REPORT OF COMMITTEE ON SOIL CEMENT ROADS

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SYNOPSIS

This report reviews the maintenance costs and conditions in service of soil-cement roads, as inspected and reported to the committee by the several states.

The construction details, age, traffic and present condition of the soil-cement base of these projects provides a complete history.

Many variables in the construction, climate and traffic indicate that six inches of soil-cement base properly constructed is entirely adequate for the purpose.

The committee desires that records of the condition of these and other earlier soil-cement projects be continued by the states and that subsequent studies be made.

Other uses of soil-cement mixtures and cement-modified soil binders for soil aggregate mixtures were considered by the committee and further studies recommended.

In 1945 the Committee on Soil-Cement Roads resumed activities. At the suggestion of the committee, the chairman circularized State Highway Departments to obtain maintenance cost data on the older soil-cement roads in service. The roads selected were those included in the 1940 committee report on Condition Survey of Soil-Cement Roads, reported on pages 812 to 820 inclusive of the Proceedings of the Twentieth Annual Meeting of the Highway Research Board. The reports from the various states replying were received quite late in the year. As a result, available data was discussed at the committee meeting held early in 1946 at Oklahoma City and reporting of the data deferred until more of the states could return the questionnaires.

The data requested on maintenance cost consisted of a year by year tabulation of maintenance expenditures for the soil-cement base, maintenance expenditures for the bituminous surface, and total maintenance for the project. This would permit calculation of the maintenance cost per mile per year of the soil-cement base, the bituminous surface, and the total. Data was also requested on the average traffic volume per day of commercial vehicles and passenger cars. In addition, it was requested that a rating be made of the present overall condition of the project.

A study of all data reported revealed that many variables entered into the base cost. With respect to bituminous surfacing it was impractical, if not impossible, to tabulate the returns for satisfactory comparison and this information was therefore, not included in Table No. 1 showing maintenance costs. Further, for the sake of simplicity, the data was reduced to show age of project, daily traffic, total soil-cement base maintenance

TABLE NO. I

MAINTENANCE COSTS OF SOIL-CEMENT ROADS (1945-6) (Carl R. Reid)

State (1940 Surv.)	No. (1)	County	Project Length Miles	Age Years	Daily Traffic Commercial	Daily Traffic Total	Soil-Cement Base Maintenance Cost Dollars Total	Year/Mile	Present Condition (3)	Remarks
Ga.	1	Clarke	2.00	8	-	-	0	0	E	
Ill.	1	Logan-Menard	2.9	6	90	185	0	0	E	
Ill.	2	Winnebago	1.14	9	-	40	525	10	G	130 ft. rd. repaired in 1940 & 43. Breakage due to heavy truck loads & excess moisture in subgrade.
Kan.	1	Stafford	1.23	7	155	1120	0	0	E	
Ky.	1	Daviess	6.54	7	180	450	0	0	E	6 small base failures have occurred-probably due to underlying clay stratum.
Md.	1	Worchester	2.65	7	24	46	0	0	E	
Md.	2	Carroll	1.1	6	41	163	0	0	E	
Miss.	1	Chickasaw & Pontotoc	23.78	6	115	637*	0	0		*1942 traffic
Ohio	1	Franklin	2.9	6	8	50	400	24	G	
Okla.	1	Caddo	5.80	5.5	200	535	2580*	81	G	*Includes fill settlement & surface.
N.C.	1	Beaufort	1.5	7	-	-	0	0	E	
"	2	Alamance	2.4	6	-	-	0	0	E	
N.C.	3	Wake	2.1	7	-	-	0	0	E	
"	4	Carteret	1.06	8	-	-	0	0	E	
Pa.	1	Lebanon	1.97	8	25	177	0	0	AV.	
Va.	1	York	2.75	6	500	2500	0	0	E	
"	2	New Kent	1.96	7	126	518	0	0	G	Maint. Cost for 1st 3 yrs. not available & not included.
Wash.	1	Whitman	1.00	7	25	120	0	0	E	
	(2) Addnl. Proj.)									
Ga.		Liberty	1.24	3	-	200	0	0	E	
Ill.		Tazewell	3.86	4	-	500*	0	0	E	*1941 traffic
Md.		Queen Annes	2.16	4	29	144	0	0	E	
Md.		Queen Annes	2.31	4	19	66	0	0	E	
"		Dorchester	2.52	4	20	80	0	0	E	
Va.		Accomack	3.00	4	56	187	0	0	G	
Va.		Powhaton	1.00	4	159	719	0	0	E	
"		Sussex	2.49	4	80	400	391	39	G	
Wash.		Spokane	3.58	4	55	255	0	0	E	2" road mix surf. placed 1942. Other maintenance has been extremely small.

