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In This Issue

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MICROCHEMICAL EXAMINATION OF SOIL SOLUTIONS

BY THE DIVISION OF TESTS, U. S. BUREAU OF PUBLIC ROADS

Reported by JAMES A. KELLEY, Junior Highway Engineer

SOILS for highway purposes are tested to determine the characteristics indicative of their performance as road surfaces, bases for thin wearing courses, subgrades, and as foundations for retaining walls, bridges, and similar structures. Information on physical properties such as stability, compressibility, elasticity, and capillarity is generally sought. In such determinations soil is assumed to consist of inert solids of constant volume and containing pores that enlarge and shrink as the soil mass changes in volume.

This assumption is not strictly true as soluble materials, organisms, and bacteria are usually present, although not in sufficient amounts to require consideration in the interpretation of the results of physical tests.

The character and amount of the soluble soil constituents may have an important bearing upon such problems as the durability of concrete and the selection of admixtures for use in the stabilization of soils. But accurate, quantitative, chemical analyses of soil solutions are difficult to make, even by the most elaborate methods. After some investigation it has been found that a comparatively simple and more or less qualitative microchemical method may be useful in analyzing soil solutions.

SOIL MOISTURE CONTAINS MINERAL MATTER IN SOLUTION [1]

According to the soil scientist the mineral constituents of soils are products of the disintegration and degradation of rocks. However, due to mixing and transporting agencies, more minerals are likely to be present than those furnished by the rocks from which a soil is primarily derived. Even in beach sand it is surprising how many minerals other than quartz can usually be found. Hence there is the generalization that practically every soil contains all of the common rock-forming minerals.

Aside from silicon and iron oxide, the principal soil minerals are silicates, ferro-silicates, alumino-silicates, or ferro-alumino-silicates of the common bases—sodium, potassium, calcium, magnesium, and ferrous iron. Other bases such as lithium, barium, or the heavy metals may occasionally be present in appreciable amounts as may other types of silicates or other mineral salts.

The silicates or silico minerals are all somewhat soluble in water, and, being salts of weak acids with strong bases, they are greatly hydrolyzed. A convenient illustration is afforded by the well-known rock and soil mineral, orthoclase, that with alteration may become kaolin. The reaction of orthoclase with water may be represented as follows:

$$KAl\,Si_3\,O_8 + HOH \rightleftarrows H\,Al\,Si_3\,O_8 + KOH$$

Under ordinary soil conditions, with a relatively large proportion of carbon dioxide in the soil atmosphere, the potash formed would be more or less completely transformed to the bicarbonate as follows:

$$KOH + CO_2 + H_2O \rightleftarrows KHCO_3 + H_2O$$

Unless the hydrolysis of a silicate of the alkalis or alkaline earths is a reversible action, no minerals containing silicon could persist in the soil for any length of time and all soils would soon become sterile wastes composed essentially of quartz, kaolin, and ferruginous oxides. It has been suggested that the original mineral particles are protected from decomposition by a jelly-like coating on the surface of the soil grains.

If a soil be shaken up thoroughly with water, the resulting solution filtered free of suspended matter and then boiled to eliminate the carbon dioxide, generally the solution will give an alkaline reaction. This is true also of the waters of most springs, ponds, or creeks. However, the mineral content of such waters varies widely. The water that passes down through the larger interstices of the soil is not long in contact with the individual soil particles and floccules, and, because diffusion of dissolved mineral substances is quite slow especially in dilute solutions, it takes up but little matter from such aqueous films as it may intercept.

Different conditions govern the action of the soil water that returns towards the surface by capillary action to form the great, natural, nutrient medium for plants. This water moves slowly over the soil particles in films. It is in contact with successive fragments of any particular mineral and with all the different minerals making up the soil for long periods of time. Consequently, it tends to become a solution saturated with the minerals encountered.

Many attempts have been made to extract and analyze solutions naturally existing in the soil. The results obtained have not been very satisfactory, mainly because solution in a soil, under conditions suitable for crop growth, is held by a force of great magnitude—9,000 to 15,000 atmospheres.

By means of powerful centrifuges it has been possible to obtain from soils small quantities (a few centimeters at a time) of dilute solutions containing about 6 to 8 parts per million of phosphoric acid (P_2O_5) and 25 to 30 parts per million of potash (K_2O). The analysis of a few cubic centimeters of a very dilute solution is in itself very difficult, necessarily involving uncertainty as to the value of the results.

Wheat, corn, and some common grasses have been grown to a satisfactory maturity in tap water having a concentration of seven parts per million of potassium and one-half part per million of phosphoric acid. In this connection, investigators believe that the ratio of potassium to phosphoric acid of 14 to 1 is quite important. Wheat, grasses, cowpeas, vetches, potatoes, and other plants have been grown satisfactorily in solutions made by shaking up a soil in distilled water and separating the solution from the solid particles with an unglazed porcelain filter.

[1] The material under this heading is summarized from the text book The Soil Solution, by Frank K. Cameron, U. S. Bureau of Chemistry and Soils. The Chemical Publishing Co., Easton, Pa., 1911, and Williams and Norgate, 14 Henrietta Street, Covent Gardens, London, England.

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MANY DIFFERENT MATERIALS FOUND IN SOIL SOLUTIONS

Some idea of the kinds and quantities of soluble constituents of soils is furnished by analyses of plant ashes and waters from springs, lakes, and rivers. Analyses of ashes of ordinary crops are given in table 1.[2] In presenting these data attention is called to the fact that plant physiologists and soil scientists are divided into different schools. One group maintains that plants do not dissolve significant quantities of minerals that would otherwise remain undissolved; another school emphasizes the important role that the root exudations exercise in this connection.[3]

Table 1.—*Chemical composition of ashes of ordinary crops*

Crops	Potash and soda alkalis	Magnesia	Lime	Phosphoric acid	Silica	Sulphuric acid	Chlorine
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Cereals:							
Grain	30	12	3	46	2	2. 5	1
Straw	13–27	3	7	5	50–70	2. 5	2
Legumes:							
Kernel	44	7	5	35	1	4	2
Straw	27–41	7	25–39	8	5	2–6	6–7
Root crops:							
Roots	60	3–9	6–12	8–18	1–4	5–12	3–9
Tops	37	3–16	10–35	3–8	3	6–13	5–17
Grasses in flower	33	4	8	8	35	4	5

Table 2 from Hilgard [4] contains data on the chemical composition of river waters. Additional analyses are given in table 3. Table 4, also from Hilgard, affords some insight into the actual and possible solvent effects of water in the soil.

Authorities agree that it seems impossible to exhaust a soil's solubility by successive leachings with water. This was demonstrated in 1863 and 1864 by Ulbricht [5] and by Schultze [6]; their general conclusions were corroborated by King [7] in 1904.

King's first leaching experiments were made by shaking up the soil sample with 10 times its dry weight of water for 3 minutes, then determining the ingredients of the filtrates by very delicate (mostly colorimetric) methods. The soil was dried at 120° C. between successive leachings. At each drying not only is the soluble matter again drawn to the surface but heating a soil renders additional amounts of soil ingredients soluble in both water and acids. (See Hilgard.)

Table 2.—*Chemical composition of river waters*

	Potash and soda	Magnesia	Lime	Phosphoric acid	Silica	Sulphuric acid	Chlorine
	Parts per million	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*
Yukon (Alaska)	8	7	30	--------	8	9	0. 4
St. Lawrence (Pointe des Cascades)	8	10	45	Trace	33	48	2. 0
Missouri (Montana)	32	18	58	0. 22	19	22	18. 0
Mississippi (near Carrollton, La.)	20	41	41	--------	9	16	10. 0
Rio Grande (Fort. Craig, N. Mex.)	44	2	23	--------	10	47	36. 0

WATER-SOLUBLE SOIL CONSTITUENTS HAVE POSSIBLE INFLUENCE ON THE DURABILITY OF CONCRETE STRUCTURES

At the eleventh annual meeting of the Highway Research Board, it was suggested that disintegration of concrete could be of three types; chemical, part chemical and part physical, and physical.[8]

The purely chemical type of disintegration results from such causes as contact with sea water, alkali, sodium and magnesium sulphates, various acids found in ground waters and sewage, or the many chemical compounds of a greater or less stability that under certain conditions may be set up in the hydration of cements.[9] The detrimental chemical, whether in soil or water, must be present in sufficient amount to produce a readily discernible action. Such action involves base exchange and would be expected to begin where the concrete is in contact with the detrimental agency and to progress from this location toward the interior of the structure. In road slabs detrimental action of this type would begin at the bottom and progress upward.

It is assumed that in the physico-chemical type of disintegration, the active chemical is either in solution in water that enters the slab by capillary movement or is dissolved by moisture contained within the structure. It is then deposited at some location on the interior of the structure where the rate of percolation changes, or at the surface where evaporation occurs. This theory serves to explain why piers, piles, and similar structures, immersed in water with chemical content obviously too low to injure the completely immersed portions of the structure, may, by continued capillary flow and evaporation, accumulate enough chemicals just above the water line to be detrimental. The theory also serves to explain the deterioration of pavement slabs that begins at the top and works downward.

The purely physical type of disintegration results from the growth of crystals without chemical action. The crystals may be formed by the freezing of water or by the crystallization of dissolved chemicals due to the evaporation of the liquid carrier.[10] This, like the physico-chemical type of disintegration, can be expected to begin at the surface of freezing or evaporation and to progress toward the interior of the slab.

Figure 1 illustrates the manner in which soil solutions are assumed to travel vertically through road slabs in order that crystals may be deposited at the tops of the slabs. The rate of travel depends upon the permeability and this is controlled more by the character of voids than by their percentage in the mortar. Fine cracks that are almost invisible to the eye afford more or less continuous channels to the surface and greatly increase the permeability.

It is well known that disintegration progresses more rapidly in natural rocks that contain cracks and laminations than in those that do not. In experiments on the phenomenon of crystal growth, Professor Taber[11] found that such materials as brick, cement mortar, and pottery also were less resistant to disintegration when containing small fissures.

[2] From the text book How Plants Grow by Samuel W. Johnson, Orange Judd Company, New York, 1908, page 171.
[3] See The Feeding Power of Plants by Walter Thomas, Plant Physiology, vol. 5, No. 4, October 1930.
[4] The text book Soils by Eugene Woldemar Hilgard, The MacMillan Co., New York, 1919, and The MacMillan Co., Ltd., London.
[5] Die Landwirtschaftlichen Versuchs Stationen, vol. V (1863), p. 207.
[6] Die Landwirtschaftlichen Versuchs Stationen, vol. VI (1864), p. 411.
[7] Proceedings of the 25th Annual Meeting of the Society for the Promotion of Agricultural Science (1904), p. 171–190.
[8] Functions of Steel Reinforcement in Concrete Pavements and Pavement Bases, by C. A. Hogentogler and E. A. Willis. Proceedings Eleventh Annual Meeting, Highway Research Board, 1931, page 299.
[9] The Durability of Concrete by C. H. Scholer. Proceedings Tenth Annual Meeting, Highway Research Board, 1930, page 132.
[10] The Mechanism of Corrosion of Portland Cement Concrete with Special Reference to the Role of Crystal Pressure, by F. O. Anderegg, 1929. Proc. A. C. I., vol. 25, 1929.
[11] Frost Heaving, by Stephen Taber. The Journal of Geology, vol. 37, No. 5, July–August 1929, p. 440.

TABLE 3.—*Results of water analyses* [1]

Sample no.	Source	Location	Potassium and sodium	Magnesium	Calcium	Carbonic acid	Silica	Sulphuric acid	Chlorine
			Parts per million	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*
1	Spring	Paris, Maine	27	16	136	27	17	370	Trace
2	do	Caledonia, N. Y	102	30	180	1	8	293	206
3	Well	Washington, D. C	6	1	3		25	8	10
4	do	Alexandria, Va	10	3	4		33	11	7
5	Spring	Loudoun County, Va	84	15	524	159	21	1, 287	10
6	do	Virginia Hot Springs, Va	22	35	133	223	24	129	3
7	do	Towesville, N. C	29	9	151	78	39	333	3
8	Well	Charleston, S. C	1, 055	8	14	40	36	Trace	944
9	Surface drainage	St. Augustine, Fla	74	17	80		15	52	108
10	Well	Clinton, Miss	132	74	198		75	985	72
11	Spring	Mountain City, Tenn	8	2	12		22	13	1
12	Well	Frankfort, Ky	481	19	21		10	187	522
13	Spring	Leansboro, Ill	300	447	542	113	14	3, 004	35
14	do	Nashville, Ill	681	277	427	1, 142	12	1, 695	24
15	Well	Story City, Iowa	19	32	76	219	Trace		1
16	Spring	Thurman, Mo	3	3	43		15	4	2
17	do	Magnet Cave, Ark	4	Trace	69		12	8	3
18	do	Sulphur, Okla	293	35	86	121	24	32	482
19	Lake	Yellowstone Lake, Wyo	20	3	9		42	8	9
20	River	Hot River, Wyo	197	63	236		50	508	160
21	Springs	Livingston, Mont	30	44	168	248	29	222	12
22	do	Denver, Colo	6, 525	7, 287	302		28	41, 362	1, 492
23	Well	Pueblo, Colo	261	33	58		10	514	
			Milligrams per liter	*Milligrams per liter*	*Milligrams per liter*	*Milligrams per liter*	*Milligrams per liter*	*Milligrams per liter*	*Milligrams per liter*
24	do	Coalburg, W. Va	4, 750	380	2, 220	Trace			11, 900
25	Brine from oil field	Houston, Tex	31, 380	290	2, 000			3, 510	53, 070
26	Lake	Lake De Smet, Wyo	1, 424	406	71	67	14	4, 129	58
27	River	Bear River, Utah	8	13	43	97	7	11	5
28	Spring	Near Ogden, Utah	7, 083	93	1, 143	144	46	218	13, 703
29	River	Walker River, Nev	32	4	23	56	23	29	13
30	Lake	Lake Tahoe, Calif	11	3	9	28	14	5	2
31	Spring	Mono, Calif	670	60	59	578		313	227
32	Lake	Albert Lake, Oreg	15, 228			6, 006	232	706	13, 462
33	do	Soap Lake, Wash	10, 504	108	Trace	6, 419	113	4, 362	3, 526
34	Sea water	Gulf of Mexico, near Tortugas	11, 596	1, 305	442	126		2, 742	20, 076

[1] These analyses were made in the laboratory of the U. S. Geological Survey. See Water Supply Paper 364, by F. W. Clarke, 1914.

TABLE 4.—*Water-extracted chemicals from soils*

Soil	Potash and soda	Magnesia	Lime	Phosphoric acid	Silica	Sulphuric acid	Sodium chloride	Carbonic acid
	Parts per million	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*	*Parts per million*
Bonn, Saxony	126	38	128	31	48	100	59	
Chemnitz, Saxony	38	37	84	Trace	26		48	
Sassafras sandy loam	13	18	74	7	6	54		14
Norfolk, N. C., sandy soil	21	23	58	10	8	43		20
Janesville, Wis., loam	25	52	135	17	40	125		29
Hagerstown, Pa., clay loam	22	77	165	12	21	188		97

The movement of solutions through mortar is disclosed by the formation of crystalline deposits such as are illustrated in the photomicrograph shown in figure 2.

ELECTROLYTIC PROPERTIES OF MINUTE FILMS IMPORTANT IN THE STABILIZATION OF SOIL

The theory of adhesives [12] has much significance in the selection of chemical admixtures for stabilizing soils. For a given cementing material to adhere strongly to a solid surface it must be adsorbed at the solid surface; it must wet the solid surface and form a liquid film there. For an adhesive to wet a soil particle coated with an existing soil gel or in the presence of air, the adhesive must be adsorbed more strongly than either the gel or the air and must displace whichever one is present.

After a period of drought, adsorbed air on the surface of dust particles will often cause raindrops to roll along in the dust without wetting it. Even after a heavy shower the dust may be wetted only to a depth of less than ¼ inch. Any treatment that cuts down the amount of adsorbed air makes the dust more easily wetted. In like manner any treatment that reduces the affinity of the soil particle for the existing film of gel with which it may be covered makes the soil particle easier to coat with the soil-stabilizing adhesive.

[12] See Applied Colloid Chemistry, by Wilder D. Bancroft. McGraw-Hill Book Co., Inc., New York and London, 1932.

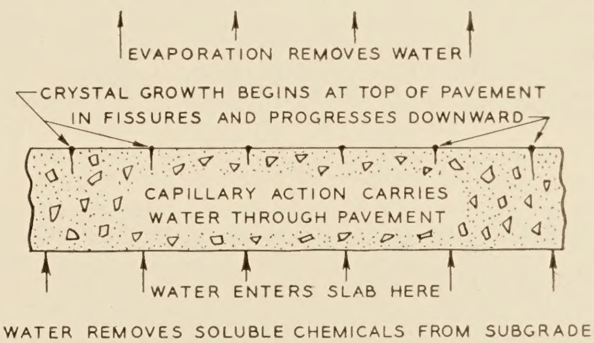

FIGURE 1.—ILLUSTRATING GROWTH OF CRYSTALS BY CHEMICALS THROWN OUT OF SOLUTION.

