How Oklahoma Uses Its Present Highways to Establish Criteria for Evaluating Future Structural Design Need

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This paper discusses the possibility of using existing highways as research projects to obtain highway performance data and using existing pedological information to define the soils, topographic and climatic environment of the highways.

It is suggested that analysis of the data from a large number of projects in many different environments would lead to a better understanding of problems of highway design.

● THE PURPOSE of this paper is to call attention to some existing sources of information which are worthy of much serious study by engineers working for the improvement of highway design methods.

Much valuable highway research has consisted of constructing a known kind of road, recording the kind and volume of traffic using it, and evaluating the performance of the paving. To some extent all highways that have been built to a rational design can be used as research projects. Although the records of the design and construction may not have been kept in as much detail as is customary on a research project, the many miles of projects and the variety of conditions and environment available for study will more than compensate for the lack of preliminary data.

The climatic environment of the area in which a research project is constructed is seldom considered as effecting pavement performance, even though there is much evidence to indicate that climate is a major factor in the depreciation of most things; for example, war experience demonstrated that many things which gave good service in the climate of the United States depreciated rapidly in the climate of the Pacific islands.

Soil is so important in the study of pavements that all information about the soils on a research project is unquestionably of value. There is a great store of pedological and agricultural soils knowledge waiting to be put to use by the engineer. The agricultural soils data consist mostly of descriptive information and differ from the usual engineering soils data, which are in the form of figures giving the results of soil tests.

This is an age of specialists. There is a tendency for each group of specialists to confine its thinking to a rather narrow field and to feel that the accumulated knowledge, the multitude of facts, and the many accepted rules developed by the group can only be used within the boundaries of that particular science. It is well to remember that a physical fact or a scientific truth belongs to all groups of people, and can be safely used in any field of study. Thus, translation of pedological ideas and terms to those of engineering may be helpful.

Both the agricultural science and highway engineering begin with the soil. The same rain that erodes a farm will wash away a highway embankment. The same rules that farmers use to reduce erosion of farms will also reduce erosion of highways. The fundamental relationship of agriculture and highway engineering is demonstrated in many ways.

In large areas of good land with a suitable climate, will be found productive farms which will support a large population. So the kind of soil and the climatic environment of the soil, to a large extent, locate the towns. Roads are built to connect towns and it can be said that the soil is a fundamental factor that determines where the farms shall be and also where the roads shall be located, or whether there shall be a road at all. Climate is a major soil-forming factor, as well as a major factor in highway depreciation. When a soil scientist classifies a soil, he also, to a degree, classifies