(1) Corresponding number used in 1940 survey report (20th Proceedings HRB).
(2) Additional projects reported since 1940 survey on which data were available.
(3) E - Excellent G-Good AV. - Average

cost during its life, the corresponding maintenance cost per mile per year and the reported condition or rating of the project.

The maintenance cost of the soil-cement base, Table No. 1, shows that the 1940 survey projects had an age varying from 5½ to 9 years. Eighteen projects are reported and of these there had been no maintenance expenditure on the soil-cement on 15 of them. On the remaining three projects, the base maintenance cost per mile per year was $10., $24., and $81. Twelve of the projects had a present condition rating of Excellent, four of them had a rating of Good, and one a rating of Average.

Also included in the tabulation are nine projects built since the 1940 survey. The age at time of reporting was four years, except for a three year job in Georgia. Only one job had any soil-cement base maintenance cost reported, and it had an average maintenance cost of $39.00 per mile per year. Seven of the jobs were rated Excellent and two were rated Good.

Traffic data was not submitted for all jobs, but of those reported, the commercial traffic varied from a minimum of eight trucks per day to a maximum of 500 trucks per day, and total traffic varied from a minimum of 40 vehicles per day to a maximum of 2500 vehicles per day.

Comments with returns by many states indicated maintenance cost records precluded separation of annual or total charges for only the base or surface course, or the actual outlay for the roadbed. also, in many instances two or more types of improvement were included in the mileage or section covered by the maintenance cost record. These prevailing methods in maintenance accounts indicated that other procedure would be required in these cases to obtain adequate data on the conditions in service of soil-cement roads.

In order to extend the record of the condition in service of these early soil-cement road projects, this committee prepared another questionnaire designed to determine the actual square yards of soil-cement base requiring repair, the time, location and cause of failure if evident, the history of construction of the base, together with similar data with reference to the bituminous surfaces and the daily and total traffic on the roads.

The questionnaire was forwarded in 1946 and 1947 to the 23 states included in the 1940 condition survey and also to eight other states that had constructed soil-cement roads to this time, or a total of 31 states and 128 soil-cement base projects. A greater number of states and projects, were thus included in this condition survey than in 1940 or the maintenance costs of 1946 as reported in Table 1. Also, improved personnel in many Highway Departments made possible increased details in reports for this survey. Nineteen of the states were able to obtain, or had available, data to prepare and return reports covering 59 projects.

Considerable data was supplied by this questionnaire which included length, width and depth of project, the type of soil processed, cement content used, daily truck and total traffic, age of project at time of survey, age at which first failure occurred and square yards of total failed areas of soil-cement base. Additional data, not practical to tabulate for comparison and study in this report, gave the age of the base at time first surfacing was placed and the type of surfacing. Many reported the type and time of subsequent surface courses and present serviceability or condition. A very complete history of these projects

from their construction up to the present, is provided by this survey.

Table 2 includes the data on soil-cement base for all projects reported by the several states. It was impractical to tabulate the many variables in bituminous surfacing.

Summarizing the data on soil cement base, the width varied from 10 to 35 feet, and depth of treatment from 5 to 10.25 inches. Forty-eight of the 59 projects reported were six inches thick.

The cement content used varied from 6 to 14 percent by volume with the majority of the work being built with 10 percent by volume. The soils processed had liquid limits varying from 2 to 72 and plasticity indexes varying from non-plastic to 35. A considerable number had plasticity indexes of the order of 10 or more.