However, materials used to reduce or increase the affinity of soil particles for existing coatings can be selected only after obtaining some knowledge of the electrolytic properties of the soil particles, of the existing films, and of the proposed adhesives.

For a given adhesive and given soil particles, the thinnest film is the strongest. A slight change in either the adhesive or the materials to be cemented is sufficient to cause considerable variation in the thickness of the adhesive film and consequently in the

FIGURE 2.—DEPOSITS OF CHEMICAL AT EDGES OF FISSURE IN MORTAR. LENGTH OF FISSURE SHOWN ABOUT ONE-SIXTEENTH INCH. MAGNIFIED 55 DIAMETERS.

strength of the resulting mixture of adhesive and aggregate.

A knowledge of the chemical composition of materials serves to throw some light on their electrolytic properties. The chemical composition of the water-soluble constituents of soils controls to some extent the electrolytic properties of the existing gel films. This explains the interest aroused in the study of soil solutions in connection with research on soil stabilization by means of chemicals or admixtures of substances other than soil materials. Such research, however, is just getting under way. To date microchemical analyses have been used principally in studying the durability of concrete and the warping of concrete pavements.

SIMPLE PROCEDURE INVOLVED IN ANALYSIS BY THE MICROCHEMICAL METHOD

Examination has been made of samples of subgrade soil and concrete from numerous locations in the United States, of samples of ground water and solutions of soil chemicals made synthetically, and of cement mortar samples treated specially in the laboratory. The procedures used were essentially as follows:

Soil samples.—Thirty-five grams of soil, air dried and prepared as for routine subgrade tests (see PUBLIC ROADS, September 1931), were placed with 30 grams of distilled water in a crystallizing dish about 2 inches in diameter and 1¼ inches high and were thoroughly mixed four times by stirring at intervals of 1 hour. The apparatus used is shown in figure 3. One hour after the last mixing the solution portion of the mixture was decanted with a pipette and filtered through high-grade filter paper. Six drops of the filtrate were then placed on a glass slide which was then placed in a desiccator. The slide was examined under the microscope when the liquid had evaporated. Photomicrographs were made of the crystal formations either as nuclei or as a mass.

Cement mortar and scale samples.—Samples of concrete, concrete scale, and the like were pulverized in a mortar with a pestle. Twenty-five grams of the resulting powder and 15 grams of distilled water were then placed in a crystallizing dish. The mixture was stirred and the slides were then prepared in the same manner as was done with the soil samples.

Ground water.—Ground water, sampled full-strength in the field, was filtered in the laboratory in the same manner as the soil and scale solutions. Slides were made from the resulting filtrates in the manner just described for the soil filtrates.

Solutions of known chemicals and synthetic alkalis.—Solutions of known chemicals and synthetic alkalis were filtered and then examined in the same manner as the other filtrates described above.

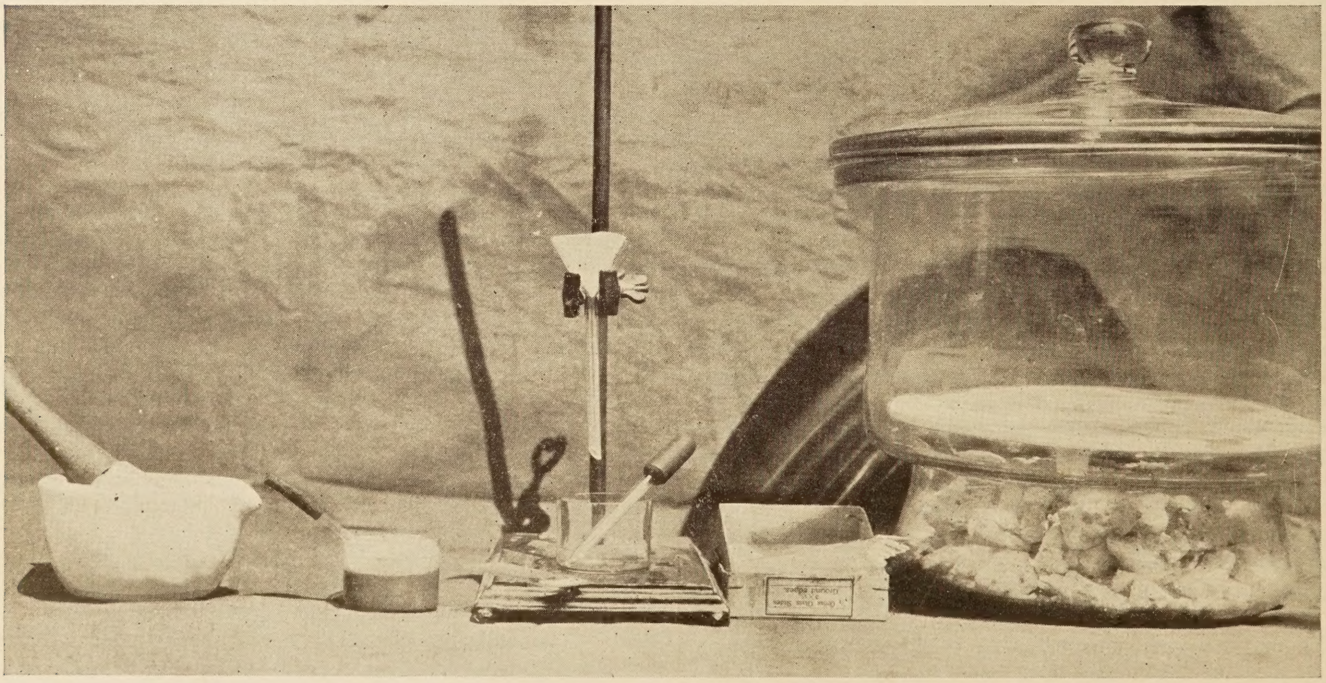

FIGURE 3.—APPARATUS USED IN THE PREPARATION OF SAMPLES FOR MICROSCOPIC EXAMINATION.

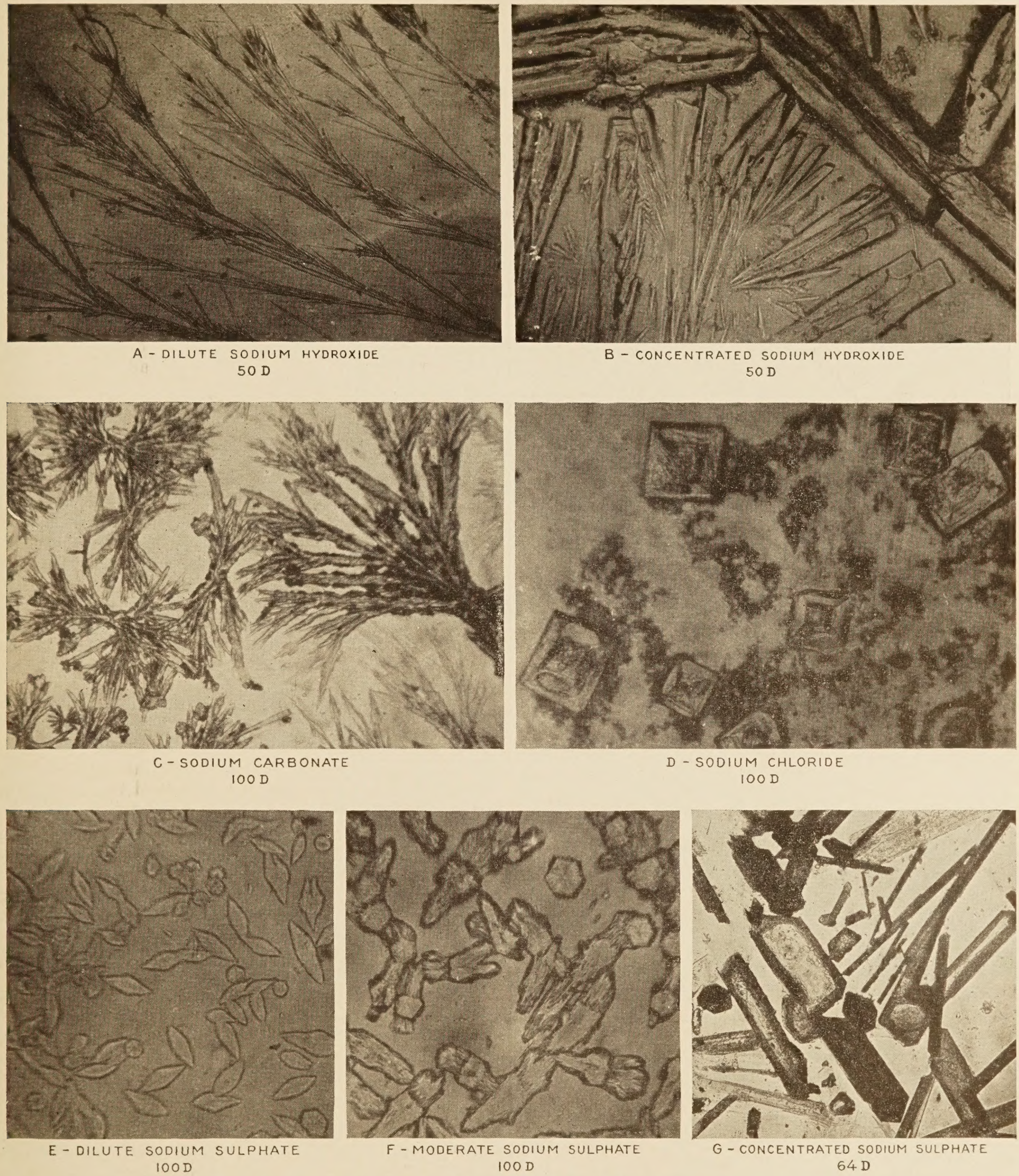

Figure 4.—Typical Sodium Crystals.

TYPICAL CRYSTALS OF WATER-SOLUBLE MATERIALS PHOTOGRAPHED

Figures 4, 5, and 6 show photomicrographs of crystals of the well-known chemicals examined. An attempt was made to include the constituents of common soils and chemicals that various authorities believe may attack concrete.[13] In figure 4 and those that follow the magnification is shown in diameters, the letter "D" being used to indicate diameters.

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13 Disintegration of Concrete, report of committee no. 803, by G. M. Williams, Journal A. C. I., vol. 1, no. 1, November 1929.
The Action of Sulphate Water on Concrete, by D. G. Miller, Public Roads, vol. 8, no. 9, November 1927.
The Causes of Concrete Destruction on Reconditioned Soils, by C. H. Gessner, Proceedings First International Congress of Soil Science, 1927, pp. 663–685.

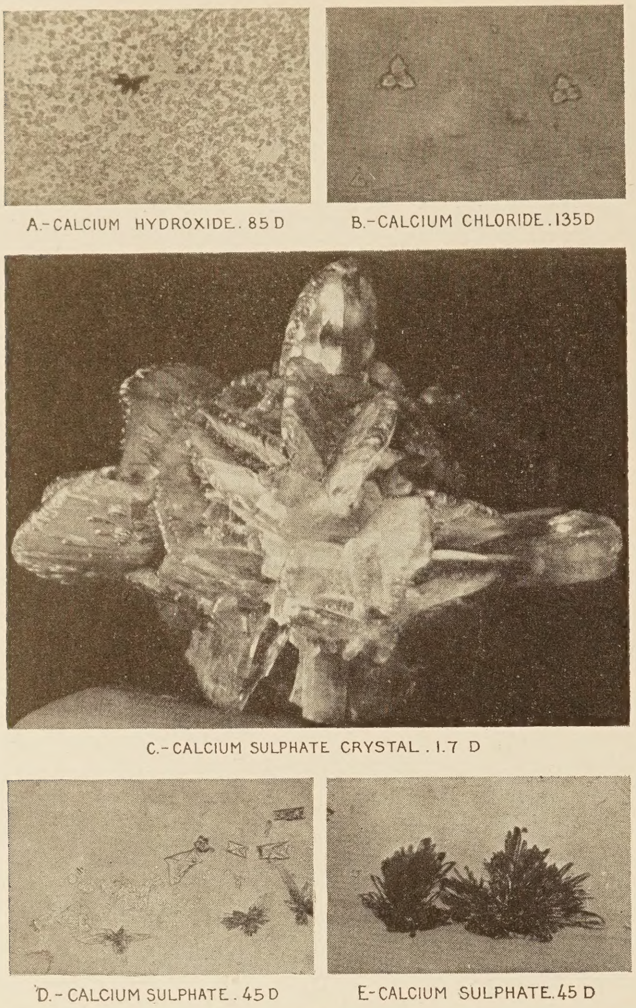


Figure 5.—Typical Calcium Crystals. D Shows Crystals Formed From a Weak Solution and E Shows Crystals Formed From a Strong Solution.

Additional information on the appearance of typical crystals is furnished by a number of reproductions of photomicrographs by Arthur W. Doubleday [14] and drawings by Carl G. Hinricks.[15]

Terms such as "strong," "normal," "weak," and "amorphous" were used to designate the degrees of crystal concentration found.

"Strong" signifies a vigorous mass-growth, one crystal occasionally extending throughout the field of vision (figs. 4–B and 5–E).

"Normal" was used to signify definitely formed individual crystals distributed generally throughout the field of vision (figs. 4–D and 6–C).

"Weak" was used to designate crystal nuclei of which a relatively few occurred in the field of vision (figs. 5–B and 6–E).

"Amorphous" was used to designate growths similar in appearance to cement mortar (fig. 6–F).

It is interesting to note how the crystals of some chemicals differ in character due to differences in the strengths of the solutions from which the crystals were obtained. This is true of crystals from sodium hydroxide (figs. 4–A and 4–B), from sodium sulphate (figs. 4–E, 4–F, and 4–G), and from calcium sulphate (figs. 5–D and 5–E). This was not found true for crystals from magnesium sulphate solutions.

The calcium sulphate or gypsum crystal shown in figure 5–C, has a maximum lineal dimension of about 2 inches. It was obtained by W. I. Watkins from the Red River valley in Minnesota. Samples of gumbo soil from this location were examined in connection with studies of the warping of concrete pavements. The alkali crystals (fig. 6–C) were made up synthetically to represent crystals that might be expected to be formed by the water at Billings, Mont. The effect of this water on concrete has been extensively studied.[16] The alkali crystals and those shown in figure 6–E have a typical saw-buck form similar to crystals from dilute sulphate solutions.

The crystals shown in figures 6–F and 6–G are from two samples of the same cement mortar. The sample of figure 6–G was subjected to the action of a synthetic alkali solution while that represented by figure 6–F was not subjected to such action. The mortar furnishing the crystals shown in figure 6–G was obtained from that portion of a test sample located about 2 inches above the portion of the sample in contact with the chemical solution. The treatment had progressed for about 2 months.

The hexagonal crystals from the treated mortar (fig. 6–G) were probably produced by the same sulphates that produced the saw-buck crystal. The hexagonal form of the sulphate crystal has been found only in cement mortars and concretes, and may be due to the presence of sulphur in the mortar as well as in the penetrating chemical solution.

VARIABLES AFFECTING CRYSTAL GROWTH DISCLOSED BY OBSERVATIONS ON MORTAR SAMPLES IN THE LABORATORY

Field inspections of concrete pavements show that crystal growth is quite erratic, occurring at times on one side of the pavement and not on the other, and even in one portion of a slab and not in the remainder. This suggests the possibility that mixing or curing conditions in addition to characteristics of materials may influence crystal growth. Variables that should be investigated are the amount of water used in the mixture, the manner of curing, and the loss of moisture from the slab by evaporation due to temperature and wind and due to absorption by the subgrade soil.