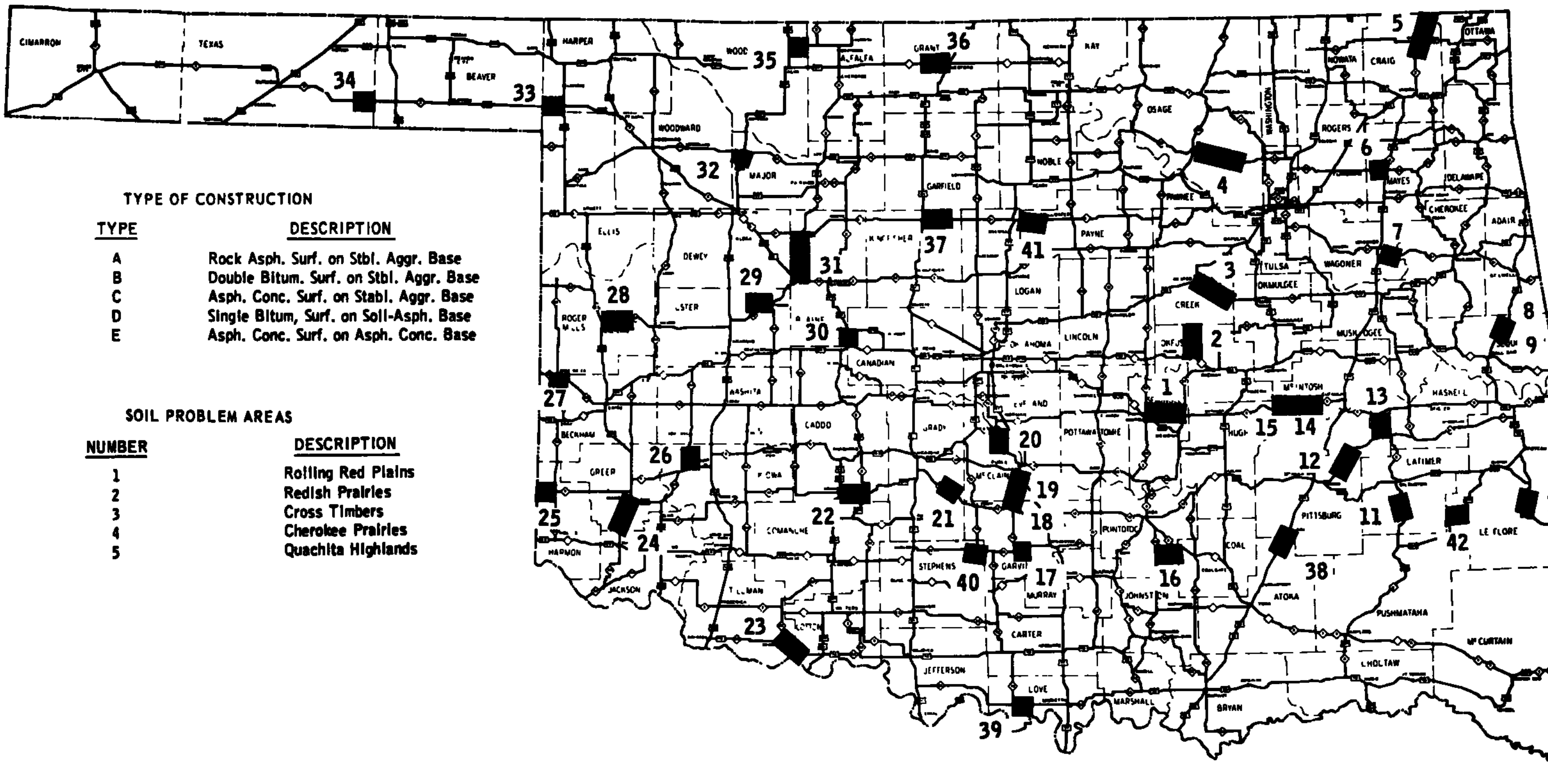


Figure 1. Location of test project sites.

Summary by Type of Construction and Soil Problem Area

PROJECT NUMBER	TYPE OF CONSTRUCTION (Mile)					SOIL PROBLEM AREA (Miles in Each)					
	A	B	C	D	E	1	2	3	4	5	Other
1	11.345							10.345	1.000		
2		10.625						5.625	5.000		
3		14.881						10.000	4.881		
4		15.591						4.591	11.000		
5			13.756						13.756		
6					3.348				3.348		
7		6.101							6.101		
8		5.473								5.473	
9		5.000								5.000	
10		4.920								4.920	
11					5.001					5.001	
12		8.770								8.770	
13	4.600								1.000	3.600	
14					5.053				5.053		
15	10.927							4.500	6.427		
16		4.880						4.880			
17					4.117		3.117	1.000			
18	7.548						7.548				
19	4.677						4.677				
20	7.503						7.503				
21					7.198		7.198				
22		8.794					8.794				
23				8.425		8.425					
24	10.684					10.684					
25	4.808					4.808					
26		4.815				4.815					
27				3.951		3.951					
28				7.568		7.568					
29		6.834				3.834	3.000				
30				5.880			5.880				
31		14.492				12.000		2.492			
32				7.801		7.801					
33				8.000		8.000					
34				6.872		6.872					
35				4.046			4.046				
36				7.989			7.989				
37				8.126			8.126				
38			10.903						10.903		
39				6.166							6.166
40			7.293					5.000			2.293
41			9.120				8.000	1.120			
42			7.630							7.630	
SUMMARY ALL PROJECTS	62.092					15.492	19.728	14.845	8.427	3.600	
		111.176				20.649	11.794	27.588	26.982	24.163	
			48.702				8.000	6.120	24.659	7.630	2.293
				74.824		42.617	26.041				6.166
					24.717		10.315	1.000	8.401	5.001	
SUBTOTALS	62.092	111.176	48.702	74.824	24.717	78.758	75.878	49.553	68.469	40.394	8.459
GRAND TOTALS	All Types: 321.511 Miles					All Areas: 321.511 Miles					