The age of the projects at the time they were surveyed varied from 2 years to 10 years, with the majority being 5 years old or more.

Data was submitted on a total of 59 projects representing 273 miles of road. On 32 of the projects there were no failures of any nature reported for the soil-cement base. On 27 of the projects some soil-cement base failure was reported, but on 18 of these projects the failures were of a very minor extent, on three projects the breakage was less than 5 percent and was not significant. This leaves only six jobs on which the extent of breakage was sufficient to warrant analysis.

The Kern County, California project on Route 139 had 2500 square yards or 20 percent failure, with the report that considerable of the surface was dry, dusty and not knit together, indicating inadequate construction control.

The Cheboygan County, Michigan job on M-16 had 59 percent reported as replaced and this included an unspecified amount removed during subsequent changes in grade on the project. Professor Housel advised in committee meeting that more details on the reasons for replacement would be obtained and supplied to the committee.

Fifteen percent breakage was reported on the Nuckolls County, Nebraska project. Breakage was reported due to insufficient base thickness (5 inches) for the type of subgrade and traffic, low cement content for type of soil processed, together with poor construction practices.

Ten percent breakage was reported on the Thayer-Fillmore, Nebraska project. Breakage was reported as probably due to insufficient base thickness (5 inches) for the very poor subgrade soils that existed on the project.

On the Lewis County, New York project, 10 percent breakage was reported on this single lane construction, but data was not submitted to indicate the nature of breakage.

On the Erie County, Pennsylvania, Route 25018, project, 33 percent of the area was broken as a result of frost heave induced by a high water table in a silt loam subgrade.

The foregoing record of breakage on a few jobs indicates that major factors involved included faulty subgrade and improper construction. The overall record is excellent, particularly when it is compared with common experiences with low cost construction.

An interesting fact is supplied by the data on the age at time of first failure. It will be noted that with five exceptions the reported breakage occurred during the first two years of service, which indicates further that the failures were due to subgrade conditions or faulty construction. Definite data were submitted showing that breakage at later ages was due to unusually heavy trucking at time of breakage