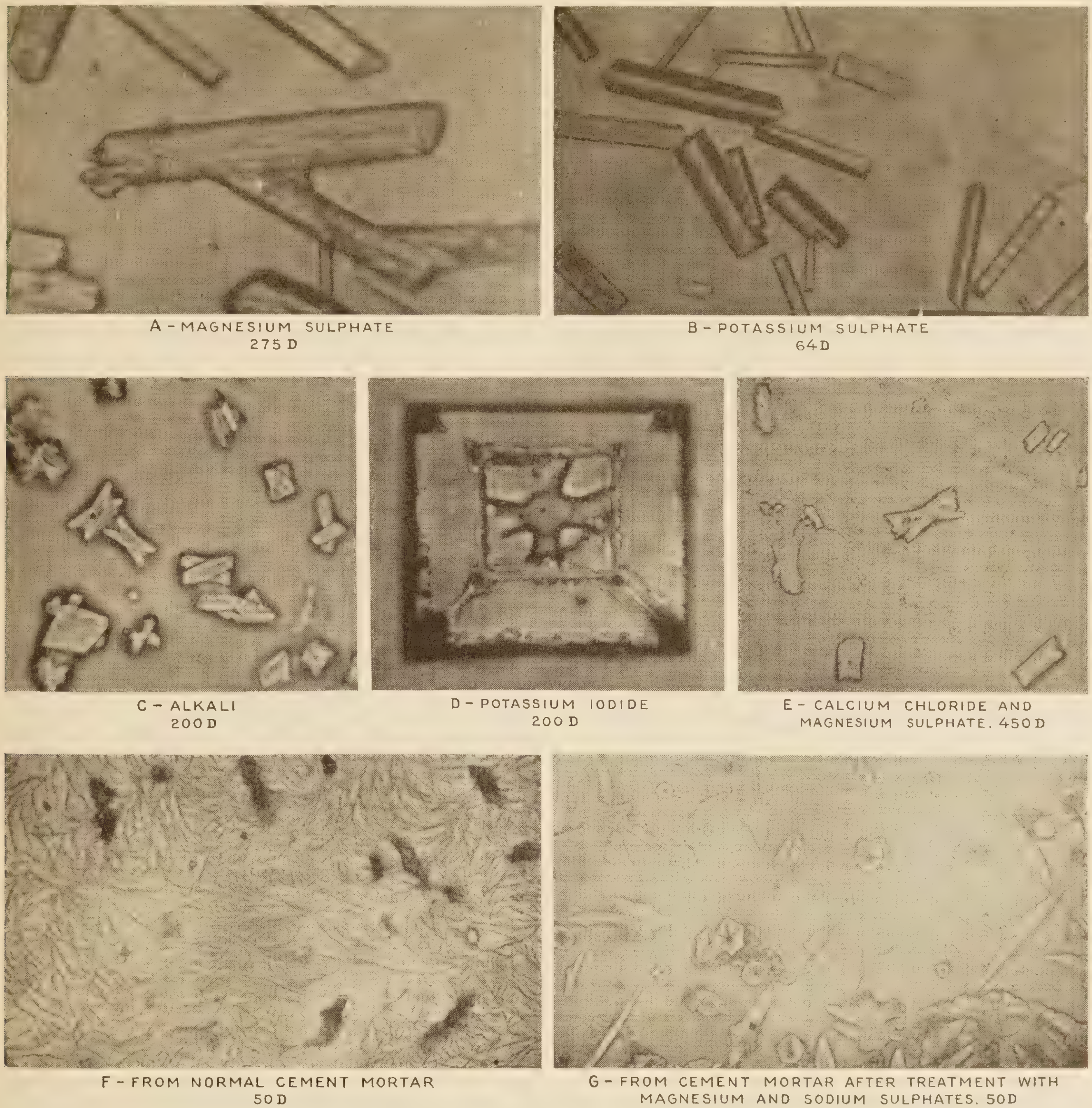
Some information was obtained on this phase of the problem as a result of observations made on three sets of samples subjected to the action of synthetic alkali solutions in the laboratory. The first set consisted of 8 samples, 2 inches in diameter and 1½ inches high made with 1:2 mortar in the spring of 1932. The second set consisted of 8 samples, 4 inches wide, 6 inches long, and ½ inch thick made with 1:1½ mortar at the same time as the first set. The third set consisted of 4 samples, 4 inches in diameter and 4 inches high, made with 1:1½ mortar in the spring of 1933.

All of these samples were placed on porous sand bases saturated with alkali solution. An impervious seal was placed around each sample to prevent the escape of the alkali solution except by capillary action through the sample.

[14] Photomicrographs of Crystallizable Salts, by Arthur W. Doubleday, 1916. Research Publishing Co., Boston, Mass.

[15] Micro-chemical Analysis, by Carl G. Hinricks.

[16] Bulletin No. 81 of Montana Agricultural College Experiment Station.



A - MAGNESIUM SULPHATE 275 D

B - POTASSIUM SULPHATE 64 D

C - ALKALI 200 D

D - POTASSIUM IODIDE 200 D

E - CALCIUM CHLORIDE AND MAGNESIUM SULPHATE. 450 D

F - FROM NORMAL CEMENT MORTAR 50 D

G - FROM CEMENT MORTAR AFTER TREATMENT WITH MAGNESIUM AND SODIUM SULPHATES. 50 D

FIGURE 6.—MISCELLANEOUS CRYSTALS.

Observations of these samples definitely disclosed that disintegration is caused by solutions drawn upward by capillary action. The disintegration began at the top of samples and progressed downward. It was also disclosed that the rate at which disintegration occurs, if it occurs at all, is considerably affected by slight changes in materials, in the method of mixing and placing, and in the curing. Figure 7 shows variations in the condition of samples of the first set after subjection to the alkali action for approximately 6 weeks.

In studying the durability of concrete, inspections were made of many concrete pavements and some attention was also given to culverts, retaining walls, piers, abutments, and sidewalls. Aside from pavements in good condition, the examinations were confined to areas with conditions as shown in figure 8.

In general, concrete pavements and adjacent subgrades were sampled in the following manner: A location representative of conditions was selected after careful visual inspection and the soil was sampled through a hole dug in the shoulder adjacent to the pavement as shown in figure 9. The concrete was sampled above the location of the soil sample by means of hammer and drill. Results of the analyses are shown in figures 10 to 18 inclusive.

Figure 11 shows crystals formed from subgrade soli beneath pavements in New York State.

Figure 13 shows a disintegrated concrete gutter, a scaled pavement adjacent to the gutter, a crystal produced from the mortar of the gutter, and a crystal produced from the subgrade soil beneath the gutter.

Figure 14 shows a miscellaneous group of saw-buck crystals formed from subgrade soils beneath pavements that had scaled and crystals formed from concrete surfaces and structures that had deteriorated.

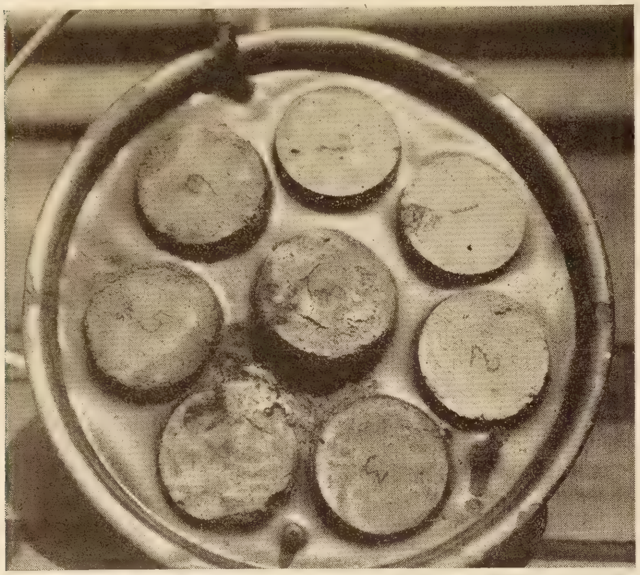


Figure 7.—Cement Mortar Samples Subjected to Sulphate Action.

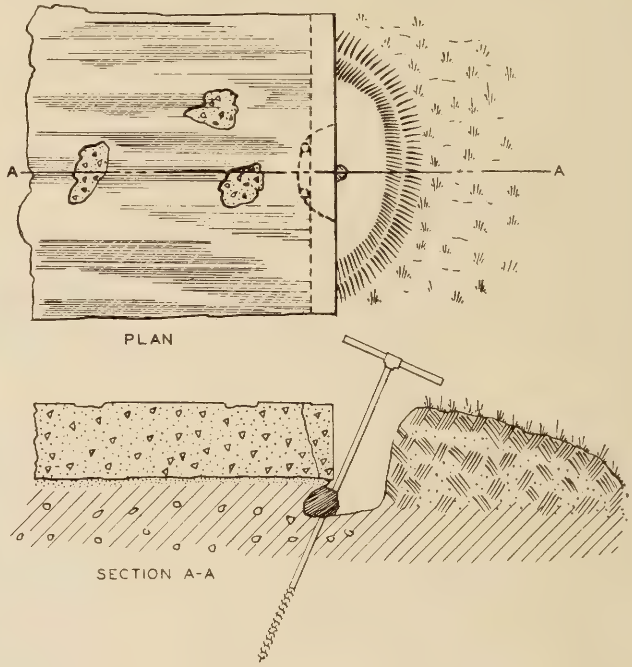
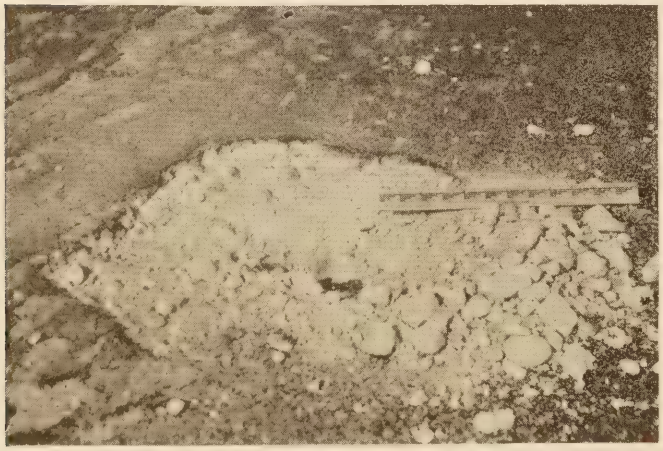


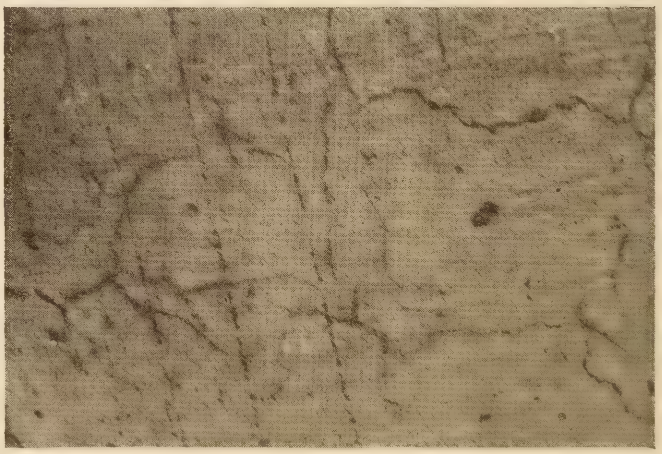
Figure 9.—Method of Sampling.

A.-MOTTLED SLAB. SERVICEABILITY NOT REDUCED. AGE 7 YEARS

B.- PROGRESSIVE SCALE AGE 9 YEARS



C.-CONCRETE POWDERED AND COHESIONLESS. AGE 10 YEARS



D.- MAP CRACKING AGE 4 YEARS

Figure 8.—Types of Pavement Condition Indicative of Crystal Growth.

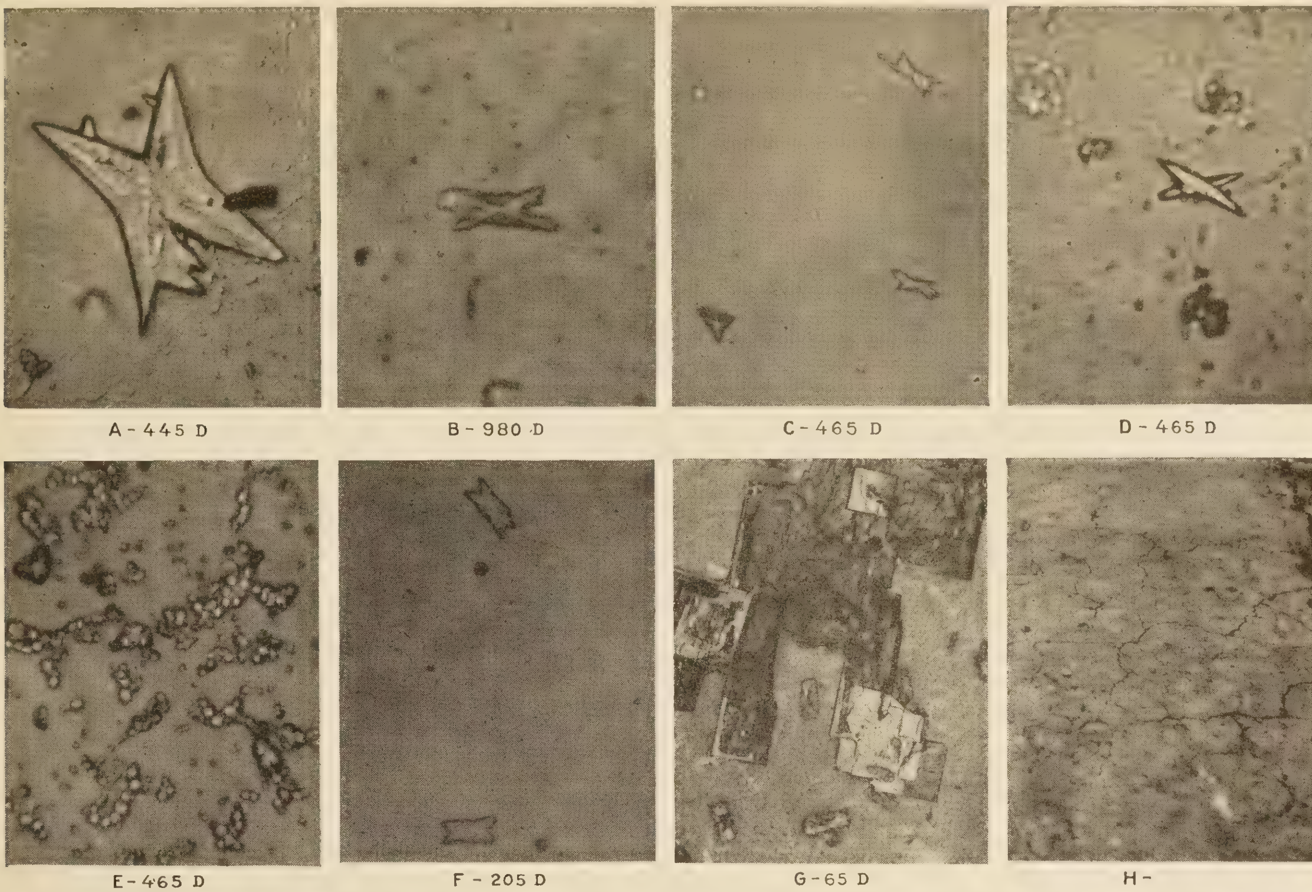


FIGURE 10.—CRYSTALS FORMED FROM DETERIORATED STRUCTURES AND THE ADJACENT SOIL AND WATER. A, FROM SOIL UNDER PROGRESSIVELY SCALED SECTION OF ROAD IN VIRGINIA. THE FISSURE SHOWN IN FIGURE 2 WAS IN A SCALED SECTION OF THIS ROAD. B, FROM DISINTEGRATED TILE IN DAMAGED WALL IN BUFFALO, N. Y. C, FROM A BADLY DISINTEGRATED WALL IN PENNSYLVANIA. D, FROM WATER FLOWING OVER SAME WALL AS IN C. E, AMORPHUS CALCIUM CARBONATE FROM SOIL IN PENNSYLVANIA. F, FROM SOIL UNDER FISSURED PAVEMENT SHOWN IN H. G, SALT CRYSTALS FROM CONCRETE IN BADLY CRACKED AND CHECKED ROAD IN ALABAMA. H, FISSURED PAVEMENT IN GEORGIA.

Figure 15 shows crystals produced from a scaled section of concrete slab, and also from the saturated sand cushion, the ground water, and the subgrade soil beneath the slab.

Figure 16 shows damage to new and old sections of a retaining wall and sulphate crystals formed from samples from the new wall and from the soil.

Figure 17 shows the hexagonal form of sulphate crystals made from six samples of mortar from different concrete structures. Five of the six structures showed evidences of scaling. The lower right crystal was made from a sample from the culvert head-wall shown.

The upper pictures of figure 18 show salt crystals formed from deteriorated concrete, probably damaged by ice-prevention measures. The lower pictures of figure 18 show strong sulphate crystals made from spring water from a side-hill cut adjactent to concrete that had disintegrated.