HIGHWAY ENGINEERING CHARACTERISTICS OF SOIL SERIES

SOIL SERIES and underlying GEOLOGIC FORMATIONS	SOIL ASSOCIATION NUMBER	MAPPED IN DIVISION NO. (ASSOC. MAP)	MAPPING UNIT	RATING NUMBER	BASE REQ'D FOR 9,000# WHEEL LOAD (by Group Index Method)	TEXTURE	PERMEABILITY	COLOR	B.P.R. SOIL CLASSIFICATION	LIQUID LIMIT	PLASTIC INDEX	% PASSING NO. 200 SIEVE	CALIFORNIA BEARING RATIO	SHRINKAGE LIMIT	FIELD MOISTURE EQUIVALENT	VOLUMETRIC SHRINKAGE	FOR STABILIZATION: % ASPHALT	FOR STABILIZATION: % PORTLAND CEMENT	LOAD SUPPORTING ABILITY: G	F	P	VOLUMETRIC SHRINKAGE: H	M	L	SOIL BINDER: Y	N	SOIL STABILIZATION: Y	N	SHOULDER CONSTRUCTION: G	F	P	EROSION CONTROL: G	F	P	SEEDING AND SODDING: G	F	P
BERTHOUD	51	6	7																																	
"A" 0-14"					9"	M	M	GB	A-4(4)	27	9	54	7				7.0				X			X		X		X			X			X		X	
"B" 14-30"					12"	MF	M	GB	A-6(9)	33	12	73	8				NO				X			X		X		X			X			X		X	
"C" 30-60"					10"	MF	M	GB,W	A-6(8)	25	8	83	7				NO				X			X		X		X			X			X		X	
"D" 60"+																																				
Dakota ss																																				
Colorado grp																																				
Purgatoire fm																																				
Morrison fm																																				
Dockum fm					15"				A-7-6(14)	49	20	84	4				NO				X	X				X		X			X		X			X	
BROWNFIELD	42	5,6	12																																	
"A" 0-25"					6"	C	MR	RB	A-2(0)	18	1	33	14				5.0				X			X		X	X				X			X		X	
"B" 25-50"					9"	MF	MR	R	A-6(2)	30	11	44	13				6.0				X			X	X			X		X				X	X		
"C" 50-70"					11"	M	MR	YR	A-6(8)	34	14	63	5				NO				X		X			X		X			X			X			X
"D" 70"+																																				
Tertiary Agefms					10"				A-2(0)	30	10	56	28				7.0				X			X		X		X			X			X		X	
Terrace deposits					9"				A-4(8)	26	3	92	8				NO				X			X		X		X			X			X			X
CAREY	38,38-A	4,5,6,7	7																																	
"A" 0-10"					10"	M	MR	RB	A-4(8)	28	5	90	4				NO				X			X		X		X			X			X		X	
"B" 10-40"					13"	MF	MR	R,RB	A-6(10)	39	14	85	6				NO				X		X			X		X			X			X		X	
"C" 40-60"					12"	M	MR	R	A-6(9)	30	12	78	9				NO				X			X		X		X			X			X		X	
"D" 60"+																																				
Cloud Chief fm					15"				A-7-6(13)	47	21	97	3				NO				X	X				X		X			X	X					X
Rush Springs ss					9"				A-4(4)	30	4	55	18				6.5				X			X		X		X			X			X		X	
Marlow fm					13"				A-7-6(10)	41	16	97	5				NO				X	X				X		X			X		X				X
Quartermaster fm					11"				A-4(8)	31	10	89	33				NO				X			X		X		X			X			X		X	
Dog Creek shale					9"				A-4(8)	23	2	94	4				NO				X			X		X		X			X			X			X
COTTONWOOD	36,37	4,5,6,7	25																																	
"A" 0-8"					10"	MF	M	GB	A-4(8)	27	4	87	9				NO				X			X		X		X			X			X		X	
"C" 8-40"+					10"			W	A-4(7)	30	4	73	8				NO				X			X		X		X			X			X		X	
Blaine gyp					14"				A-7-6(12)	43	19	97	5				NO				X	X				X		X			X		X				X
Flowerpot shale					12"				A-4(8)	37	10	92	11				NO				X		X			X		X			X			X			X
Cloud Chief fm					15"				A-7-6(13)	47	21	97	3				NO				X	X				X		X			X	X					X
DALHART	48,50	6	12																																	
"A" 0-8"					6"	MC	M	YB	A-2-3(0)	NP	NP	14	13				4.0			X				X		X		X			X			X			X
"B" 8-33"					8"	MF	M	B	A-4(1)	29	10	42	10				6.0				X			X	X			X		X				X	X		
"Cca" 33-54"					11"	F	M	B	A-6(7)	35	15	62	5				NO				X		X			X		X			X		X			X	
"C" 54"+																																				
Tertiary Age fm					6"				A-2-3(0)	NP	NP	10	32				NO			X				X		X		X			X			X			X
Terrace deposits					9"				A-4(8)	26	3	92	8				NO				X			X		X		X			X			X			X

ENTERPRISE	44	5,6,7	7X																																		
"A" 0-15"					6"	MC	MR	RB	A-2-3(0)	NP	NP	13	4				NO				X			X		X		X			X			X			X
"C" 15-50"					6"	MC	MR	RB	A-3(0)	NP	NP	9	5				NO			X				X		X		X			X			X			X
"D" 50"+																																					
Terrace deposit					9"				A-4(8)	26	3	92	8				NO				X			X		X		X			X		X				X
Tertiary Age fms					11"				A-2-3(0)	30	10	56	28				7.0				X			X		X		X			X			X		X	
Dog Creek shale					14"				A-6(11)	39	18	84	5				NO				X		X			X		X			X		X			X	
Dune sand					6"				A-2(0)	17	1	17	12				4.0			X				X		X	X				X			X		X	
Alluvium					10"				A-4(8)	27	6	77	9				NO				X			X		X		X			X			X		X	
GRANT	31	4,6	7																																		
"A" 0-20"					9"	MF	MR	B	A-4(1)	23	3	41	28				5.5				X			X		X	X			X				X		X	
"B" 20-48"					6"	MF	MR	RB,YR	A-4(2)	23	1	45	16				5.5				X			X		X	X				X			X		X	
"C" 48-72"					10"	MF	MR	YR	A-4(8)	29	5	85	12				NO				X			X		X		X			X			X		X	
"D" 72"+																																					
Cedar Hills ss																																					
Hennessey shale					14"				A-7-6(12)	43	20	94	9				NO				X	X				X		X			X		X				X
Flowerpot shale					12"				A-4(8)	37	10	92	11				NO				X		X			X		X			X			X			X
KIRKLAND	28,29	3,4,5,6,7,8	5																																		
"A" 0-11"					10"	M	VS	B	A-4(8)	28	6	94	4				NO				X			X		X		X			X			X			X
"B" 11-38"					19"	F	VS	B	A-7-6(19)	53	30	95	9				NO				X	X				X		X			X	X					X
"C" 38-100"					15"	F	VS	RB	A-7-6(15)	49	23	98	4				NO				X	X				X		X			X	X					X
"D" 100"+																																					
Hennessey shale					16"				A-7-6(16)	47	26	95	7				NO				X	X				X		X			X	X					X
Garber ss					13"				A-6(6)	38	13	61	10				NO				X		X			X		X			X			X		X	
Wichita fm					12"				A-6(9)	33	13	96	5				NO				X		X			X		X			X			X			X
Wellington fm					17"				A-7-6(18)	50	28	93	4				NO				X	X				X		X			X	X					X
Flowerpot shale					12"				A-4(8)	37	10	92	11				NO				X		X			X		X			X			X			X
Upper Pontotoc grp																																					
LELA	7	ALL	3																																		
"A" 0-45"					14"	F	VS	G	A-7-6(13)	42	20	90	5				NO				X	X				X		X			X		X			X	
"AC" 45-75"						F	VS	RB																													
"C" 75-90"						F	VS	RB																													
"D" 90"+																																					
Alluvium					16"				A-7-6(15)	50	23	90	5				NO				X	X				X		X			X			X		X	
LINCOLN	6	ALL	15																																		
"A" 0-15"					9"	C	R	B	A-4(5)	24	4	61	4				NO				X	X				X		X			X			X		X	
"C" 15-60"+					6"	C	R	YB	A-2-3(0)	NP	NP	17	13				NO			X				X		X	X				X			X			X
Alluvium					10"				A-4(8)	28	3	81	12				NO				X	X				X		X			X			X		X	
MANSKER	47	6,	18																																		
"A" 0-15"					8"	MF	M	GB	A-4(4)	22	5	45	10				5.5				X			X		X	X			X				X		X	
"Cca" 15-40"					12"	MF	M	B	A-6(7)	35	11	71	9				NO				X		X			X		X			X			X		X	
"C" 40-60"					10"	MF	M	B	A-4(4)	28	10	57	3				7.0				X			X		X		X			X			X		X	
"D" 60"+																																					
Tertiary Age fms																																					
Cloud Chief fm					5"				A-7-6(13)	49	18	76	3				NO				X	X				X		X			X		X			X	
Dakota ss																																					
Morrison fm																																					
MILLER	1,6	ALL	3																																		
"A" 0-8"					12"	F	VS	RB	A-6(8)	32	11	93	4				NO				X			X		X		X			X			X			X
"C" 8-46"					13"	F	VS	RB	A-6(10)	39	14	98	5				NO				X		X			X		X			X			X			X
"D" 46"+																																					
Alluvium					16"				A-7-6(15)	50	23	90	5				NO				X	X				X		X			X	X				X	