TABLE NO. 2
CONDITION SURVEY OF SOIL-CEMENT ROADS
1946-7

State	Location County	Route	Length, Miles	Width, Feet	Depth, Inch	Cement % by Vol.	Soils Processed PRA Group	L.L.	P.I.	Daily Traffic Trucks	Total	Age of Project, Years	Age at Time of First Failure Years		Total Failed Areas Sq.Yds	%
Ala.	Marshall	32	4.04	24	8	9	A-2,4	14-26	0-5	50	500	2	None		None	
Ariz.	Cochise	666	1.82	28	6	10-12	A-2	20-24	1-3	50	100	6	None		None	
Calif.	Contra Costa	106	3.35	24	5.5	8	A-2,5	20-37	4-12	235	2250	7	None		None	
"	Kern	466	1.02	24	10.25	6	A-4	38	16	47	518	8	None		None	
"	"	139	1.00	22	6	9	A-2	-	-	197	1129	8	1	(a)	2500	20
"	Siskiyou	97	3.00	22	6	9	A-2	22	0	52	777	8	None		None	
Del.	Kent	Dover-Wyoming	2.91	18	6	10	A-1	20	5	100	1000	6	None		None	
Ga.	Calhoun	62	11.63	21	6	6	A-2	9-20	-	105	339	6	None		None	
"	Coweta	14	12.35	(b)	8	10	A-2	-	-	265	1422	3	None	(b)	None	
"	Clarke	24	2.0	21	6	8,10,12	-	37-58	1-3	-	362	8	None		None	
"	Fulton	14	10.42	(b)	8	9	A-2	-	-	265	1422	2	None	(b)	None	
"	Liberty - Liberty Field		1.33	20	6	6	A-2	-	-	7	117	3	None		None	
"	Twiggs	127	0.86	35	6	10	A-2,4	28-44	12-21	-	288	6	None		None	
Ill.	Logan-Menard	SA385	2.90	20	6	14	-	35	16	90	185	7	2	(c)	90	-
"	Tazewell	461	3.86	20	6	10	-	23-24	9-8	-	500	5	1		16	-
"	Winnebago	SA26	1.14	18	6	10	-	14-22	0-5	-	50	10	7	(d)	580	5
Ky.	Caldwell	139	11.0	20	6	10	A-4-2	-	-	-	-	5	-		93	0.1
"	Daviess	144	1.0	19	6	10	A-4	-	-	-	-	4	-		105	0.9
"	Daviess	144	2.3	19	6	10	A-4	-	-	-	-	4	-		7	-
"	Daviess	144	6.54	20	6	8,10	A-4,6	20	2	180	450	7	-		34	-
"	Henderson	54	9.2	20	6	10	A-4,a-7-6	-	-	-	-	5	-		25	-
"	Magoffin	7	7.0	19	6	10	A-2,to A-7-5	-	-	-	-	3	-	(e)	3085	3.9
"	Ohio	54	4.9	20	6	8,10	A-4	-	-	-	-	4	-		None	
"	Webster	56	8.9	20,24	6	10,12	A-2,4	-	-	-	-	4	-	(f)	9	-
Maine	Androscoggin	136	0.67	18	6	12	A-3	-	-	45	191	6	None		None	
Mich.	Cheboygan	M-16	1.27	20	6	8-12	A-2,4,6	-	-	-	-	9	1	(g)	9400	59
"	Crawford	M-72	1.57	22	5	8-10	A-2	-	-	-	196	5	None		None	
"	Ingham	M-92	3.02	22	6	8	A-2	11-20	0	-	403	5	None		None	
Minn.	Fillmore	139	3.0	24	6	14	-	40	17	-	-	5	1		196	0.5
"	Marshall	1	6.2	24	6	10,12,14	-	22-36	0-17	-	-	4	1	(b)	2282	0.2
Miss.	Chickasaw & Pontotoc	15	23.78	22	6	10	A-2F & A-2P	24-34	0-9	-	-	8	None		None	
Neb.	Fillmore-York	81	7.35	29	6	8	-	20-24	2-6	138	690	4-5	None		None	
"	Grant	2	3.80	24	5	6,8,10	-	25	4	50	190	7	None		None	
"	Platte	81	14.77	29	6	8	-	18-25	2-4	173	680	4-5	None		None	
"	Lancaster	33	5.01	24	5	10	-	35	13	131	810	8	1		100	0.1
"	Madison-Pierce	81	4.46	24	5	8,12	-	2-34	2-12	264	1340	8	None		None	
"	Huckalls	281	13.56	24	5	7.5,8,8.5	-	30	8	138	555	7	1	(i)	28000	15
"	Thayer-Fillmore	81	5.43	24	5	9,10,11	-	23	7	203	915	7	3	(j)	7500	10
"	York	81	7.79	28	6	8.5	-	25	4	182	990	3	None		None	
Nev.	Churchill	61	2.06	24	6	8*	A-2,3	17-23	NP	9	43	6	None		None	
N.J.	Hunterdone	Mt.Airy-Bowne Sta.	1.22	16	6	-	-	-	-	-	-	7	2		75	
"	"	(Ringoes-Groton	1.20	18	6	10	A-2-4	26	6	25	100	8	2		60	
N.Y.	Lewis	County	1.13	10	6	10	A-2,3	-	-	-	50	7	1	(k)	800	10
Okla.	Comanche	S-8	5.8	25	6	8-10	A-2,4	28	9	266	945	7	5		91	0.1
"	Woodward	S-15	6.8	24	6	8-10	A-2,3,4	17-39	0-19	220	832	6	None		None	
Pa.	Erie	25018	3.31	16.5	6	10	A-3	-	16-22	86	692	5	0.5	(l)	9000	33
"	"	25025	1.43	14	6	10	A-3	7-23	-	46	258	5	3		1	-
"	"	25068	5.16	16.5	6	10	A-3	-	-	68	366	6	0.5		140	-
"	"	25116	3.90	14	6	10	A-3	-	-	48	276	5	0.5		20	-
"	Lebanon	38050	1.97	14	6	10	A-2,3,4	25	6	31	213	8.5	None		None	
Va.	Accomac	695	2.95	18	6	12	-	15-16	NP-3	-	-	5	None		None	
"	Gloucester	198	7.26	18	6	10,12	A-2	16-35	2-18	45	103	2	None		None	
"	New Kent	168	1.96	20	6	8,10	-	23-43	6-19	79	295	8	None		None	
"	Powhatan	60	1.00	22	6	12	-	18-25	NP-9	152	1447	5	None		None	
"	Prince Edward	134	0.50	-	6	12	A-7	65-72	22-35	-	-	2	None	(m)	None	
"	Sussex	40	2.47	20	6	10,12	-	18-45	NP-16	55	335	5	3	(n)	34	0.1
"	York	168	2.80	20	6	8,10	-	20-47	4-8	195	1038	7	4	(o)	800	2.5
Wash.	Spokane	3N	3.58	20	6	10	A-4	28-31	6-11	55	275	4	None		None	
"	Whitman	3N	1.00	20	6	7.4	A-2,4	32	10	25	120	8	None		None	