LABORATORY TESTS CONVINCING THAT HARMFUL CHEMICALS ARE DEPOSITED BY CAPILLARY ACTION

The foregoing data have been presented to demonstrate the suitability of the microchemical method of analysis for determining the presence of chemicals in

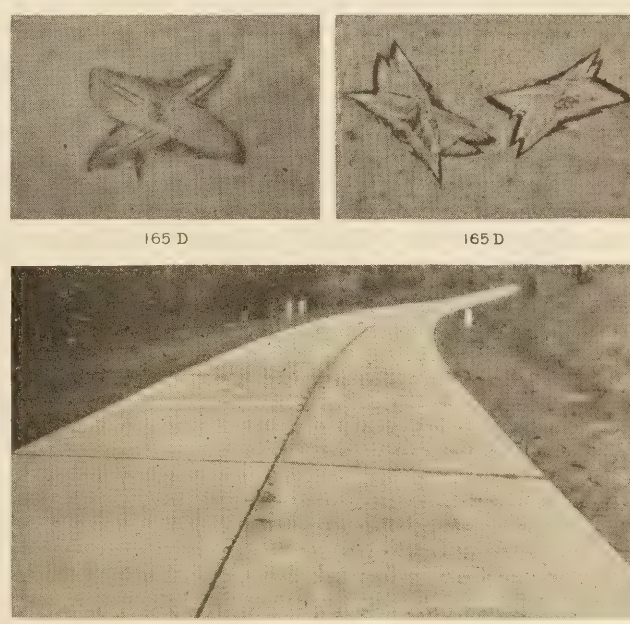


FIGURE 11.—PROGRESSIVE SCALING OF PAVEMENT, AND CRYSTALS FORMED FROM SOIL SAMPLES TAKEN FROM BENEATH THE PAVEMENT.

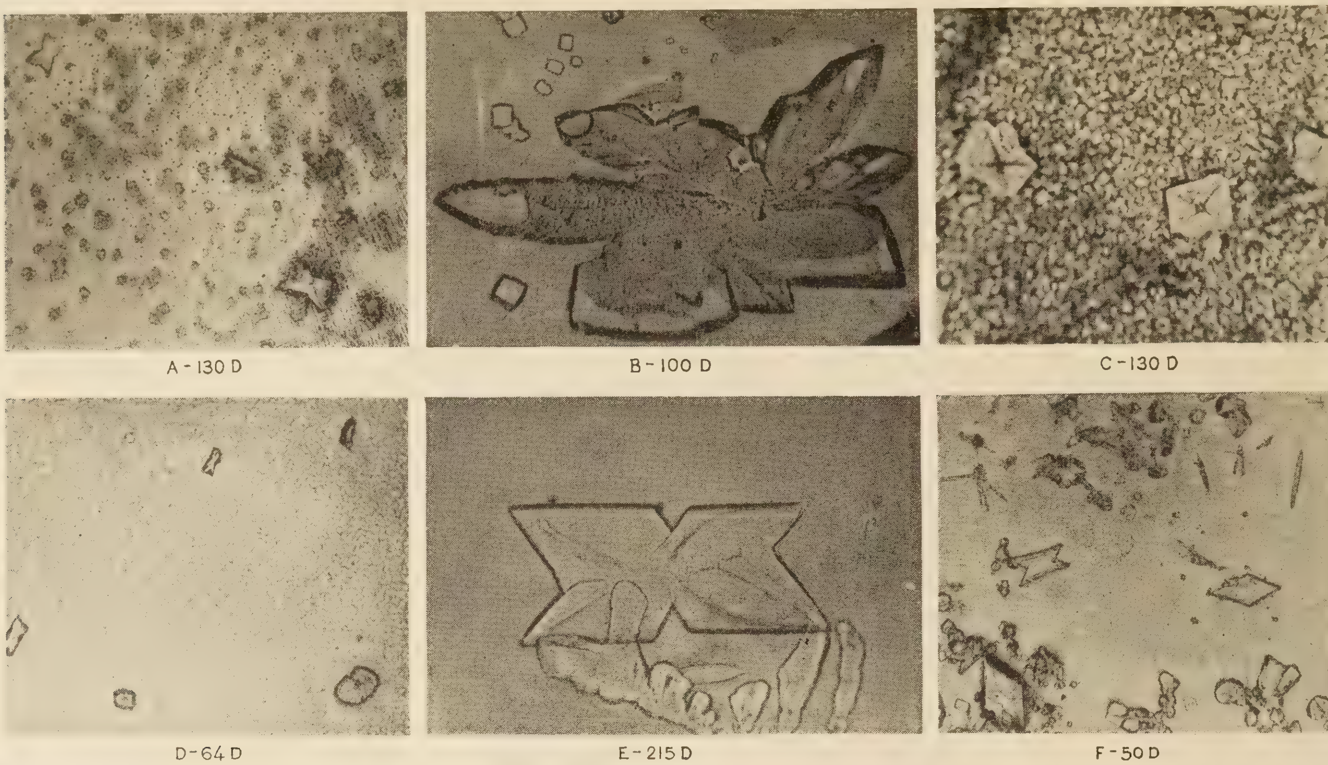


FIGURE 12.—TYPICAL CRYSTALS FROM SOILS AND MORTARS. A, FROM RED RIVER VALLEY GUMBO IN MINNESOTA. B, AND C, FROM DETERIORATED PAVEMENT SLAB IN ALABAMA. D, FROM A TEXAS SOIL ASSOCIATED WITH PAVEMENT WARPING. E AND F, FROM CALIFORNIA SOILS ASSOCIATED WITH PAVEMENT WARPING.

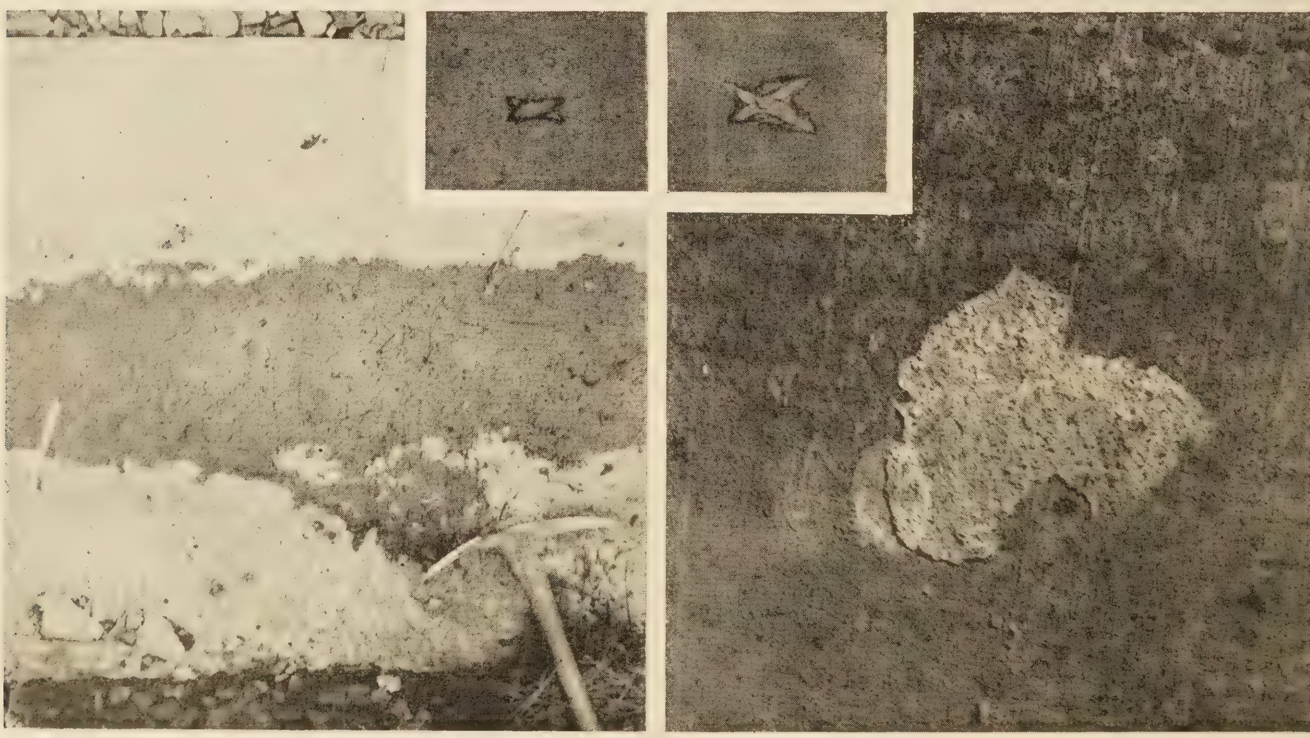


FIGURE 13.—SCALING OF CONCRETE GUTTER AND ADJACENT ROAD SURFACE. THE LEFT INSET SHOWS A CRYSTAL (220 D) FORMED FROM THE SOIL BENEATH THE GUTTER, AND THE RIGHT INSET SHOWS A CRYSTAL (70 D) FORMED FROM A SAMPLE OF CONCRETE FROM THE GUTTER.

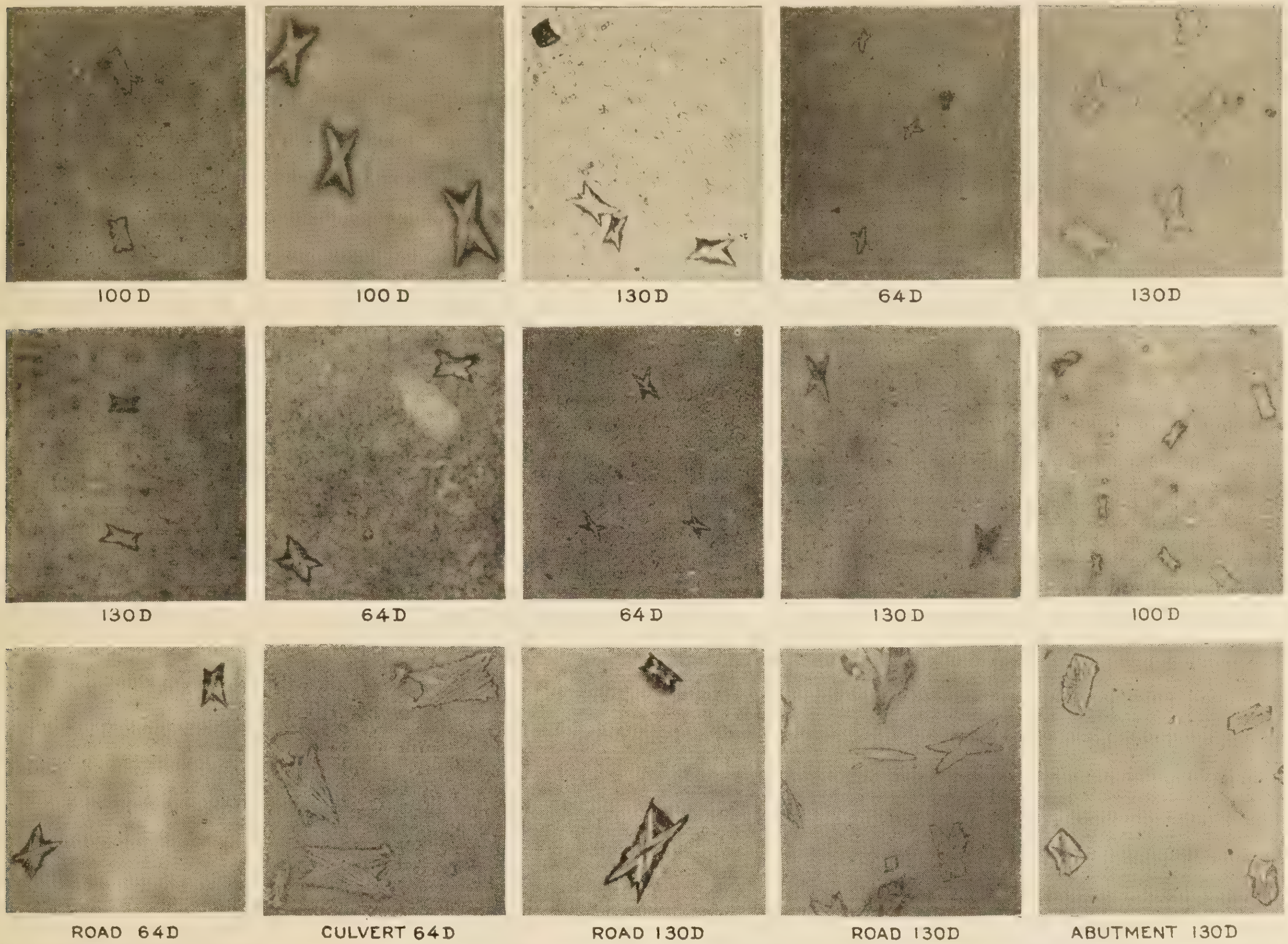


Figure 14.—The Two Upper Rows Show Crystals Formed from Soils Beneath Pavements that had Scaled. The Lower Row Shows Similar Crystals Formed from Concrete that had Deteriorated, the Source of Each Crystal Being Indicated.

weak solutions containing soluble constituents of soil, concrete, or other materials.

In studies of soil stabilization it is important that something be known of the character of the films surrounding soil particles. This is indicated by studies made by R. C. Schappler of the Missouri State Highway Department. Referring to clay binders [17] he states that:

> The nature of the ions held on the surface of the colloid, besides affecting the plastic index of the soil, also influences the vapor pressure and the swelling properties of the clay in contact with free water surfaces. The importance of the above facts is apparent since, by taking advantage of the base exchange capacity of the soils available, it is possible in some cases to adjust the properties of soil so as to supply a satisfactory binder. With a given soil it is possible to select a cation for exchange which will result in a small amount of swelling, a relatively large plastic index and a low vapor pressure.

None of our highway surfaces are ideal in composition since they all have voids or interstices filled with unstable materials, air or water being the most common. The distribution of these voids has been shown by Professor Taber's experiments to be of primary importance. A rigid body of porous, homogeneous material will withstand weathering much better than a body having a fissured or laminated composition. The fissured condition produces planes of weakness and the fissures are accentuated by thermal changes, flow of

[17] Stabilizing Sand and Gravel Surfaces, by R. C. Schappler, an unpublished paper presented at the Kansas Highway Conference, Manhattan, Kans., Feb. 5, 1934.

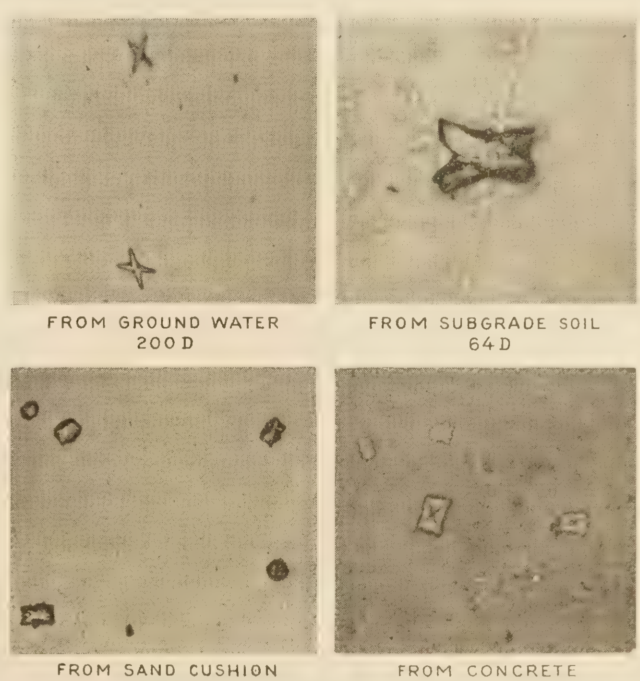
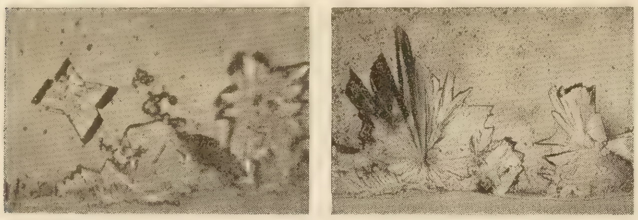
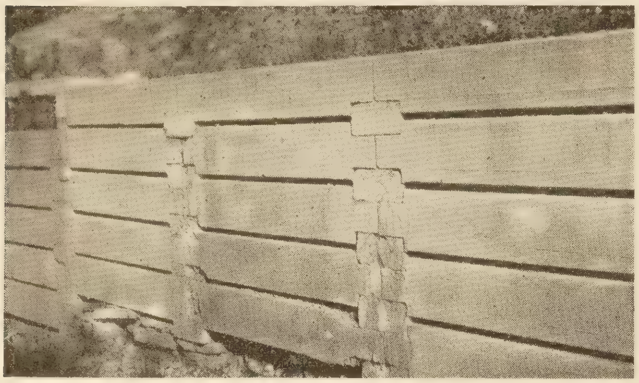


Figure 15.—Crystals Made from Materials Taken from the Same Location on a Concrete Road.