HIGHWAY ENGINEERING CHARACTERISTICS OF SOIL SERIES

SOIL SERIES and underlying GEOLOGIC FORMATIONS	SOIL ASSOCIATION NUMBER	MAPPED IN DIVISION NO (ASSOC. MAP)	MAPPING UNIT	RATING NUMBER	BASE REQ'D FOR 9,000# WHEEL LOAD (by Group Index Method)	TEXTURE	PERMEABILITY	COLOR	B P R SOIL CLASSIFICATION	LIQUID LIMIT	PLASTIC INDEX	% PASSING NO 200 SIEVE	CALIFORNIA BEARING RATIO	SHRINKAGE LIMIT	FIELD MOISTURE EQUIVALENT	VOLUMETRIC SHRINKAGE	FOR STABILIZATION: % ASPHALT	FOR STABILIZATION: % PORTLAND CEMENT	LOAD SUPPORTING ABILITY			VOLUMETRIC SHRINKAGE			SOIL BINDER		SOIL STABILIZATION		SHOULDER CONSTRUCTION			EROSION CONTROL			SEEDING AND SODDING		
																			G	F	P	H	M	L	Y	N	Y	N	G	F	P	G	F	P	G	F	P
NASH "A" 0-6"	31	4,6	7		8"	M	MR	RB	A-4(3)	24	3	52	22				6.0				X			X		X		X			X			X		X	
"B" 6-26"					8"	M	MR	YR	A-4(2)	27	2	46	29				5.5				X			X		X	X				X			X		X	
"C" 26-36"+ Cedar Hills ss Hennessey shale Flowerpot shale					13"				A-6(10)	36	14	76	9				NO				X		X			X		X			X			X		X	
POND CREEK "A" 0-15"	31	4,6	6		10"	M	M	B	A-4(8)	30	7	60	9				NO				X			X		X		X			X			X		X	
"B" 15-36"					13"	MF	M	B	A-6(9)	37	13	81	8				NO				X		X			X		X			X			X		X	
"C" 36-72"					8"	MF	M	B,R	A-4(2)	24	5	48	9				6.0				X			X		X	X			X				X		X	
"D" 72"+ Cedar Hills ss Hennessey shale Flowerpot shale					13"				A-6(10)	36	14	76	9				NO				X		X			X		X			X	X				X	
PORT "A" 0-14"	7	ALL	4		9"	MF	M	B	A-4(7)	25	6	70	5				NO				X			X		X		X			X			X		X	
"AC" 14-30"					10"	MF	M	B	A-4(8)	27	8	77	3				NO				X			X		X		X			X			X		X	
"C" 30-60"+						MF	M	RB																													
Alluvium					16"				A-7-6(15)	50	23	90	5				NO				X	X				X		X			X	X				X	
POTTER "A" 0-8"	47	6	25		6"	M	M	GB	A-2-4(0)	34	7	21	23				NO			X				X		X	X		X					X	X		
"C" 8"+					7"				A-4(2)	22	3	45	31				5.5				X			X		X	X			X				X		X	
Tertiary Age fms Cloud Chief fm					6"				A-2-3(0)	NP	NP	10	37				NO			X				X		X	X				X			X			X
PRATT "A" 0-12"	40	4,5,6	12X		6"	MC	MR	B	A-2(0)	21	3	34	17				5.0				X			X		X	X			X				X		X	
"B" 12-26"					6"	MF	MR	B,YR	A-4(1)	25	6	30	22				5.0			X				X		X	X			X				X	X		
"C" 26-40"					6"	MC	MR	B	A-2(0)	20	3	26	11				4.5			X				X		X	X			X				X		X	
"D" 40"+ Terrace deposits					9"				A-4(8)	26	3	92	8				NO				X			X		X		X			X			X			X
Tertiary Age fms					6"				A-2-3(0)	NP	NP	10	32				NO			X				X		X		X			X			X			X
Dune sand					6"				A-2(0)	17	1	17	12				4.0			X				X		X	X				X			X		X	
PULASKI "A" 0-18"	7	ALL	9		6"	M	MR	B	A-2-3(0)	NP	NP	31	18				5.0			X				X		X	X				X			X			X
"C" 18-50"+					6"	M	MR	B	A-4(1)	21	1	41	21				5.5				X			X		X	X				X			X		X	
Alluvium					10"				A-4(8)	26	5	81	15				NO				X			X		X		X			X			X		X	

