping program. It will be used extensively in conjunction with the new agricultural soil surveys that contain engineering test data. Figure 2 shows the thirty-one county engineering soils maps that have been completed as of December 1960. Four more are in various stages of completion, and the present rate of production is about two per year.

An example of a published county engineering soils map is shown in Figure 3. Selective sampling of major soil profiles and parent material areas are conducted in conjunction with the mapping program and laboratory soil tests are performed. A summary table of soil tests is presented as a part of the map. These data show the range of engineering soil types that may be expected in the county. No attempt is made to sample in the quantity needed to develop pavement designs.

The standard system of line symbols used in the county engineering soils mapping program is shown in Figure 4. Persons familiar with this symbol system will recognize that it is an attempt to show parent material-land form conditions, topographic conditions, soil drainage conditions, and soil textural conditions of the parent material. Only line symbols are used, and problems naturally arise in such a mapping system. At the scale of maps presently being developed it is serving its purpose.

These maps are used in preliminary studies to anticipate problem soil areas or to locate areas that may be developed as borrow materials. In essence they provide the soils engineer and the location engineer with information on the distribution of coarse-textured soils, fine-textured soils, and peat deposits.

FIG. 3 ENGINEERING SOILS MAP OF
 CASS COUNTY, INDIANA

SYSTEM OF SYMBOLS FOR ENGINEERING SOIL-MATERIALS MAPPING

PART-A

BASIC SYMBOLS AND GROUPING OF PARENT MATERIALS ACCORDING TO ORIGIN

RESIDUAL			TRANSPORTED BY		
SEDIMENTARY	METAMORPHIC	IGNEOUS	ICE	WATER	WIND
10 SANDSTONE	13 GNEISS	15 GRANITE	20 OLD DRIFT, TILL PLAIN	28 VALLEY TRAIN, TRANSITION	39 SAND WITH INCIPIENT DUNE DEVELOPMENT
11 LIMESTONE	14 SCHIST	17 BASALT	21 YOUNG DRIFT, TILL PLAIN	29 VALLEY TRAIN, TERRACE	40 DUNES
12 SHALE	15 SLATE	18 LAVA	22 MORaine	30 RECENT ALLUVIUM	41 LOESS (SILT)
		19 VOLCANIC ASH	23 KETTLE-KAME	31 ALLUVIAL FAN	
			24 ESKER	32 OUTWASH PLAIN, TRANSITION	
			25 KAME	33 OUTWASH PLAIN	
			26 DRUMLIN	34 VALLEY FILL	
			27 WATER-MODIFIED YOUNG DRIFT	35 LAKEBED	
MISCELLANEOUS				36 BEACHES AND BEACH RIDGES	
42 PEAT & MUCK, SMALL AREAS	47 GRAVEL PITS			37 CORAL	
43 PEAT & MUCK, LARGE AREAS	48 ROCK QUARRIES			38 DELTA	
44 HIGHLY ORGANIC TOP SOIL	49 STRIP MINES				
45 MARSH					
46 BOULDER BELT					

PART-B

TEXTURAL SYMBOLS

NOTE: The textural symbols are to be superimposed on the basic symbols.

FIG. 4

This information assists in the study of alternate routes. It assists in determining those soil areas of somewhat uniform conditions versus those areas of complex soil conditions; thus, enabling the development of a field survey to secure maximum soil information with limited testing.

The county engineering soils maps are prepared at a scale of one-inch equals one-mile. No attempt is made to obtain the detail that is presented on the recent agricultural soil surveys. Such detail could not be obtained by the art of airphoto interpretation unless the airphoto was used as a plane-table base map in the field. In most cases, it is believed that this detail is not warranted. It is believed that the location and preliminary design is influenced by the average textural conditions of soil horizons and parent material types with special designs required over organic terrain or other special terrain types.

Highway Soil Strip Maps

The Joint Highway Research Project prepares special soil strip maps from aerial photographs. The purpose of these maps is to provide the Soils Section of the State Highway Department of Indiana with advanced information on soil types and drainage conditions along proposed routes. The maps serve as a guide for the planning of any detailed investigation that may appear advisable.