FROM SOIL. 125 D   FROM CONCRETE. 40 D



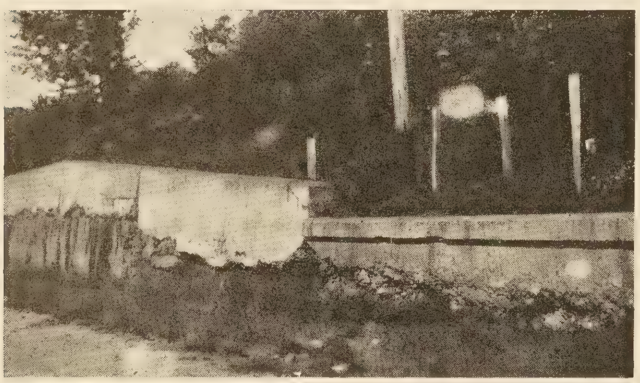
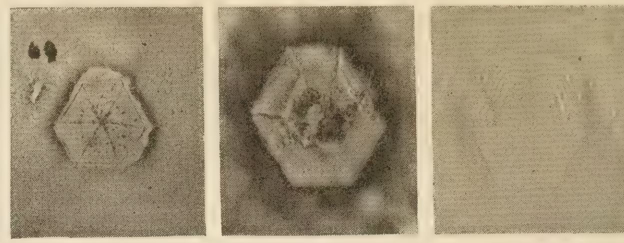
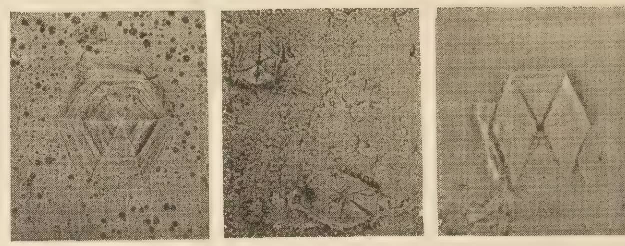


Figure 16.—Disintegrated Retaining Walls and Crystals Formed from the Concrete and Adjacent Soil Indicating Presence of Sulphates.



105 D   350 D   225 D



105 D   52 D   105 D

Figure 17.—Six-sided Crystals from Deteriorated Concrete. The Crystals, with the Exception of the One Illustrated on the Lower Right, Were Made from Samples of Road Surfaces. The Lower Right Crystal Was Made from a Sample of the Culvert Head-wall Shown.

moisture, and concentration of deposited material carried in solution or suspension. Fissured surfaces of materials such as rock, wood, and concrete often have a ridge of foreign material along the opening of each fissure.

All natural waters carry some material in solution or suspension, and the logical sources of the material are the soil and the atmosphere. Ground water with concentrations of chemicals as low as seven parts per million of potash and one-half part per million of phosphoric acid will sustain the growth of wheat, corn, or hay. Ground waters and river waters as a rule have much higher concentrations and, in addition to the potash and phosphoric acid, they may contain crystal-forming chlorides, sulphates, and carbonates. A concrete pavement does not have a root system for collecting water from deep in the soil but subgrades often have high capillarity and are capable of continuously supplying moisture to the bottom of the pavement slab. The amount of moisture entering the bottom of the slab and escaping by evaporation from the top depends upon the permeability of the concrete.

Laboratory tests on mortar samples clearly disclosed how solutions in contact with the bottom of the samples were able to pass up through the mortar, deposit crystals, and thus cause deterioration beginning at the tops of the samples. With the crystal growth, there was a horizontal expansion of the mortar amounting to as much as several percent in a month and occurring throughout the height of the sample.

Some samples were able to withstand sulphate action indefinitely without showing any signs of distress. In others resistance to the sulphate action varied greatly depending upon the water-cement ratio used in mixing and also upon the methods of curing.

Table 5 is based on the field studies made and shows that of the 98 samples of mortar from sections of pavement that had scaled, 71 contained soluble chemicals; 78 were from sections constructed on subgrade with poor drainage; 88 were on subgrades with high capillarity; and 65 were on subgrades that furnished crystals, of which 39 were of the saw-buck type.

Of 28 samples of mortar from pavements that had not scaled, but 5 contained soluble chemicals, only one of which furnished crystals of the saw-buck type. Twenty-two samples were from sections laid on poorly drained subgrades, 23 were from sections on subgrades with high capillary properties, and 12 were from sections on subgrades furnishing crystals four of which were of the saw-buck type.

Of 43 samples of mortar from pavements located on subgrade soils yielding the sulphate crystal of saw-buck shape, 39 were from pavements that had scaled.

In some instances, the data may seem to indicate quite positively that a definite relation exists between

Table 5.—*Classification of pavement and subgrade samples studied*

Pavement condition	Subgrade soil										Crystals of soluble chemicals in concrete			
	Drainage conditions			Capillary properties			Crystals of soluble chemicals							
	A Good	B Poor	Ratio A:B	C Low	D High	Ratio C:D	E None	F Sawbuck type	G Other types	Ratio E:(F+G)	H None	I Sawbuck type	J Other types	Ratio H:(I+J)
	Number	*Number*		*Number*	*Number*		*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	
Good	6	22	1:3.7	5	23	1:4.6	16	4	8	1:0.8	23	1	4	1:0.2
Scaled	20	78	1:3.9	10	88	1:8.8	33	39	26	1:2.0	27	21	50	1:2.6
Total	126			126			126				126			

the performance of pavements and the occurrence or the character of soluble chemicals in the subgrade soils under the pavements. However, the pavements studied have been subjected to a number of other influences with individual effects that have not been disclosed by the present investigations.

Crystals from the Red River valley gumbo soil on which pavement slabs had warped slightly were similar to gypsum crystals that were found in a Mississippi soil under warped pavement investigated by the bureau.[18] Saw-buck crystals, indicative of the presence of sulphates, were found also in Texas and California soils under slabs that had warped. However, it is not yet definitely known whether the presence of the sulphates was due to a coincidence or if they were factors contributing to the warp.

Until the relative effect of such variables as the drainage and physical characteristics of the subgrade has been determined, data on the association of the water-soluble constituents of the subgrade soil and the occurrence of crystal growth in concrete pavements can be considered of value only as assistance to those interested in making similar research. Information is presented for this reason and not because it is in any way conclusive.

CONCLUSIONS PRESENTED

Results of investigations seem to indicate that in studies of the factors affecting the performance of concrete surfaces and structures careful consideration should be given to the drainage of the subgrade, the capillarity of the subgrade soil, and the water-soluble constituents in both the concrete and the contiguous soil.

While much yet remains to be learned regarding the microchemical method of analysis, it seems to be especially promising for use as an indicator of the presence of very small amounts of soluble constituents in cements, mortars, road soils, and similar substances.

[18] See The Soil Profile and the Subgrade Survey by W. I. Watkins and Henry Aaron, Public Roads, vol. 12, no. 7, September 1931.

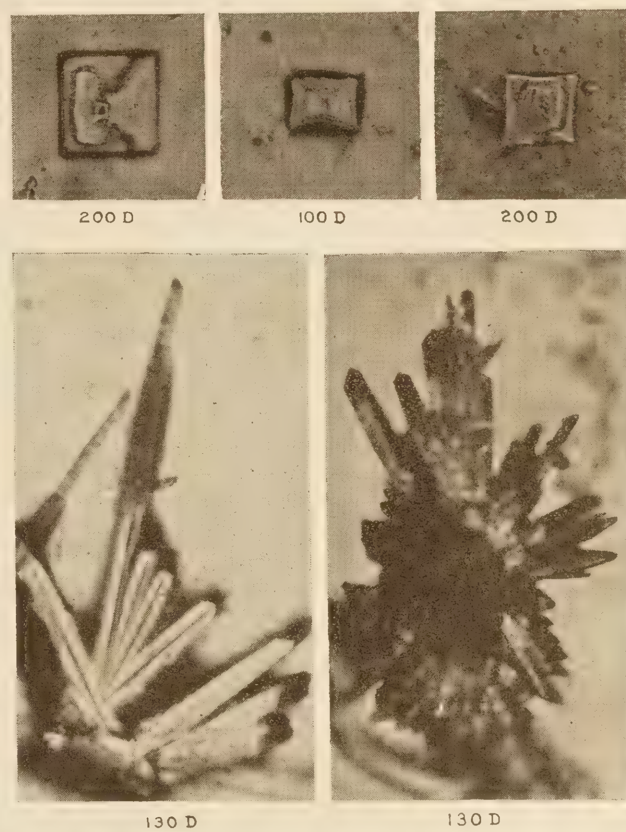


Figure 18.—The Upper Row Shows Salt Crystals Made from Samples of Concrete. The Lower Illustrations Show Sulphate Crystals Made from Spring Water.

PUBLICATION ON BRIDGE PIERS AVAILABLE

Bridge Piers as Channel Obstructions, by David L. Yarnell, senior drainage engineer of the Bureau of Agricultural Engineering, has recently been published by the Department of Agriculture as Technical Bulletin No. 442.

This bulletin presents the results of numerous experiments on the obstruction of bridge piers to the flow of water. It describes test procedures used and develops coefficients for different shapes of piers using larger piers and a more extensive range of conditions than has hitherto been attempted. The four bridge-pier formulas most commonly used in the United States are discussed.

The bulletin contains numerous illustrations, charts, and applications of the bridge-pier formulas to test and theoretical conditions.

Copies of this publication may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents each.

STATE MOTOR-VEHICLE REGISTRATIONS, 1934

[Compiled from reports of State authorities]

State	Registered motor vehicles, private and commercial [1]								Other registered vehicles		Publicly owned vehicles				1933 total registered motor vehicles	Year's change in motor-vehicle registration		State
	Total motor vehicles	Passenger motor vehicles				Freight motor vehicles			Trailers and semi-trailers	Motorcycles	Federal [2]		State, county, and municipal [3]			Increase or decrease (−)	Percentage change	
		Total	Automobiles (including taxicabs)	Motor busses [4]	Ambulances and hearses [5]	Total	Motor trucks	Tractor trucks, tractors, etc.[6]			Motor vehicles	Motorcycles	Motor vehicles	Motorcycles				
Alabama [7]	225,732	191,631	190,971	211	449	34,101	34,094	7	4,671	620	403	24	831		206,361	19,371	9.3	Alabama.[7]
Arizona	96,586	79,795				16,791			2,313	344	672	7	1,525	33	89,496	7,090	7.9	Arizona.
Arkansas	198,091	162,391	162,062	329		35,700			7,950	450	297	8	1,172		188,242	9,849	5.2	Arkansas.
California	2,006,255	[8] 1,768,699		(9)		[10] 237,556			82,110	8,328	2,502	56	19,663	829	[11] 1,971,929	34,326	1.7	California.
Colorado	274,231	246,373				27,858			946	826	521	6	(12)		266,491	7,740	2.9	Colorado.
Connecticut	357,787	301,909	301,002	667	240	55,878	55,818	60	2,370	2,256	733	2	2,856	122	314,751	43,036	13.7	Connecticut.
Delaware	54,240	44,846	44,776	(13)	70	9,394			1,356	334	149	32	25	90	51,099	3,141	6.1	Delaware.
Florida	335,205	279,846	277,489	502	1,855	55,359			9,886	1,002	596	39	3,902		279,265	55,940	20.0	Florida.
Georgia	376,993	316,731				60,262			9,293	990	698	33	(14)		330,147	46,846	14.2	Georgia.
Idaho	108,863	91,002	90,926	76		17,861			11,733	354	263	1	1,148	12	96,255	12,608	13.1	Idaho.
Illinois	1,456,241	1,281,976		(13)		174,265			10,720	4,836	1,810	20	7,689	30	1,463,050	−6,809	−.5	Illinois.
Indiana	803,271	680,480	679,582	898		122,791	119,405	3,386	34,425	2,794	589	4	(12)		770,071	33,200	4.3	Indiana.
Iowa	666,440	591,090	590,873	217		75,350			[15] 44,477	1,837	424	40	[16] 4,446	[16] 154	632,292	34,148	5.4	Iowa.
Kansas	528,664	453,099	452,855	244		75,565			3,733	706	338	2	(12)		517,987	10,677	2.1	Kansas.
Kentucky	332,177	294,732	294,268	464		37,445			(17)	1,015	466	32	1,684		294,547	37,630	12.8	Kentucky.
Louisiana	244,007	199,228	198,885	343		44,779	41,157	3,622	6,528	731	450	2	[16] 4,430	[16] 61	232,688	11,319	4.9	Louisiana.
Maine	178,995	141,302	141,185	117		37,693			[18] 7,578	1,057	229	7	2,048	62	168,173	10,822	6.4	Maine.
Maryland	332,892	287,541	286,638	903		45,351	44,618	733	1,434	1,553	1,018	20	[12] 2,500		313,274	19,618	6.3	Maryland.
Massachusetts	785,392	686,884	682,750	4,134		98,508			752	1,375	1,301	12	(12)		789,788	−4,396	−.6	Massachusetts.
Michigan	1,148,953	1,025,548		(13)		123,405			92,184	3,062	866	1	[12] 12,667		1,077,209	71,744	6.7	Michigan.
Minnesota	697,672	593,790	593,584	206		103,882	103,499	383	24,707	1,731	644	15	[19] 755		679,243	18,429	2.7	Minnesota.
Mississippi	174,934	140,819				34,115			707	160	262		(12)		164,688	10,246	6.2	Mississippi.
Missouri	739,813	632,104	631,783	321		107,709			18,024	1,638	842	11	1,961	8	698,362	41,451	5.9	Missouri.
Montana	128,336	97,249		(13)		31,087			506	308	631	7	1,340		110,245	18,091	16.4	Montana.
Nebraska	406,632	350,072	349,893	179		56,560			18,640	1,050	278	4	1,816		390,651	15,981	4.1	Nebraska.
Nevada	32,230	25,839	25,755	84		6,391			910	104	116		533	9	28,324	3,906	13.8	Nevada.
New Hampshire	113,134	90,752	90,525	227		22,382	21,674	[20] 708	2,354	1,081	231	53	450	77	107,631	5,503	5.1	New Hampshire.
New Jersey	864,641	741,290	735,725	4,904	661	123,351			3,734	5,262	872	28	8,676	755	845,734	18,907	2.2	New Jersey.
New Mexico	82,900	66,788	66,606	182		16,112			918	264	410	2	1,015	15	76,643	6,257	8.2	New Mexico.
New York	2,269,355	1,970,976	1,965,341	5,098	537	298,379			17,417	11,148	3,048	88	[16] 21,960	[16] 1,009	2,240,757	28,598	1.3	New York.
North Carolina	439,351	384,585	384,193	392		54,766			20,649	1,297	563	9	9,787		382,308	57,043	14.9	North Carolina.
North Dakota	156,203	129,888	129,825	63		26,315			263	249	181		462		153,889	2,314	1.5	North Dakota.
Ohio	1,613,265	1,453,420		(13)		159,845			73,287	6,753	1,664	33	14,575	331	1,554,314	58,951	3.8	Ohio.
Oklahoma	477,292	403,364				73,928			5,420	1,023	742		4,369		451,712	25,580	5.7	Oklahoma.
Oregon [21]	274,117	232,706				41,411			[18] 1,276	1,468	538	3	3,539		239,410	34,707	14.5	Oregon.[21]
Pennsylvania	1,681,202	1,466,186	1,460,724	5,462		215,016			13,642	10,549	1,816	53	14,190	1,415	1,635,019	46,183	2.8	Pennsylvania.
Rhode Island	142,394	124,062	123,548	514		18,332			147	772	189	6	1,101	95	136,261	6,133	4.5	Rhode Island.
South Carolina	202,834	181,957	181,828	129		20,877			1,919	559	290	22	2,581	141	162,735	40,099	24.6	South Carolina.[22]
South Dakota	169,975	146,143	146,071	72		23,832			10,128	352	342		943	8	169,249	726	.4	South Dakota.
Tennessee	336,313	298,558				37,755			2,991	1,188	415	16	5,800		312,180	24,133	7.7	Tennessee.
Texas [23]	1,312,152	1,085,876	1,085,108	768		226,276	226,164	112	36,798	3,467	1,729	61	12,448	319	1,201,762	110,390	9.2	Texas.[23]
Utah	101,926	84,823	84,366	457		17,103			1,359	431	428	17	806		100,362	1,564	1.6	Utah.
Vermont	77,921	69,309	69,223	86		[24] 8,612			964	600	138	14	(12)		73,576	4,345	5.9	Vermont.
Virginia [25]	373,908	316,640	315,940	700		57,268			[26] 2,509	1,785	1,366	45	4,536	175	[11] 347,883	26,025	7.5	Virginia.[25]
Washington	422,238	357,917	357,280	637		64,321			5,470	1,569	1,220	19	5,898	196	427,406	−5,168	−1.2	Washington.
West Virginia [27]	194,231	166,978	166,527	451		27,253	26,682	571	1,084	865	162		(14)		226,985	−32,754		West Virginia [27]
Wisconsin	709,359	589,179	588,733	446		120,180			8,466	2,476	514		6,309	286	670,797	38,562	5.7	Wisconsin.
Wyoming	64,990	51,888	51,660	228		13,102			5,398	177	332	10	521		52,560	12,430	23.6	Wyoming.
District of Columbia	163,070	145,807	145,065	742		17,263			1,169	696	1,854	101	954	67	149,790	13,280	8.9	District of Columbia.
Detailed totals [28]			14,143,565	31,453	3,812		673,111	9,582										Detailed totals.[28]
Grand total	24,933,403	21,524,068				3,409,335			615,315	93,492	36,475	965	193,911	6,299	23,843,591	1,089,812	4.6	Grand total.