PULLMAN	49	6	2																																	
"A" 0-5"						MF	S	GB										12																		
"B" 5-40"						F	S	B										12																		
"C" 40-60"						F	S	RY										12																		
"D" 60"/																																				
Tertiary Age fms																																				
QUINLAN	32,38,39.	4,5,6,7	20																																	
"A" 0-15"					6"	M	R	RB	A-2(0)	26	2	34	12				5.0			X				X		X	X				X			X		X	
"C" 15"/					6"	C	R	R	A-2(0)	26	2	40	19				5.5				X			X		X	X				X			X		X	
Rush Springs ss					8"				A-4(4)	30	4	55	18				6.5				X			X		X		X			X			X		X	
Cloud Chief fm					9"				A-4(8)	23	1	90	11				NO				X			X		X		X			X			X		X	
Quartermaster fm																																				
Marlow fm					11"				A-4(8)	33	10	88	5				NO				X			X		X		X			X			X		X	
Flowerpot shale																																				
RENFROW	28,30	3,4,5,6,7,8	1																																	
"A" 0-10"					10"	MF	VS	RB	A-4(7)	26	4	70	3				NO				X			X		X		X			X			X		X	
"B" 10-26"					14"	F	VS	RB	A-7-6(12)	43	19	84	10				NO				X	X				X		X			X		X			X	
"C" 26-50"					18"	F	VS	R	A-7-6(19)	53	29	87	10				NO				X	X				X		X			X	X					X
"D" 50"/																																				
Hennessey shale					16"				A-7-6(16)	47	26	95	7				NO				X	X				X		X			X	X					X
Garber ss					12"				A-6(6)	38	13	61	10				NO				X		X			X		X			X			X		X	
Wichita fm					12"				A-6(9)	33	13	96	5				NO				X		X			X		X			X			X			X
Upper Pontotoc grp																																				
Wellington fm					17"				A-7-6(18)	50	28	93	3				NO				X	X				X		X			X	X					X
Flowerpot shale					12"				A-4(8)	37	10	92	11				NO				X		X			X		X			X			X			X
RICHFIELD	48,49	6	2																																	
"A" 0-13"					13"	M	M	GB	A-6(10)	36	16	82	2				NO	10			X		X			X		X			X		X			X	
"B" 13-35"					16"	MF	M	B	A-7-6(15)	48	23	89	4				NO	12			X	X				X		X			X	X				X	
"C" 35-130"					12"	MF	M	B,W,P	A-6(9)	34	12	74	5				NO	12			X		X			X		X			X			X		X	
"D" 130"/																																				
Tertiary Age fms																																				
Terrace deposits					9"				A-4(8)	26	3	92	8				NO				X			X		X		X			X			X			X
ST. PAUL	38-A	5,6	6																																	
"A" 0-20"					12"	MF	M	B	A-4(8)	33	10	82	5				NO	10			X			X		X		X			X			X		X	
"B" 20-60"					13"	F	M	RY	A-6(10)	40	16	74	9				NO	10			X		X			X		X			X		X			X	
"C" 60-90"					14"	F	M	RY	A-6(12)	40	21	87	5				NO	10			X	X				X		X			X	X				X	
"D" 90"/																																				
Rush Springs ss																																				
Cloud Chief fm					11"				A-4(8)	30	10	83	8				NO				X			X		X		X			X			X		X	
TIPTON	44	5,6,7	9H																																	
"A" 0-35"					10"	MF	M	B	A-4(8)	26	4	85	11				NO				X			X		X		X			X			X		X	
"B" 35-70"					13"	MF	M	RB,RY	A-6(11)	37	16	81	5				NO				X		X			X		X			X		X			X	
"C" 70-90"					13"	MF	M	RY	A-6(11)	36	18	89	6				NO				X		X			X		X			X		X			X	
"D" 90"/																																				
Terrace deposits																																				
Tertiary Age fms																																				
Dog Creek shale					14"				A-6(11)	39	18	86	5				NO				X		X			X		X			X		X			X	
Alluvium					10"				A-4(8)	27	6	77	9				NO				X			X		X		X			X			X		X	
TIVOLI	41,42	4,5,6	13																																	
"A" 0-8"					6"	C	R	B	A-3(0)	NP	NP	8	9				NO	10		X				X		X		X			X			X			X
"C" 8-60"					6"	C	R	Y	A-3(0)	NP	NP	3	10				NO	10		X				X		X		X			X			X			X
"D" 60"/																																				
Dune sand					6"				A-3(0)	NP	NP	8	10				NO			X				X		X		X			X			X			X
Terrace deposits					6"				A-2-3(0)	NP	NP	16	11				4.0			X				X		X	X				X			X			X
Tertiary Age fms					6"				A-2-3(0)	NP	NP	10	32				NO			X				X		X		X			X			X			X