Two types of strip maps have been prepared. One type is a line drawing showing the distribution of soil materials. Typical soil profiles as shown on Chart 1 and as obtained from the engineering soils manual previously mentioned provide a guide to the three dimensional development of soils within the region mapped. The profiles are intended to indicate either uniform soil development where extensive sampling is not required, complex soil development that requires detailed field sampling and the probable depth of organic soils that may require

CHART I — PEDOLOGICAL SOILS AND THEIR RELATIONSHIP TO PARENT MATERIALS AND TOPOGRAPHY

PARENT MATERIAL AREA	NATURE OF PROFILE	CLASSIFICATION				RECENT ALLUVIAL SOILS AND SPECIALS
		S	L	O	P	
		55% 16%	16% 4%	0%		
WISCONSIN	I SILTY-CLAYS	MIAMI HENNEPIN	MIAMI PARR RUSSELL CARRINGTON GALENA ST CLAIR	CROSBY CONOVER FINGASTLE TORONTO NAPPANEE	BETHEL ODELL DELMAR HELT CORWIN DANA FOX WARSAW HOMER BRONSON DELPHI HARTMAN WAUKESHA MILL CREEK TRACY WEA	BROOKSTON CLYDE GENESEE EEL WAYLAND COPE PAULDING ABINGTON BRADY DILFORD WESTLAND WAUMEE MUCKS, ETC. CARLISLE EDWARDS HOUGHTON KERSTON MALLKILL PEAT MARL
	II POROUS SUBSTRATA (SANDS AND GRAVELS)	BELLEFONTAINE RODMAN	BELLEFONTAINE			
DRIFT	III SANDS	PLAINFIELD BRIDGEMAN	PLAINFIELD COLOMA HILLSDALE METEA ALLENDALE	PLAINFIELD BUCKNER METEA ALLENDALE MILTON HARTMAN LUCAS	NEWTON MAUMEE DILLON DE MOTTE MILLSDALE FULTON	GRIFFIN
	IV SHALLOW SOILS ON BEDROCK	FARMINGTON LORDSTOWN	FARMINGTON LORDSTOWN MILTON			
LACUSTRINE	V DERIVED FROM WISCONSIN DRIFT					
	VI DERIVED FROM ILLINOIAN DRIFT (SILT AND SILTY-CLAY)	BAINBRIDGE	BAINBRIDGE DWELL WHEELING	HAUBSTADT ELKINSVILLE PEKIN BARTLE SCOTTSVILLE WEINBACH GINAT MARKLAND MCARY TYLER CALHOUN BUCKNER	DUBOIS ROBINSON LYLES ZIPP MONTGOMERY SHARKEY VINCENNES BLANCHESTER GENESEE EEL	HUNTINGTON LINDSIDE POPE PHILO ATKINS STENDAL
ILLINOIAN TILL	VII SILTS AND SILTY-CLAYS	PARKE	CINCINNATI GIBSON PARKE	GIBSON ROSSMOYNE VIGO CORY	AVONBURG CLERMONT LOY	
	VIII SHALLOW SOILS ON BEDROCK		GRAYFORD JENNINGS	CANA WHITCOMB		
WINDBLOWN AND LOESS-LIKE	IX SANDS	PIKE	PRINGETON OAKTOWN	ELKINSVILLE		STASER INGLEFIELD MCOUTCHAN
	X SILTS		PIKE PRINGETON ALFORD HOSMER	OWENSVILLE AYRSHIRE IVA COE		
RESIDUAL	XI LIMESTONES	CORYDON	ORLEANS FREDERICK HAGERSTOWN BLODMINGTON	LAWRENCE BEUFORD	OUTHRIE	BURGIN HUNTINGTON
	XII STRATIFIED LIMESTONES AND SHALES	FAIRMOUNT	SWITZERLAND	ALLENSVILLE LAWRENCE	OUTHRIE	
RESIDUAL	XIII SANDSTONES AND SHALES	MUSKINGUM	ZANESVILLE WELLSTON	TILSIT	LICKDALE	STENDAL

† LESS DRILLABLE PARENT MATERIAL THAN OTHER SOILS IN BOX
NOTE — SEE INDIVIDUAL PLATES FOR DETAILED SOIL PROFILES

• SAND • SAND SUBSTRATUM • SAND ON SILTY CLAY • SAND SUBSTRATUM

removal. An example of this type of map for use in preliminary surveys is illustrated in Figure 5. The maps are prepared at a scale of three inches equals one mile or larger. They are prepared by direct tracing of the aerial photographs, and are symbolized in the standard manner as used by the Joint Highway Research Project as shown on Figure 4.

The second type of strip map that has been prepared consists of a plan showing soil borders with the actual aerial photographs serving as the base map. It is produced by photographic reproduction of annotated aerial photographs. It may be prepared at the scale of the photographs or it may be enlarged two to four diameters. A difficulty that has been encountered in the enlarging process has been that the smooth borders drawn on the aerial photographs are irregular and much larger than needed upon enlargement as shown in Figure 6.

The soil strip map prepared with the aerial photographic base is much preferred over the line drawing. It should be prepared at the largest scale possible, and if enlargement is desired the aerial photographic stereopairs should be enlarged prior to annotation. A written report should accompany each map, or the qualitative description of the soils may be typed and attached to the photo base so that it will reproduce as a part of the strip map.