[1] Wherever possible, reregistrations, nonresident registrations, publicly-owned vehicles, and vehicles not for highway use (farm tractors, etc.) have been eliminated from these columns.

[2] As reported by the Budget Bureau in 1931. Total includes 333 motor vehicles "at large" not assignable to any State.

[3] Figures on publicly-owned vehicles are incomplete as State records on this subject are meager in many cases. Some States give State-owned vehicles only; others exclude certain classes, such as fire apparatus and police vehicles, from registration. Publicly-owned vehicles in Maryland and Michigan were given as a total but were not deducted by types from the private and commercial registrations.

[4] A complete segregation of motor busses from other vehicles is not available. The figures given below represent common-carrier busses in most cases, although in some States contract busses and contract school busses are included. In a number of cases city busses are not included, rural and interurban carriers only being given. Where no busses are tabulated, the busses are included in the total passenger registrations, except as noted otherwise.

[5] Ambulances and hearses are reported separately in only a few States, being included with passenger vehicles in some States and with freight vehicles in others.

[6] Included in total freight motor vehicles except where tabulated separately.

[7] For registration year ended Sept. 30, 1934.

[8] Includes 13,139 registrations issued without charge to public service corporations, which pay a gross receipts tax. All common carriers, both passenger and freight, are included with these vehicles.

[9] Common-carrier busses with passenger registrations, contract carriers with trucks.

[10] Includes 23,194 contract carriers, both freight and passenger; common carriers included in passenger registrations.

[11] Revised figure.

[12] Included in private and commercial registrations.

[13] Included with freight motor vehicles.

[14] Not reported.

[15] Includes 41,150 light trailers licensed without charge.

[16] Includes unknown number of Federal vehicles.

[17] Trailers prohibited on highways although permitted in cities under city license; tractor-semitrailers registered as trucks. Passenger-car trailers and those of less than 1,000 pounds capacity are permitted but not registered.

[18] Light trailers only; heavy trailers with freight motor vehicles.

[19] Registration required every 3 years; these are 1934 registrations only.

[20] Includes unknown number of agricultural tractors.

[21] Date of ending registration year changed in 1933 from June 30 to Dec. 31. Registrations from July 1 to Dec. 31, 1933, as follows: Passenger motor vehicles, 208,166; freight vehicles, including trailers and semitrailers, 36,185; motorcycles, 1,133.

[22] For registration year ended Oct. 31, 1934. The 1933 registration was for 10-month period.

[23] For 15-month period ended Mar. 31, 1935. Date of ending registration year changed from Dec. 31.

[24] Light delivery trucks with passenger cars.

[25] For registration year ended Mar. 31, 1935.

[26] Contract and common-carrier trailers included with freight motor vehicles.

[27] For 6-month period ended June 30, 1934. Date of ending registration year changed from Dec. 31.

[28] Totals of columns for which figures were obtained from only part of the States. Only the grand totals (line below) give full national figures.

STATE MOTOR-VEHICLE RECEIPTS, 1934

[Includes registration fees, miscellaneous receipts of motor-vehicle departments, and special taxes imposed on motor carriers]

[Compiled from reports of State authorities]

State	Total receipts, registration and other fees [1]	Motor-vehicle registration fees: Total motor-vehicle registration fees [2]	Passenger motor vehicles: Total	Passenger motor vehicles: Automobiles (including taxicabs)	Passenger motor vehicles: Motor busses [3]	Passenger motor vehicles: Ambulances and hearses [4]	Freight motor vehicles: Total	Freight motor vehicles: Motor trucks	Freight motor vehicles: Tractor trucks, tractors, etc. [5]	Registration fees, other vehicles: Trailers and semitrailers	Registration fees, other vehicles: Motorcycles	Total registration fees, all vehicles	Miscellaneous receipts: Total	Miscellaneous receipts: Dealers' licenses and plates	Miscellaneous receipts: Operators' and chauffeurs' permits	Miscellaneous receipts: Certificates of title	Miscellaneous receipts: Fines and penalties	Miscellaneous receipts: Transfer fees and other miscellaneous	Special taxes paid by motor carriers [6]	Grand total, all motor-vehicle fees and taxes [7]	State
	1,000 dollars	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	*1,000 dollars*	
Alabama [8]	3,188	[2] 3,183										3,183	5	2				3	63	3,251	Alabama. [8]
Arizona	759	600	300				300			28	1	629	130	3	15	50	1	61	105	864	Arizona.
Arkansas	2,184	1,972	1,353	1,312	41		619			158	1	2,131	53	17	22		8	6	19	2,203	Arkansas.
California	10,140	8,431	[9] 5,846		(10)		[11] 2,585			426	25	8,882	1,258	34	155		66	1,003	1,377	11,517	California.
Colorado	2,172	1,632	1,253				379			18	1	1,651	521	19	25	121		[12] 356	186	2,358	Colorado.
Connecticut	7,948	6,292	4,759	4,613	140	6	1,533	1,531	2	45	9	6,346	1,602	72	1,293		142	95	151	8,099	Connecticut.
Delaware	883	715	490	489	(13)	1	225			13	1	729	154	5	110	27		12	(14)	883	Delaware.
Florida	4,409	4,091	2,910	2,785	83	42	1,181			97	5	4,193	216	17	6	149		44	(15)	4,409	Florida.
Georgia	1,193	1,129	949				180			27	3	1,159	34	6	14			14	(15)	1,193	Georgia.
Idaho	1,560	1,514	1,102	1,095	7		412			17	2	1,533	27	19	2			6	41	1,601	Idaho.
Illinois	18,278	16,359	12,388		(13)		3,971			97	16	16,472	1,806	79	237	930		560	6	18,284	Illinois.
Indiana	7,260	5,986	4,463	4,384	79		1,523	1,445	78	186	5	6,177	1,083	39	466	224		[16] 354	25	7,285	Indiana.
Iowa	10,034	9,677	7,625				2,052			52	6	9,735	299	46	36		1	216	376	10,410	Iowa.
Kansas	3,278	3,130	2,438		(13)		692			42	3	3,175	103	20	25			58	629	3,907	Kansas.
Kentucky	3,013	2,875	1,967	1,917	50		908			(17)	2	2,877	136	22	18			96	204	3,217	Kentucky.
Louisiana	4,380	4,010	3,026	2,988	38		984	936	48	283	5	4,298	82	13	62		8	[18] −1	(15)	4,380	Louisiana.
Maine	3,165	2,474	1,674	1,663	11		800			[19] 8	6	2,488	677	32	482		12	151	(15)	3,165	Maine.
Maryland	3,523	2,807	2,269	2,151	118		538	521	17	69	7	2,883	640	32	245	144	179	40	(20)	3,523	Maryland.
Massachusetts	6,634	3,791	2,551	2,454	97		1,240			27	2	3,820	2,814	62	2,107		431	214	(15)	6,634	Massachusetts.
Michigan	15,901	13,588	9,494		(13)		4,094			607	11	14,206	1,695	58	785	531		321	297	16,198	Michigan.
Minnesota	6,867	6,409	4,677	4,592	85		1,732	1,722	10	172	6	6,587	280	29	252		2	[18] −3	17	6,884	Minnesota.
Mississippi	1,950	[2] 1,926										1,926	24	2			20	2	73	2,023	Mississippi.
Missouri	7,344	6,562	5,555		(13)		1,007			56	8	6,626	718	64	128	300		226	326	7,670	Missouri.
Montana	1,071	1,006	789		(13)		217			(15)	(15)	1,006	65	15	1	20		29	11	1,082	Montana.
Nebraska	1,945	1,752	1,145	1,131	14		607			26	2	1,780	165	11	65			89	(14)	1,945	Nebraska.
Nevada	248	233	129		(21)		104			4	1	238	10	2				8	139	387	Nevada.
New Hampshire	2,477	[2] 2,035									6	2,041	436	22	316		77	21	5	2,482	New Hampshire.
New Jersey	15,614	11,179	7,800	7,502	281	17	3,379			138	10	11,327	4,287	59	3,296	366	91	475	73	15,687	New Jersey.
New Mexico	843	806	532	511	21		274			8	1	815	28	6			1	21	67	910	New Mexico.
New York	41,664	36,891	26,818				10,073			301	49	37,241	4,423	176	2,993			1,254	(14)	41,664	New York.
North Carolina	6,944	6,793	5,327	5,298	29		1,466			(22)	5	6,798	146			139		7	126	7,070	NorthCarolina.
North Dakota	1,291	1,233	942	936	6		291			3	1	1,237	54	11		17		26	15	1,306	North Dakota.
Ohio	19,961	18,322	12,011		(13)		6,311			609	27	18,958	1,003	92	191			720	(15)	19,961	Ohio.
Oklahoma	3,251	2,724	1,859				865			87	4	2,815	436	32		209		195	610	3,861	Oklahoma.
Oregon [23]	1,843	1,564	1,056				508			(22)	4	1,568	275	10	200	53		12	227	2,070	Oregon. [23]
	2,219	1,986	1,195				791			[19] 6	5	1,997	222	15	70	107		30	620	2,839	
Pennsylvania	30,842	22,658	15,644	15,120	524		7,014			185	29	22,872	7,970	301	4,610	1,337	383	1,339	(15)	30,842	Pennsylvania.
Rhode Island	2,315	1,879	1,428	1,379	49		451			2	3	1,884	431	15	354			62	(14)	2,315	Rhode Island.
South Carolina [24]	2,831	2,510	2,062				448			50	2	2,562	269	13	150		41	65	81	2,912	South Carolina. [24]
South Dakota	1,314	1,267	1,110	1,108	2		157			13	(25)	1,280	34	10		19		5	264	1,578	South Dakota.
Tennessee	3,322	[2] 3,292										3,292	30	8			19	3	37	3,359	Tennessee.
Texas [26]	14,921	14,106	9,663	9,566	97		4,443	4,440	3	309	15	14,430	491	38	152			301	48	14,969	Texas. [26]
Utah	966	850	584	575	9		266			13	1	864	102	9	43	31	2	17	218	1,184	Utah.
Vermont	2,157	1,849	1,365	1,352	13		[27] 484			4	4	1,857	300	24	237			39	(14)	2,157	Vermont.
Virginia [28]	4,947	4,289	3,184	3,125	59		1,105			[29] 27	5	4,321	626	42	262	192		130	116	5,063	Virginia. [28]
Washington	2,727	2,296	1,139	1,082	57		1,157			90	4	2,390	337	8	180	138		11	186	2,913	Washington.
West Virginia [30]	1,987	1,766	1,421	1,412	9		345	344	1	11	2	1,779	208	15	100	63		30	30	2,017	West Virginia. [30]
Wisconsin	10,051	9,743	7,340	7,144	196		2,403			173	12	9,928	123	23	18			82	1,034	11,085	Wisconsin.
Wyoming	437	411	275	270	5		136			16	(31)	427	10	5				5	46	483	Wyoming.
District of Columbia	677	169	146	145	1		23			1	1	171	506	3	192	79	203	29	153	830	District of Columbia.
Detailed totals [32]			182,053	88,099	2,121	66	70,273	10,939	159	4,504	318										Detailed totals. [32]
Grand totals	304,928	262,762										267,584	37,314	1,657	19,915	5,246	1,687	8,839	8,001	312,929	Grand totals.

[1] Total of all fees listed, with the exception of special taxes paid by motor carriers.
[2] No segregation of registration fees by type of vehicle was available in Alabama, Mississippi, New Hampshire, and Tennessee. In these cases the total motor vehicle registration fees include those of trailers and motorcycles, except in the case of New Hampshire, for which the motorcycle fees are given.
[3] The figures for registration fees of busses are incomplete (see preceding table, note 4). Where no fees are tabulated the fees of busses are included in the total passenger registration fees, except as otherwise noted.
[4] Only a few States reported ambulances and hearses separately (see preceding table, note 5). In New York 537 ambulances were reported, but were exempted from payment of registration fees.
[5] Included in total for freight motor vehicles, except where tabulated separately.
[6] Special taxes, such as mileage, ton-mile, and passenger-mile taxes, gross receipts taxes, franchise fees, and special license fees, imposed on motor vehicles operated for hire and other motor carriers. Gross receipts taxes paid by common carriers in California and passenger-mile taxes paid by interurban common carrier busses in Maryland are included with registration fees and omitted from this column, as these taxes were paid in lieu of registration fees.
[7] Total including special taxes paid by motor carriers.
[8] For registration year ended Sept. 30, 1934.
[9] Includes gross receipts taxes of $579,000 paid in lieu of registration fees by common carriers, both freight and passenger.
[10] Gross receipts taxes paid by common carrier busses included with passenger vehicle fees; registration fees paid by contract carriers of passengers included with freight vehicle fees.
[11] Includes registration fees paid by contract carriers of passengers; gross receipts taxes paid by common freight carriers included with passenger vehicle fees.
[12] Includes $305,000 paid in $1 assessments on motor vehicle registrations for old age pension fund.
[13] Included with fees of freight motor vehicles.
[14] No special taxes on motor carriers.
[15] Not reported.
[16] Includes $180,000 in service charges on registrations in branch offices, not segregated by type of vehicle.
[17] Commercial full trailers prohibited; light trailers not registered; semitrailer units registered as trucks.
[18] Negative item due to deduction of refunds from miscellaneous receipts.
[19] Fees of light trailers only; fees of heavy trailers with those of freight motor vehicles.
[20] Passenger-mile taxes paid by interurban common carrier busses included with registration fees of passenger motor vehicles.
[21] Bus fees $420.
[22] Included with fees of freight motor vehicles.
[23] Date of ending registration year changed in 1933 from June 30 to Dec. 31. Upper line gives figures for 6-month period.
[24] For registration year ended Oct. 31, 1934.
[25] Motorcycle fees $399.
[26] For 15-month period ended Mar. 31, 1935. Date of ending registration year changed from Dec. 31.
[27] Fees of light delivery trucks with those of passenger cars.
[28] For registration year ended Mar. 31, 1935.
[29] Fees of contract and common carrier trailers included with those of freight motor vehicles.
[30] For 6-month period ended June 30, 1934. Date of ending registration year changed from Dec. 31.
[31] Motorcycle fees $396.
[32] Totals of columns for which figures were obtained from only part of the States. Only the grand totals (line below) give full national figures.