HIGHWAY ENGINEERING CHARACTERISTICS OF SOIL SERIES

SOIL SERIES and underlying GEOLOGIC FORMATIONS	SOIL ASSOCIATION NUMBER	MAPPED IN DIVISION NO. (ASSOC. MAP)	MAPPING UNIT	RATING NUMBER	BASE REQ'D FOR 9,000# WHEEL LOAD (by Group Index Method)	TEXTURE	PERMEABILITY	COLOR	B.P.R. SOIL CLASSIFICATION	LIQUID LIMIT	PLASTIC INDEX	% PASSING NO.200 SIEVE	CALIFORNIA BEARING RATIO	SHRINKAGE LIMIT	FIELD MOISTURE EQUIVALENT	VOLUMETRIC SHRINKAGE	FOR STABILIZATION		LOAD SUPPORTING ABILITY			VOLUMETRIC SHRINKAGE			SOIL BINDER		SOIL STABILIZATION		SHOULDER CONSTRUCTION			EROSION CONTROL			SEEDING AND SODDING		
																	% ASPHALT	% PORTLAND CEMENT	G	F	P	H	M	L	Y	N	Y	N	G	F	P	G	F	P	G	F	P
TRAVESSILLA "A" 0-8" "C" 8"+ Dakota ss Colorado grp Purgatoire grp Morrison fm Dockum fm	51	6	20		9"	M	M	B	A-4(3)	27	9	52	2				6.5				X			X		X		X			X			X		X	
VERNON "A" 0-8" "C" 8-15" "D" 50"+ Hennessey shale Wichita fm Upper Pontotoc grp Garber ss Wellington fm Flowerpot sh	28,34	3,4,5,6,7,8	17		12"	F	VS	B	A-6(8)	34	11	73	6				NO				X			X		X		X			X			X		X	
					14"	F	VS	RB	A-7-6(12)	44	18	87	6				NO				X	X				X		X			X		X			X	
					16"				A-7-6(16)	47	26	95	7				NO				X	X				X		X			X	X					X
					12"				A-6(9)	33	13	96	5				NO				X		X			X		X			X			X			X
					11"				A-6(6)	38	13	61	10				NO				X		X			X		X			X			X		X	
					17"				A-7-6(18)	50	28	93	4				NO				X	X				X		X			X	X					X
YOMA "A" 0-8" "B" 8-36" "C" 36-50" "D" 50"+ Tertiary Age fms Terrace deposits Dune sand	50	6	7X		6"	MC MF	R R	B B	A-2(0)	20	1	16	6				NO			X					X		X	X				X			X		X	
					6"	C	R	B	A-3(0)	NP	NP	5	9				NO			X					X		X		X			X			X			X
					6"				A-2-3(0)	NP	NP	10	32				NO			X					X		X		X			X			X			X
					6"				A-2-3(0)	NP	NP	10	16				NO			X					X		X		X			X			X			X
WOODWARD "A" 0-20" "Cca" 20-26" "C" 26"+ Cloud Chief fm Rush Springs ss Marlow fm Dog Creek shale	38	4,5,6,7	20		10"	M	MR	RB	A-4(8)	27	5	77	4				NO				X			X		X		X			X			X		X	
					11"	M	MR	R	A-4(8)	30	8	89	7				NO				X			X		X		X			X			X		X	
					11"	M	MR	R	A-4(7)	33	9	72	5				NO				X			X		X		X			X			X		X	
					11"				A-4(8)	30	10	83	8				NO				X			X		X		X			X			X		X	
					9"				A-4(3)	28	4	68	13				NO				X			X		X		X			X			X		X	
					12"				A-4(8)	33	10	82	8				NO				X			X		X		X			X			X		X	
					9"				A-4(8)	23	2	94	4				NO				X			X		X		X			X			X			X
YAHOLA "A" 0-18" "C" 18-60" "D" 60"+ Alluvium	1,4,6	ALL	9		10"	M	MR	RB	A-4(6)	22	6	63	8				NO				X			X		X		X			X			X		X	
					6"	M	R	RB	A-2-3(0)	NP	NP	30	13				5.0			X					X		X	X				X			X			X
					11"				A-4(8)	29	7	95	9				NO				X			X		X		X			X			X			X

Highways, like rocks, are subject to damage by water, by wetting and drying, by expansion and contraction from heat and cold, and by the powerful forces of freezing moisture. The damage over a period of time will be large or small depending on the magnitude of the destructive factors at the particular location. If, by determining the name of the soil series, the subgrade soils are defined and the materials and climatic conditions that produce the soil are indicated, some of the factors which determine the behavior of the paving are also known. By using past experience, the name of the soil series might indicate the condition of the road that one would expect to find in areas where the soil is used as subgrade along the highway.