NP — Non-plastic *by weight —not shown

(a)—Considerable dry, powdery soil-cement between mat and soil-cement.
(b)—Used for patching and widening.
(c)—Large coal trucks. Breakage caused by peculiar soil conditions.
(d)—Breakage due to hauling 4020 loads of crushed stone on soft subgrade in cut section.
(e)—Breakage at locations of poor drainage and bad subgrade reported as due to an unusual amount of logging truck traffic.
(f)—Information submitted showed considerable surface raval and some settlement.
(g)—Includes soil-cement removed during subsequent changes in grade.
(h)—Failures induced by heavily loaded beet trucks traveling and parking on one side of road.
(i)—Failures primarily due to bad subgrade conditions, insufficient base thickness (5") for type of subgrade and traffic, low cement content, and poor construction practices.
(j)—Failures due to insufficient base thickness (5") for the very poor subgrade and traffic.
(k)—One traffic lane paved.
(l)—Breakage caused by frost heave of silt loam subgrade.
(m)—Closed to traffic soon after completion due to failure of adjoining section of stabilization.
(n)—Failures due to poor drainage.
(o)—All breaks on one side of road due to heavy hauling when Camp Peary was built.

and in two cases to poor drainage and bad subgrade conditions. In the fifth case relative to breakage at later ages no date was given, but the breakage amounted to only one square yard and is of no significance.

The traffic reported on the projects in this condition survey varied from a minimum of 7 trucks per day to a maximum of 265 trucks per day, with total traffic varying from a minimum of 43 vehicles to a maximum of 2250 vehicles.

There is no evident correlation between the type of soil processed, truck traffic and breakage. It is, therefore, indicated that the 6-inch depth was adequate for the variables encountered on the projects reported to date which covers many typical conditions in the several states.

All the data included in the tables on soil-cement base maintenance cost and soil-cement base condition indicate that these many roads are serving their purpose quite adequately and economically for the variable conditions of climate, subgrade and traffic encountered. A report on total mileage of soil-cement roads built to date was requested from the Portland Cement Association, which shows more than 1500 miles of soil-cement roads have been built in 39 states.

The very valuable detailed information supplied by the several states and the individuals who inspected the projects and prepared the reports, is very much appreciated by this committee and particularly from the fact we are fully aware of the personnel shortages with which they were confronted.

The value of these historical data on soil-cement roads will be greatly increased if continued studies can be evaluated after five years or more of additional service. It is, therefore, the desire of the committee that each state follow up the service behavior of all earlier projects, both for their own information and to make the data available for comparative studies and reporting in subsequent years.

The committee discussed the use of soil-cement and soil-cement mixtures for bases for concrete pavements to prevent pumping and distortion on heavy textured soils, for use as back fill at bridge abutments and to reduce volume changes and displacement problems in earth fills. The production of cement-modified soil binders in granular base materials was discussed. Their possible economy was explored for areas where use would result in lower construction costs than would result from the use of soil-cement bases involving fine grain soils, predominantely clays and high cement contents of the order of 16 percent by volume or more.

It was the sense of the Committee that these several uses of soil-cement and soil-cement mixtures warrant further study and investigation.