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

CLASS 1.—PROJECTS ON THE FEDERAL-AID HIGHWAY SYSTEM OUTSIDE OF MUNICIPALITIES

AS OF JUNE 30, 1935

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 3,947,753	$ 2,129,921	$ 6,241,479	$ 3,370,574	$ 35,889	340.2	$ 2,164,640	$ 530,262	$ 1,235,513	124.0	$ 37,466	$ 459,429	15.5	$ 9,452	$ 399,089
Arizona	3,855,555	1,338,712	4,973,171	3,832,517	458,905	352.6	982,994		870,052	42.4				23,038	9,756
Arkansas	3,334,167	1,714,000	3,407,901	2,517,988	335,091	165.1	1,903,327	643,216	973,715	90.0	158,919	138,897	9.8	14,044	266,297
California	7,912,928	3,713,643	10,979,471	7,752,828	476,000	364.1	3,187,701	158,741	2,119,795	61.1		826,273	21.3	1,360	291,575
Colorado	3,437,265	2,424,504	5,110,152	3,347,941	1,628,991	242.9	957,977	82,697	786,222	44.5	6,627		5.5		9,291
Connecticut	1,404,213	607,500	794,426	791,923		14.5	1,473,554	611,294	554,726	23.4				996	52,774
Delaware	877,566	461,697	1,205,831	868,470	317,537	45.6	138,523	4,973	133,550	3.2	4,082	7,442		40	3,169
Florida	2,469,370	1,116,600	3,289,674	2,214,247	264,420	125.6	864,776	220,895	606,335	30.2		214,470	1.7	34,228	31,375
Georgia	5,045,592	2,556,745	4,583,226	3,921,288	424,651	319.0	2,210,774	978,717	1,149,033	105.1	6,394	240,661	4.6	139,193	742,400
Idaho	2,166,858	1,131,910	2,253,186	2,027,114	154,028	198.5	603,339	131,759	445,173	33.3		283,676	13.7	7,986	249,033
Illinois	4,408,827	2,408,778	2,581,258	2,392,590	142,890	40.3	3,990,572	2,002,682	1,987,890	67.1	3,000	277,998	.4	10,555	
Indiana	5,018,921	2,816,687	3,609,966	3,451,916	35,317	112.9	3,872,034	1,427,908	2,279,625	163.3	77,951	383,180	21.8	61,146	118,564
Iowa	5,027,830	2,217,361	5,139,249	4,720,930	314,620	317.3	2,330,010	306,900	1,715,529	118.1		56,500	4.0		130,712
Kansas	5,044,802	2,354,131	5,916,637	5,004,394	780,019	637.4	1,646,247	31,530	1,546,923	125.2		27,189	1.3	8,878	
Kentucky	3,751,605	1,302,209	3,821,618	3,379,305	196,985	280.5	1,193,398	316,514	792,539	56.7		234,307	11.2	55,786	78,378
Louisiana	2,693,135	1,380,419	2,705,069	2,295,365	40,687	76.8	1,620,868	368,904	1,098,700	28.9	11,070	1,326	.2	17,795	239,706
Maine	1,567,012	782,195	1,557,493	1,433,664	93,720	47.4	612,469	117,934	494,535	10.1		192,289	6.8	15,415	1,652
Maryland	1,782,263	289,609	867,379	791,495	74,649	15.5	975,803	797,232	178,571	21.3	106,646		1.1	86,889	36,389
Massachusetts	1,101,716	1,582,874	1,466,324	1,049,029		37.4	1,094,397	52,687	989,888	20.2		5,351			587,635
Michigan	6,051,533	3,226,284	5,256,446	4,921,541	81,400	234.2	3,447,600	1,075,800	2,351,441	135.8		579,025	26.6	54,191	214,417
Minnesota	4,561,011	2,533,733	5,781,092	4,235,784	1,365,525	910.1	929,965	192,248	737,117	119.9	50,482	284,629	41.8	82,498	146,462
Mississippi	3,489,337	2,832,182	5,139,817	2,521,709	490,683	269.2	2,870,880	893,810	1,323,253	160.1	5,574	684,578	34.6	68,244	333,666
Missouri	5,237,532	2,890,666	4,883,071	4,295,899		198.1	2,917,170	861,589	1,877,066	84.8		1,013,600	41.0	80,044	
Montana	4,463,849	2,714,208	6,439,794	4,403,621	1,566,281	564.4	1,081,902	4,129	975,696	71.6		129,645	.2	56,099	42,586
Nebraska	3,914,481	1,982,182	5,153,191	3,888,842	137,284	369.4	2,124,944	25,639	1,748,712	105.0		40,817	.4		55,369
Nevada	2,909,387	1,350,356	3,360,319	2,683,175	604,881	322.5	687,097	187,644	498,786	99.7	34,908	234,342	60.3	3,660	12,347
New Hampshire	692,118	465,404	728,305	612,389	89,273	12.6	453,251	79,729	352,131	10.7					24,000
New Jersey	3,173,019	951,379	2,231,743	2,025,846	15,000	37.4	1,786,167	1,113,074	575,607	15.2		10,167		34,100	350,605
New Mexico	2,846,648	1,676,769	3,704,872	2,748,086	812,459	363.9	677,033	98,562	562,946	45.0		301,364	18.6		
New York	10,465,672	3,748,600	11,541,859	9,011,288	230,230	224.0	7,545,310	1,262,472	3,246,552	137.4		26,900		191,912	244,918
North Carolina	4,761,147	1,930,365	4,954,230	3,616,813	390,706	602.7	1,506,646	786,550	528,689	156.7	64,450	367,269	19.0	293,334	643,701
North Dakota	2,902,224	1,469,484	3,257,884	2,602,966	217,676	1,122.4	682,417	97,071	409,315	203.6	148,356	255,096	157.6	53,830	587,396
Ohio	7,277,758	3,539,255	7,519,150	7,040,235	88,100	195.2	3,374,726	186,081	2,854,513	69.1	42,800	3,420	.8	8,642	593,223
Oklahoma	4,608,399	2,342,590	4,722,067	4,201,027	384,143	318.1	2,037,234	396,183	1,428,537	79.9	10,819	367,151	11.2	369	162,759
Oregon	3,053,448	1,452,741	3,615,203	2,942,973	279,947	193.9	1,304,366	80,590	1,103,852	55.4				29,885	68,942
Pennsylvania	6,691,194	4,554,082	7,057,671	6,190,605	593,079	139.9	4,430,735	442,031	3,757,564	81.1	2,126	6,816		56,432	196,623
Rhode Island	979,367	474,772	968,005	899,627		20.5	560,592	79,740	464,572	14.3					10,200
South Carolina	2,729,583	940,954	2,536,142	2,359,621	111,965	217.0	667,046	315,630	351,416	55.7	18,520	27,220	.3	35,811	450,354
South Dakota	3,005,739	1,523,821	3,081,134	2,448,081	160,756	556.1	1,501,471	481,212	966,353	235.4	17,187	272,886	37.0	59,260	123,826
Tennessee	4,246,309	2,105,454	4,978,949	4,004,621	333,219	192.2	1,586,094	176,547	1,313,146	55.7	2,195	412,890	9.1	62,946	46,199
Texas	11,588,643	6,858,253	12,754,565	11,174,336	983,267	1,117.7	5,152,015	387,981	4,564,420	373.0		658,163	47.1	26,326	652,404
Utah	2,367,205	1,066,345	3,145,038	2,324,852	553,524	273.9	506,372	37,000	360,550	29.1		15,000	1.1	5,353	137,271
Vermont	928,184	466,042	987,200	911,184	34,775	48.0	391,632	10,670	353,388	17.7		68,421	1.7	6,330	9,457
Virginia	3,731,207	1,916,178	4,081,114	3,322,846	469,945	165.0	1,514,335	233,865	1,101,176	77.2	51,680	189,121	13.4	122,815	155,937
Washington	3,057,934	1,553,206	3,056,123	2,794,489	200,521	106.4	1,560,705	227,922	1,212,203	23.6		130,299	.3	35,524	10,183
West Virginia	2,013,405	1,140,167	2,138,931	1,901,842	195,860	79.3	513,824	57,156	456,668	17.2	54,407	119,087	4.7		368,552
Wisconsin	4,697,518	1,818,970	4,589,510	4,220,288	151,271	214.8	2,056,979	445,827	1,531,644	87.5	25,000	92,796	6.8	6,403	43,259
Wyoming	2,250,663	1,686,368	2,679,692	2,064,028	452,284	515.8	1,239,296	182,391	1,030,740	196.8		158,392	20.9	4,243	44,952
District of Columbia															
Hawaii	1,693,344	598,778	829,029	526,724		19.3	1,331,572	1,126,855		20.3	20,973	273,416	1.7	18,793	325,362
TOTALS	185,235,236	94,139,083	201,675,656	162,058,916	16,768,453	13,337.6	88,262,779	20,330,843	57,996,367	4,002.6	961,632	10,071,498	675.1	1,883,845	9,302,765

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

CLASS 2.—PROJECTS ON EXTENSIONS OF THE FEDERAL-AID HIGHWAY SYSTEM INTO AND THROUGH MUNICIPALITIES

AS OF JUNE 30, 1935

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 2,389,928	$ 1,064,961	$ 1,875,533	$ 1,768,480	$ 98,284	46.1	$ 851,205	$ 568,564	$ 282,641	26.1	$ 29,878	$ 134,766	2.0	$ 23,006	$ 549,270
Arizona	756,982	305,191	680,103	623,659	37,303	14.2	107,877		95,500	.6	129,322	110,505	.2	4,001	61,883
Arkansas	1,964,534	857,025	1,770,332	1,599,134	70,342	44.4	577,173	248,967	326,804	10.6	101,076	200,694	4.5	15,357	259,186
California	4,213,986	2,219,360	4,735,403	3,849,724	258,050	60.2	3,400,728	356,840	1,749,826	13.4		100,000	1.6	7,422	111,484
Colorado	1,718,633	190,000	1,938,348	1,675,081	169,411	39.9					15,949		.8	27,602	20,589
Connecticut	802,407	426,500	838,549	802,407	9,362	10.2	193,692		142,521	1.6		134,613	1.3		140,004
Delaware	460,409	230,849	520,332	460,282	51,542	7.3	40,288		40,288	1.8				127	139,019
Florida	1,459,648	501,200	1,836,588	1,437,885	102,827	21.4	157,148	2,898	154,250	1.4				18,865	244,123
Georgia	2,724,620	1,278,373	2,268,156	2,200,120	35,648	70.0	730,891	308,554	405,049	21.2		143,961	3.0	215,947	693,715
Idaho	1,197,829	321,126	1,161,507	1,107,063	11,572	20.1	251,554	45,372	204,994	1.3				45,394	104,560
Illinois	7,381,910	2,230,350	6,418,737	6,122,746		66.4	2,218,287	1,202,054	1,016,233	11.1	47,260	615,618	3.2	9,851	600,498
Indiana	4,287,050	2,136,306	3,188,039	3,034,021	14,012	63.8	2,071,711	1,073,165	996,082	28.3	148,115	835,239	11.9	31,749	290,973
Iowa	2,614,472	1,311,000	2,174,064	2,013,668	71,035	57.4	1,493,395	600,765	795,665	23.4		158,535	1.4	39	285,765
Kansas	2,522,401	1,432,949	2,735,303	2,401,599	176,992	42.3	1,332,164	71,884	1,244,977	14.8	48,918	10,980	1.2		
Kentucky	1,927,828	958,599	1,495,742	1,416,934	27,428	34.2	895,386	450,854	435,366	8.7	30,000	215,702	3.9	30,041	280,102
Louisiana	1,708,577	744,560	810,261	744,921	61,391	20.2	1,261,370	946,157	273,172	17.6	10,666	272,960	3.6	6,834	137,037
Maine	960,426	484,379	830,661	825,162		16.4	264,446	67,228	197,218	3.0	58,912	280,254	3.9	9,123	6,908
Maryland	891,132	452,515	390,021	384,017		3.6	1,075,978	262,457		.9				244,659	452,515
Massachusetts	5,007,199	847,600	2,143,777	2,102,232		13.4	3,131,553	2,876,372	230,206	5.8		38,077	.7	28,595	579,318
Michigan	3,500,637	1,613,142	3,343,570	3,104,881	104,400	39.6	1,686,250	357,250	1,291,100	17.8	19,400	120,500	2.3	19,107	97,142
Minnesota	3,719,143	1,421,494	3,479,627	3,140,756	288,822	110.8	1,052,213	520,813	436,917	17.8	2,310	12,581	1.3	55,264	683,174
Mississippi	1,744,669	354,022	1,007,091	897,960	95,559	32.0	945,865	764,058	106,745	26.8	9,152	30,897	1.6	73,498	120,822
Missouri	4,019,501	919,152	2,939,422	2,844,981	18,791	51.9	1,225,029	1,022,062	157,129	11.2		743,232	5.4	152,458	
Montana	1,115,962	113,092	1,057,941	1,012,209	32,919	34.0	125,031	66,068	31,671	6.6	30,012	7,553	3.0	7,673	40,949
Nebraska	1,957,240	991,091	2,272,456	1,917,390	320,655	40.9	531,566		531,566	8.9		344		39,850	138,525
Nevada	500,051	100,000	529,131	473,901	49,331	10.2	8,511		8,511	.6				26,150	42,157
New Hampshire	740,335	242,465	774,421	668,776	102,288	16.9	150,945	71,559	79,176	3.9		50,935	.3		10,066
New Jersey	3,117,921	1,809,500	2,956,249	2,828,272	3,316	22.9	1,062,365	182,690	641,127	5.1		104,946		106,959	1,060,111
New Mexico	1,674,158	529,506	1,651,781	1,471,120	180,097	39.0	192,758	123,326	69,432	2.9	1,010			78,702	279,977
New York	8,255,661	3,756,621	7,926,871	7,168,742	338,700	60.4	4,116,341	887,217	3,009,990	25.9	76,700	62,000		123,002	345,931
North Carolina	2,380,573	1,210,236	2,669,957	2,125,249	536,087	91.7	627,695	122,144	472,005	16.6	91,217	135,600	3.9	41,963	66,544
North Dakota	1,451,112	734,741	1,079,198	1,070,593	1,164	46.7	396,262	238,527	157,735	15.3	119,305	177,547	19.4	22,688	398,296
Ohio	4,335,686	2,359,504	4,874,050	4,238,314	163,665	65.1	1,661,797		1,533,452	15.4	93,352	191,200	2.4	4,020	471,186
Oklahoma	2,304,200	1,171,295	2,377,598	2,098,728	199,102	48.3	744,578	167,849	573,544	8.5	35,871	129,271	2.7	1,752	269,379
Oregon	1,526,724	867,977	1,574,266	1,424,031	103,907	31.2	666,463	66,635	591,819	10.9	518	80,000	.2	35,540	92,251
Pennsylvania	4,854,988	2,397,703	4,868,578	4,197,457	505,373	69.4	1,687,812	592,457	972,115	15.1		288,881	.9	65,074	631,333
Rhode Island	579,625	285,760	519,890	518,991		7.4	141,760		141,760	1.5				60,634	144,000
South Carolina	1,364,791	488,000	1,095,076	1,092,876		34.5	429,543	252,617	171,376	15.3	19,298	103,791	1.2		212,833
South Dakota	1,502,870	761,911	1,072,130	1,070,366	1,361	36.8	342,653	183,142	159,511	10.4	55,948	104,395	7.1	193,413	496,644
Tennessee	2,123,155	1,121,789	1,875,660	1,740,186	116,431	25.9	760,139	371,898	388,241	6.8	11,071	355,677	3.8		261,441
Texas	6,642,863	1,795,000	5,384,528	5,093,601	167,665	128.8	2,135,160	1,244,952	713,846	22.4	52,836	476,685	13.1	251,474	436,804
Utah	778,826	533,173	775,662	649,146	63,066	20.2	500,781	129,130	315,800	9.4		152,000	4.8	550	2,306
Vermont	500,509	240,611	566,604	460,328	36,000	14.4	190,448	26,802	149,376	3.3		27,844	.9	13,380	27,390
Virginia	1,948,780	956,021	1,502,927	1,250,265	215,043	30.4	1,312,724	634,441	368,146	9.2	15,975	288,439	7.6	50,099	84,393
Washington	1,977,260	776,603	2,250,860	1,922,046	305,761	40.4	455,395	48,798	406,597	7.0		43,513	.2	6,415	20,732
West Virginia	1,342,270	570,085	1,070,754	1,005,009	28,109	17.7	322,153	307,661	14,492	4.2	28,642	216,075	4.0	957	311,409
Wisconsin	2,596,143	1,379,513	2,601,041	2,401,818	123,789	55.5	1,107,316	113,025	994,291	15.1	57,664	238,352	4.7	23,635	23,082
Wyoming	1,125,332	29,416	977,168	971,191	2,784	22.5	155,723	141,009	14,132	3.0	6,658		.4	6,473	12,500
District of Columbia	946,445	181,051	877,332	696,281	181,051	6.5	250,164	250,164		.2					
Hawaii															
TOTALS	115,617,401	47,703,317	103,763,295	94,124,599	5,480,435	1,903.5	45,040,286	17,968,425	23,092,394	508.7	1,345,035	7,392,162	134.4	2,179,342	11,738,326