The records of the Oklahoma research project give the names of not many more than 100 soil series in 321 miles of paving. It is estimated that these 100 principal soils cover about 75 percent of the area of Oklahoma. When the topsoil, the subsoil, and the underlying geology are each counted as a kind of engineering soil, there are then 300 kinds of soil indicated by the 100 different series. If it is assumed that one-half of the 300 miles of highway in the research project is in fill, there are about 150 miles in cut, and it is indicated that the average soil extent for each of the 300 engineering soils is something less than one-half mile. Therefore, for the roads covered by the pedological soil survey of the project, there exists for each half-mile of paving a record that gives not only the thickness and texture of each soil horizon, but also the climate, topography, the internal drainage of the soil, the name or description of the underlying geology, and the natural vegetation in the area. The highway records for these projects have been investigated, the condition of the paving recorded, the depreciation of these roads calculated, and the information classified by soil series name.

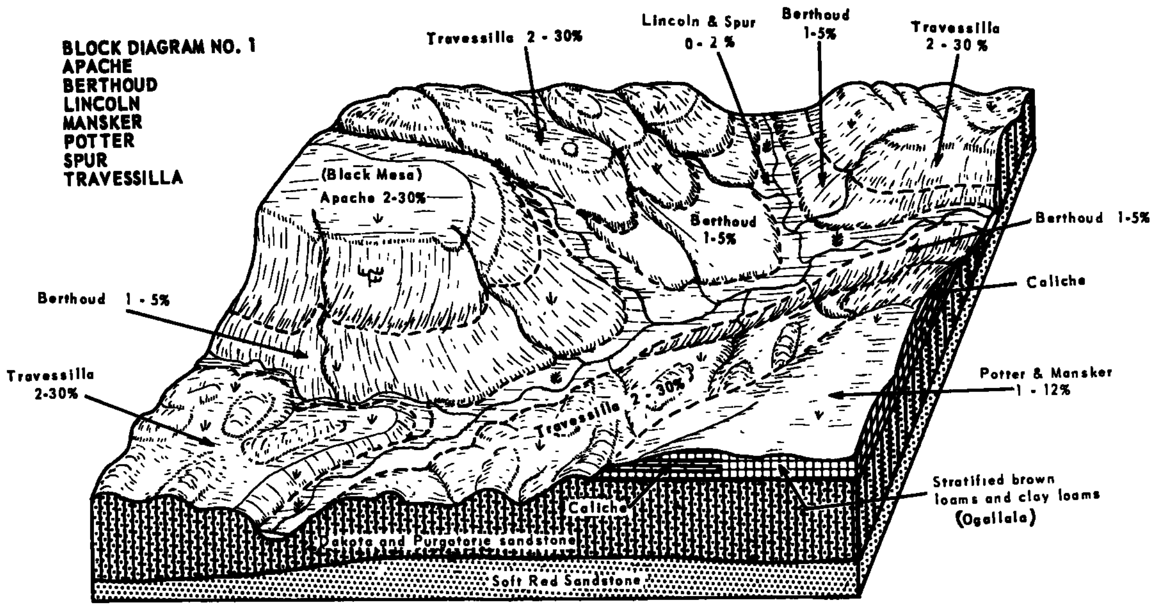
An attempt has been made to organize the wealth of published pedological soil data and develop methods of interpretation so it can be used to identify soils by inspection and examination in the field and to evaluate the principal Oklahoma soils for engineering uses. Laboratory tests of the soil and geology samples have been recorded by the name and horizon of the soil series and the name of the geologic formation. These tests have been interpreted for highway use and an estimate has been made of the suitability of the materials for the following common uses that are made of soils in highway work: subgrade, shoulders, erosion control, seeding and sodding, shrinkage, soil binder, and soil stabilization. Also by correlating the soil series name with the records of highway experience, there have been assigned to each soil series such detailed information as required base thickness, load supporting value, and the depreciation of various kinds of paving constructed on it.

For field identification, a policy has been adopted of dividing the soils of the state into groups of principal soils by location; for example, the soils found in each individual maintenance division. By considering each of the eight divisions separately, the number of principal soils to be recognized is reduced from 94 for the state to approximately 30 in each division. With only 30 soils to classify, the problem of classification and identification in the field is greatly simplified.

The U. S. Soil Conservation Service has divided the state into a number of problem areas. These areas are large; one may extend into several states, so only a few of them are found in any one maintenance division. The descriptions for these large soil problem areas are very general. The areas are defined by climate, underlying geological material, vegetation, and topography. The study has suggested that soils are not the basic cause of highway problems but, like the soils themselves these problems are the result of the conditions of climate, geology, topography and traffic prevailing in certain areas of the state and the problems of highways are problems of the environment in which the highway is constructed. These large areas of similar environment can be thought of as areas of similar highway problems. The problem areas have been divided into soil associations and the soil association areas can be divided into soil series areas.

This research project can be thought of as the installation of a bookkeeping system to record, by soil series name, all soils and highway information as it becomes known and to make it available for future use. As time goes on and the records include more and more material, their value will increase.

It has been said that the kind of soil present at a particular place is determined by



Soils of Northwest Cimarron County, Oklahoma developed in sandstones, shales and in basalts, (Black Mesa) Remmants of Ogallala loams and clay loams in right front corner. Caliche outcrops along "Breaks".