The soil strip maps shown in Figure 5 and 6 illustrate primarily a region of glacial-fluvial outwash plains with low sand dunes and broad muck basins. The regional extent of the soil materials can be readily outlined on the airphotos, and good correlation can be obtained with typical engineering soil profiles contained in the soils manual on the basis of topographic position and photo tonality. A field inspection of the project by the Soils Section confirmed the accuracy of the information supplied by the written report and the strip maps.

AIRPHOTO MOSAIC

NORTHERN SECTION

S.R. 39

LAPORTE COUNTY

Scale 1" = 3 mi

FIG. 6. ENGINEERING SOILS STRIP MAP PREPARED BY PHOTOGRAPHIC REPRODUCTION

Since the low, flat terrain dictated a high level profile and deep special side ditches, the only problem that needed special attention was limited to the profiling of the muck and organic sand deposits. The organic sands were found not to be objectionable, but the removal of the muck areas were incorporated in the construction project. The limits of removal were defined by field surveys.

Figure 7 illustrates an engineering soils strip map along two highway sections that were programmed for reconstruction. The soils strip map was made from aerial photographs, and a soil survey was conducted in the field to verify the accuracy of the map. The field survey also served to define the limits of the peat and organic deposits so that the Soils Section could determine the type and extent of treatment required.

The engineering soils strip map shows symbolically that the area consists of a sand plain, scattered sand dunes, an organic sand plain underlain with sand, and muck depressions and channels. The soil profiles illustrated were taken directly from the soils manual by reference to Chart 1 using topography and parent materials as the variables in the airphoto study. It was expected that the sand deposits would be classified as either A-3 or A-2 and that problems of compaction would occur. The organic deposits were expected to be of variable depth with some exceeding eight feet.

The field inspection confirmed the accuracy of the map and report, and verified its use as a source of information in preliminary studies. Only limited testing seemed advisable. Table 1 is a summary of the tests performed on field samples secured along the alignment of State Road 10.

Information obtained from the airphoto study and, of course, from the field study dictated a high level grade line with a deep side ditch. Construction of the project confirmed the accuracy of the information obtained from the written report, strip maps, and field soil survey.

FIG.7. ENGINEERING SOILS STRIP MAP ALONG TWO HIGHWAY SECTIONS PROGRAMMED FOR RECONSTRUCTION.

TABLE 1
Summary of Soil Tests

Station	Depth	Gravel	Sand	Silt	Clay	LL	PI	Loss on Ignition	Texture	AASHTO
380-10' Rt	0.0- 1.5	2	85	7	6	22	3	5	Sand	A-2 (0)
405-15' Rt	0.0- 4.5	0	94	4	2	19	NP	--	Sand	A-3 (0)
411-45' Rt	0.0- 2.6	0	79	--	21	97	2	40	Org. Sandy Loam	A-8 (Peat)
467-5' Rt	0.0- 7.7	0	71	--	29	99	8	73	Org. Sandy Loam	A-8 (Peat)
561-15' Rt	0.0- 4.0	0	91	5	4	17	NP	--	Sand	A-3 (0)
580-30' Rt	0.0- 0.7	0	83	12	5	33	2	7	Sand	A-2 (0)
635-10' Lt	9.5-11.8	-	--	--	--	48	8	6	Marl	Marl
636-11' Lt	1.5- 4.5	-	--	--	--	83	3	35	Peat	A-8 (Peat)
	4.5-13.0	-	--	--	--	62	NP	32	Peat	A-8 (Peat)
636-40' Lt	0.0- 2.8	-	--	--	--	155	12	67	Peat	A-8 (Peat)
	2.8-10.8	-	--	--	--	172	9	77	Peat	A-8 (Peat)
723-25' Lt	0.0- 2.0	0	87	6	7	19	2	3	Sand	A-2 (0)
730-26' Rt	1.2- 3.0	0	85	4	11	17	1	--	Sand	A-2 (0)

Summary

The cooperative soil mapping projects discussed are valuable in preliminary studies. The agricultural soil survey maps properly evaluated, the county engineering soils map, and the individual engineering soil strip maps with typical soil profiles are highly adaptable to highway planning, design and construction. The consistency or variability of soils to be encountered in cuts can be determined for establishing the pavement grades and types of treatment to be used. Locations of possible sources of granular materials for project uses

can be indicated. Areas for special borrow, where materials are needed for embankment construction and not available within the right-of-way can be selected.

The system of soil mapping symbols is suitable for uniform mapping practices of counties and small scale strip maps. Even these symbols require "interpretation", and typical soil profiles are needed to complete the soils information. The soil profiles as contained in the soils manual for Indiana are suitable for preliminary studies.

The ideal soil strip map should be prepared by using large scale aerial photographs or enlargements as the base map with annotations to show soil areas and soil profiles. To determine the applicability of this type of map, it is anticipated that a cooperative soil strip mapping project will be developed using contact prints at a scale of 200 feet per inch and enlargements at 50 feet per inch. This scale should provide the detail for a master soil plan along proposed routes.