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

CLASS 3.—PROJECTS ON SECONDARY OR FEEDER ROADS

AS OF JUNE 30, 1935

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 2,032,452	$ 1,064,960	$ 1,579,597	$ 1,482,576	$ 92,974	116.2	$ 1,142,906	$ 507,248	$ 635,658	76.3		$ 194,367	12.0	$ 42,628	$ 141,962
Arizona	599,423	998,032	766,744	531,273	186,413	65.3	768,207		694,494	63.5	$ 45,000	10,000	7.1	23,150	107,124
Arkansas	1,449,634	857,024	1,249,714	1,243,182		149.1	686,580	152,569	531,639	87.4		173,441	24.4	53,884	151,944
California	3,480,440	1,999,203	3,631,530	2,984,134	37,900	170.4	1,925,434	494,606	1,283,365	58.6		455,377	14.8	1,700	222,560
Colorado	1,718,632	871,502	2,252,224	1,605,435	277,324	232.0	806,909	110,000	504,962	76.8	3,197	89,216	1.2		
Connecticut	659,120	420,868	192,666	160,281	12,889	3.5	727,514	498,839	222,880	16.0					185,099
Delaware	481,113	230,849	428,692	265,666	155,213	51.5	296,824	215,448	70,330	19.9					5,305
Florida	1,302,816	1,043,543	1,620,458	1,284,727	322,934	88.5	580,944		580,944	34.4		103,591	6.8	18,088	36,075
Georgia	2,320,973	1,278,373	1,623,725	1,604,794		123.1	963,710	620,787	342,923	70.9		158,613	5.9	95,391	776,837
Idaho	1,121,562	824,450	1,407,455	1,094,530	135,240	164.1	510,166		510,166	59.6				27,032	179,044
Illinois	5,780,033	4,282,273	3,073,728	3,035,676		160.0	5,732,152	2,727,238	3,004,914	311.9	9,848	994,669	27.4	7,271	282,690
Indiana	731,872	135,970	425,394	386,212		44.2	388,720	310,433	78,287	50.0		30,839	5.7	35,227	26,844
Iowa	2,413,358	1,590,000	2,623,739	2,241,349	315,850	413.4	1,608,508	171,302	1,222,625	270.6		51,400	16.3	707	125
Kansas	2,522,401	1,330,595	2,229,491	2,085,242	141,391	227.8	1,574,717	393,660	1,181,057	84.7	43,499	8,147	1.6		
Kentucky	1,837,926	1,557,503	2,153,944	1,750,680	275,369	238.2	1,337,008	67,733	1,191,635	168.7		49,903	4.7	19,513	40,595
Louisiana	1,426,879	838,953	1,146,988	1,035,963	101,176	50.5	849,730	260,030	589,700	38.8	127,388	129,772	9.3	3,499	18,305
Maine	842,479	445,012	1,246,208	842,404	319,279	98.4	155,427		117,980	8.0				75	7,753
Maryland	891,132	1,067,934	870,902	781,556	41,223	59.5	477,913	99,746	378,167	24.3	9,800	176,376	4.1	30	472,168
Massachusetts	488,185	920,000	477,470	469,741		15.2	415,063		415,063	10.4		115,369	5.5	18,443	389,567
Michigan	3,184,057	1,613,142	3,145,400	2,906,940	39,700	205.7	1,699,244	241,227	1,458,017	82.0		115,425	12.9	35,890	
Minnesota	2,376,415	1,470,324	2,762,148	2,194,840	484,889	299.4	1,079,216	149,444	824,872	100.2		70,695	7.7	32,131	89,868
Mississippi	1,744,669	354,023	1,175,847	1,165,847	10,000	130.2	605,813	543,534	62,279	50.7		133,134	14.1	35,288	148,610
Missouri	2,923,273	2,363,922	3,001,615	2,686,006	239,273	648.8	1,716,231	235,551	1,426,306	302.7		698,343	110.6	1,715	
Montana	1,859,937	942,434	2,165,413	1,751,641	405,178	264.2	438,840		438,840	46.2		42,981	5.2	108,296	55,435
Nebraska	1,957,240	991,091	2,429,004	1,957,240	456,960	420.9	430,845		430,845	67.8		37,136	4.6		66,151
Nevada	1,136,479	852,000	1,493,280	1,113,353	352,874	185.4	244,478		244,478	24.5	20,813		11.2	2,312	254,648
New Hampshire	477,386	261,593	537,176	448,386	43,004	25.7	239,542	29,000	206,408	8.9					12,181
New Jersey	55,099	460,000	56,528	55,099		.5	107,525		107,525	1.7					352,475
New Mexico	1,272,129	735,425	1,497,633	1,235,198	262,435	241.2	420,632	36,931	383,701	55.6		73,135	2.6		16,154
New York	3,608,768	3,822,700	3,680,845	3,035,560	209,289	93.0	4,594,770	515,500	3,403,050	283.5				57,708	210,362
North Carolina	2,380,573	1,700,340	2,649,116	2,187,037	458,052	289.9	1,127,187	160,265	966,922	125.7		120,717	5.4	33,270	154,649
North Dakota	1,451,112	734,742	1,060,224	1,013,518	46,074	322.4	345,193	303,198	41,995	109.0	78,423	196,748	70.7	55,973	449,925
Ohio	3,871,148	1,966,253	4,114,608	3,754,142	101,950	311.8	1,473,086	32,860	1,390,843	95.9	17,000	27,200	8.2	67,145	446,260
Oklahoma	2,304,199	1,171,295	2,210,713	2,032,584	50,770	271.3	1,284,518	265,838	854,360	53.7		91,283	8.7	5,777	174,883
Oregon	1,526,724	777,096	2,098,916	1,501,341	419,957	152.5	431,077	19,526	357,139	21.9				5,858	
Pennsylvania	7,344,822	2,639,003	6,655,128	6,260,219	225,687	554.7	3,445,212	1,066,649	2,275,714	200.4				17,954	137,602
Rhode Island	439,716	254,040	449,748	439,716		33.1	212,563		212,563	6.7		36,815	1.4		4,663
South Carolina	1,364,791	1,342,000	1,186,390	1,086,655	99,102	124.4	1,342,330	227,518	1,076,463	158.9	36,000	99,940	14.2	14,619	66,495
South Dakota	1,502,870	761,911	1,348,466	1,270,007	78,373	397.4	521,851	232,863	288,988	133.6		228,183	71.1		166,368
Tennessee	2,123,155	1,075,748	1,803,755	1,612,243	124,458	132.6	997,727	429,040	568,687	51.3	17,895	106,609	6.0	63,978	275,994
Texas	6,012,518	3,638,000	6,857,715	5,954,262	448,006	850.8	2,893,134	16,517	2,876,597	168.0	18,000	226,000	28.2	23,740	87,397
Utah	1,048,677	533,173	1,353,700	954,655	192,800	195.4	479,682	94,022	314,372	71.1		25,000	2.9		1,000
Vermont	438,880	241,354	563,155	438,631	57,504	39.5	197,199		182,947	13.7				248	903
Virginia	1,736,770	893,188	1,656,585	1,567,019	22,310	211.8	694,412	104,247	582,892	64.6	65,504	239,411	23.7		48,575
Washington	1,080,673	776,603	1,334,664	1,080,673	226,229	100.8	556,610		549,109	24.1					1,265
West Virginia	1,118,559	570,083	770,892	726,068		42.0	688,309	387,152	301,157	26.8		93,524	9.9	5,339	175,402
Wisconsin	2,431,220	1,743,354	2,347,060	2,158,518	48,583	170.4	1,822,266	258,460	1,361,660	60.2		213,229	6.2	14,242	119,881
Wyoming	1,125,332	571,928	1,200,238	1,047,458	135,376	156.8	365,568	33,494	332,063	75.5	41,790	83,412	44.9	2,591	21,077
District of Columbia	972,024	792,791	1,138,516	972,024	166,491	10.2	337,625		337,625	2.7					288,675
Hawaii	177,718	351,000	178,209	177,718		4.9									351,000
TOTALS	93,147,363	58,157,600	91,923,356	79,670,019	7,820,499	9,358.6	51,741,117	12,012,475	37,415,206	4,018.4	534,157	5,700,000	617.2	930,712	7,221,895

PUBLICATIONS *of the* BUREAU OF PUBLIC ROADS

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1924. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1927. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1928. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1929. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1932. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1933.

Report of the Chief of the Bureau of Public Roads, 1934.

DEPARTMENT BULLETINS

No. 136D . . Highway Bonds. 20 cents.

No. 347D . . Methods for the Determination of the Physical Properties of Road-Building Rock. 10 cents.

No. 583D . . Reports on Experimental Convict Road Camp, Fulton County, Ga. 25 cents.

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922.

TECHNICAL BULLETINS

No. 55T . . Highway Bridge Surveys. 20 cents.

No. 265T . . Electrical Equipment on Movable Bridges. 35 cents.

MISCELLANEOUS CIRCULARS

No. 62MC . . Standards Governing Plans, Specifications, Contract Forms, and Estimates for Federal-Aid Highway Projects. 5 cents.

MISCELLANEOUS PUBLICATIONS

No. 76MP . . The results of Physical Tests of Road-Building Rock. 25 cents.

Federal Legislation and Regulations Relating to Highway Construction. 10 cents.

Supplement No. 1 to Federal Legislation and Regulations Relating to Highway Construction.

No. 191 . . . Roadside Improvement. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

REPRINT FROM PUBLIC ROADS

Reports on Subgrade Soil Studies. 40 cents.

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U. S. Bureau of Public Roads, Willard Building, Washington, D. C.

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

SUMMARY OF CLASSES 1, 2, AND 3.

AS OF JUNE 30, 1935

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 8,370,133	$ 4,259,842	$ 9,696,610	$ 6,621,629	$ 227,147	502.4	$ 4,158,750	$ 1,606,073	$ 2,153,812	226.4	$ 67,343	$ 788,562	29.6	$ 75,086	$ 1,090,321
Arizona	5,211,960	2,641,935	6,420,017	4,987,449	682,620	432.1	1,859,078		1,660,047	106.5	174,322	120,505	7.4	50,189	178,763
Arkansas	6,748,335	3,428,049	6,427,947	5,360,304	405,433	358.5	3,167,080	1,044,751	1,832,157	188.0	259,995	513,032	38.7	83,285	677,427
California	15,607,354	7,932,206	19,346,404	14,586,686	771,950	594.7	8,513,863	1,010,186	5,152,986	133.2		1,381,651	37.8	10,482	625,619
Colorado	6,874,530	3,486,006	9,300,724	6,628,457	2,075,726	514.8	1,764,886	192,697	1,291,185	121.2	25,774	89,216	7.6	27,602	29,880
Connecticut	2,865,740	1,454,868	1,825,641	1,754,612	22,251	28.3	2,394,760	1,110,133	920,127	41.0		134,613	1.3	996	377,877
Delaware	1,819,088	923,395	2,154,854	1,594,418	524,293	104.4	475,634	220,421	244,168	24.9	4,082	7,442		167	147,493
Florida	5,231,834	2,661,343	6,746,721	4,936,859	690,181	235.5	1,602,868	223,793	1,341,528	66.1		318,061	8.6	71,181	311,573
Georgia	10,091,185	5,113,491	8,475,106	7,726,202	460,299	512.1	3,905,375	1,908,059	1,897,004	197.2	6,394	543,235	13.6	450,531	2,212,952
Idaho	4,486,249	2,277,486	4,822,148	4,228,706	300,840	382.7	1,365,059	177,130	1,160,333	94.3		283,676	13.7	80,412	532,637
Illinois	17,570,770	8,921,401	12,073,723	11,551,012	142,890	266.6	11,941,012	5,931,974	6,009,038	390.1	60,108	1,886,285	31.0	27,677	883,188
Indiana	10,037,843	5,088,963	7,223,398	6,872,150	49,329	220.8	6,332,464	2,811,506	3,353,995	241.6	226,066	1,249,258	39.4	128,122	436,381
Iowa	10,055,660	5,118,361	9,937,052	8,975,947	701,505	788.2	5,431,913	1,078,967	3,733,819	412.1		266,435	21.7	746	416,602
Kansas	10,089,604	5,117,675	10,881,431	9,491,234	1,098,403	907.4	4,553,128	497,074	3,972,957	224.7	92,417	46,315	4.2	8,878	
Kentucky	7,517,359	3,818,311	7,471,304	6,546,919	499,783	553.0	3,425,792	835,100	2,419,540	234.0	30,000	499,913	19.9	105,340	399,075
Louisiana	5,828,591	2,963,932	4,662,318	4,076,249	203,254	147.6	3,731,968	1,575,091	1,961,572	85.4	149,123	404,058	13.0	28,128	395,048
Maine	3,369,917	1,711,586	3,634,361	3,101,229	412,998	162.2	1,032,342	185,162	809,733	21.1	58,912	472,542	10.7	24,613	16,313
Maryland	3,564,527	1,810,158	2,128,302	1,957,068	115,872	78.6	2,529,694	1,159,435	556,739	46.5	116,446	176,376	5.2	331,578	961,072
Massachusetts	6,597,100	3,350,474	4,087,571	3,621,003		66.0	4,641,014	2,929,059	1,635,157	36.4		158,797	6.2	47,038	1,556,520
Michigan	12,736,227	6,452,568	11,745,416	10,933,362	225,500	479.5	6,833,094	1,674,277	5,100,558	235.5	19,400	814,950	41.8	109,188	311,559
Minnesota	10,656,569	5,425,551	12,022,867	9,571,380	2,139,235	1,320.3	3,061,394	862,504	1,998,906	237.8	52,792	367,905	50.6	169,893	919,504
Mississippi	6,978,675	3,540,227	7,322,755	4,585,516	596,242	431.5	4,422,558	2,201,403	1,492,278	237.6	14,727	848,609	50.2	177,030	603,098
Missouri	12,180,306	6,173,740	10,824,108	9,826,887	258,063	898.8	5,858,430	2,119,202	3,460,501	398.7		2,455,176	156.9	234,217	
Montana	7,439,748	3,769,734	9,663,148	7,167,471	2,004,378	862.7	1,645,773	70,197	1,446,207	124.4	30,012	180,179	8.3	172,068	138,970
Nebraska	7,828,961	3,964,364	9,854,651	7,763,472	914,899	831.2	3,087,355	25,639	2,711,123	181.7		78,297	5.1	39,850	260,045
Nevada	4,545,917	2,302,356	5,382,730	4,270,430	1,007,087	518.1	940,086	187,644	751,774	124.8	55,722	234,342	71.5	32,122	309,152
New Hampshire	1,909,839	969,462	2,039,902	1,729,551	234,565	55.2	843,738	180,288	637,716	23.5		50,935	.3		46,247
New Jersey	6,346,039	3,220,879	5,244,520	4,909,216	18,316	60.8	2,956,057	1,295,764	1,324,259	22.0		115,113		141,059	1,763,191
New Mexico	5,792,935	2,941,700	6,854,286	5,454,404	1,254,992	644.0	1,290,424	258,819	1,016,079	103.6	1,010	374,499	21.2	78,702	296,131
New York	22,330,101	11,327,921	23,149,575	19,215,590	778,219	377.4	16,256,421	2,665,189	9,659,592	446.7	76,700	88,900		372,622	801,211
North Carolina	9,522,293	4,840,941	10,273,304	7,929,100	1,384,845	984.3	3,261,528	1,068,960	1,967,616	299.0	155,667	623,585	28.3	368,567	864,894
North Dakota	5,804,448	2,938,967	5,397,306	4,687,077	264,914	1,491.5	1,423,871	638,796	609,045	327.9	346,084	629,392	247.7	132,491	1,435,617
Ohio	15,484,592	7,865,012	16,507,808	15,032,692	353,715	572.0	6,509,609	218,941	5,778,808	180.4	153,152	221,820	11.4	79,807	1,510,669
Oklahoma	9,216,798	4,685,180	9,310,378	8,332,339	634,015	637.7	4,066,331	829,870	2,856,440	142.2	46,690	587,704	22.6	7,898	607,021
Oregon	6,106,896	3,097,814	7,288,385	5,868,344	803,811	377.7	2,401,907	166,751	2,052,810	88.1	518	80,000	.2	71,283	161,193
Pennsylvania	18,891,004	9,590,788	18,581,377	16,648,281	1,324,139	763.9	9,563,758	2,101,137	7,005,393	296.6	2,126	295,697	.9	139,460	965,558
Rhode Island	1,998,708	1,014,572	1,937,643	1,858,334		61.1	914,914	79,740	818,895	22.5		36,815	1.4	60,634	158,863
South Carolina	5,459,165	2,770,954	4,817,608	4,539,153	211,067	376.0	2,438,919	795,765	1,599,254	229.9	73,818	230,951	15.7	50,430	729,682
South Dakota	6,011,479	3,047,643	5,501,730	4,788,454	240,490	990.2	2,365,975	897,217	1,414,851	379.3	73,135	605,465	115.1	252,673	786,838
Tennessee	8,492,619	4,302,991	8,658,365	7,357,050	574,108	350.7	3,343,960	977,485	2,270,074	113.8	31,160	875,175	18.9	126,924	583,634
Texas	24,244,024	12,291,253	24,996,808	22,222,198	1,598,937	2,097.3	10,180,309	1,649,450	8,154,862	563.4	70,836	1,360,848	88.4	301,540	1,176,605
Utah	4,194,708	2,132,691	5,274,400	3,928,652	809,391	489.4	1,486,835	260,153	990,723	109.6		192,000	8.8	5,903	140,577
Vermont	1,867,573	948,007	2,116,960	1,810,143	128,279	101.8	779,279	37,472	685,712	34.7		96,266	2.6	19,958	37,750
Virginia	7,416,757	3,765,387	7,240,626	6,140,130	707,298	407.3	3,521,472	972,554	2,052,213	151.1	131,159	716,970	44.7	172,914	288,905
Washington	6,115,867	3,106,412	6,641,647	5,797,208	732,511	247.6	2,572,710	276,720	2,167,910	54.7		173,812	.5	41,939	32,180
West Virginia	4,474,234	2,280,335	3,980,577	3,632,919	223,969	139.0	1,524,286	751,970	772,316	48.3	83,049	428,686	18.5	6,296	855,363
Wisconsin	9,724,881	4,941,837	9,537,611	8,780,624	323,642	440.8	4,986,561	817,312	3,887,595	162.8	82,664	544,377	17.7	44,280	186,222
Wyoming	4,501,327	2,287,712	4,857,099	4,082,677	590,444	695.1	1,760,587	356,894	1,376,935	275.3	48,448	241,804	66.1	13,307	78,529
District of Columbia	1,918,469	973,842	2,015,847	1,668,305	347,542	16.7	587,789	250,164	337,625	2.8					288,675
Hawaii	1,871,062	949,778	1,007,238	704,442		24.2	1,331,572	1,126,855		20.3	20,973	273,416	1.7	18,793	676,362
TOTALS	394,000,000	200,000,000	397,362,307	335,853,534	30,069,387	24,599.7	185,044,182	50,311,743	118,503,967	8,529.7	2,840,824	23,163,660	1,426.7	4,993,899	28,262,986

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