ORIGINAL VEGETATION

Short Grass · Tall Grass · Pinon - Juniper

Figure 2. Typical block diagram for soils and geology.

five principal soil-forming factors, which are the action of climate and living organisms (such as plant and animal life) upon the parent material (such as geological strata) or reworked material (such as alluvium) modified by local relief and the time during which the action has been going on. This definition implies that the type of local relief is more or less uniform for a given soil series and also for each soil series the underlying geology is of a similar kind. Because this is true, a typical environment of topography and geology can be shown for each soil series by a diagram.

Block diagrams which show the typical topographic environment and underlying geology of the principal soil series within each soil association can be used to divide the soil association areas when maps which show the soil areas occupied by each soil series are not available. These block diagrams give a detailed picture of where each principal soil series in a soil association may be found and the location of some of the minor soils found associated with the principal soils (see Fig. 2).

The steps of classification of the soils of Oklahoma by maps are as follows:

1. Maintenance division.
2. Problem area.
3. Soil association
4. Block diagram.

The soil series have been mapped in detail by the Department of Agriculture for many counties of the state. If these maps are available, the location of each individual soil series has already been determined and the name of the soil series at any location can be obtained by finding the particular location on the map. The engineering data about a principal soil can be found in the State Highway Department records. An estimate for a minor soil can be made by comparing it with a similar principal soil.

When using county soil maps, the block diagrams help the engineer to recognize a soil in the field by indicating the underlying geology and the kind of topography on which the soil will be developed.

Engineering soil information is obtained for many purposes. The degree of detail to which it is necessary to define the soil depends on the purpose for which it is intended to use the information. At times, the name of only the soil problem area or soil association may give all the information necessary.

The system of filing the records of highway behavior by the soil series name is very new. In fact, it has not yet been fully developed. But already there are examples of failures in a highway that can be analyzed by referring to the soil series descriptions. The road was built in 1949 and gave excellent service for about seven years. In 1956 it was in excellent condition; a detailed condition survey gave this road a rating of 99 percent perfect. In 1957, the rains came in a record-breaking quantity. A condition survey afterward gave the highway a rating of 84 percent perfect, a loss of 15 percent in a year or less. This 14-mile long project was built at a cost (1950 prices) of about $23,500 per mile, an investment of something more than $329,000 in the paving of this project. If the damage in one year is 15 percent, the loss was in the neighborhood of $50,000 on this 14 miles of paving. This road is constructed in a area of Dennis, Bates, and Parsons soils. The second condition survey indicated that the damaged areas occurred in the transition zone where the soils changed from Dennis or Bates to the Parsons soil. The typical pedological descriptions of these soils give the information that Dennis and Bates soils are on steeper slopes than Parsons soils. The surface runoff of these soils is indicated to be slow to moderately rapid. The internal drainage is moderate to moderately slow and silty and sandy clay loams are found at depths of from 10 to 22 inches. On the other hand, a Parsons soil is described as being on nearly level land with a runoff that is medium to low. The internal drainage is indicated to be slow to very slow, with a claypan at a depth of 12 to 18 inches.

With this general information about the soils it is easy to visualize the development of these failures. This road was built and put in service during a period of below normal rainfall. When sufficient water was present and the soils became saturated, the more permeable soils on the steeper slopes and the higher elevations gradually drained downgrade to the transition zone between these soils and the Parsons soil, which was in the flats and had a claypan to block further drainage. This condition resulted in an accumulation of water in the transition zone. The claypan of the Parsons soils and the clay loam soils of the Dennis and Bates soils became waterlogged. Being saturated with water, the subgrade soil beneath the paving lost its cohesive strength and could not support the weight of the traffic on the highway and failure resulted. From the engineering tests of the soils at the time this project was constructed, it was impossible to predict or visualize a condition of internal drainage that would develop seven years in the future.

With this knowledge available for future use on other projects, whether the wet condition is apparent or not at the time of construction, it will be known that these possible failure areas should be protected. This kind of failure can be prevented by placing subdrains to carry off the accumulated moisture at the transition zones between the more pervious soils on the steeper slopes and the Parsons soils lying on the flats below them.

EXAMPLE OF USE OF RECORDS

Highways are located by control points, such as towns, and crossings of rivers and railroads. The problem is to find the best and cheapest route between two points.

US 70 in Oklahoma was located long ago. It crosses Choctaw County from east to west, a distance of 45 miles. A soil survey of this county published in 1943 showed that about 13 miles of this highway are in an area which has principally sandy loams of the Bowie, Cuthbert, Kirvin, Sawyer, and other similar soils. Roughly, the average thickness of paving for a highway on these soils is 15 inches of base and subbase. The remaining 32 miles are in an area having principally such plastic soils as Choctaw, Durant, Denton clay, and San Saba clay. The required thickness of base and subbase for these plastic soils is much greater than for the sandy loams and an average thickness of about 26 inches would be required. This is a difference of about 11 inches for the 32 miles of heavy soils. Using a 1950 price index, an inch of paving costs from $1,800 to $2,000 per mile, or a total of $700,000 for the 32 miles. The soil map indicates that by moving the highway location not much more than a mile the clay areas could have been avoided. If the survey had been available at the time the road was located, and if this information had been used, the mapping of the soils in Choctaw County could have been worth $700,000 to the people who pay the tax on gasoline.