(flake form) was added to each hole.

The soil profile 10' R. of ℄ was determined by auger borings along the edge of the slab. The subgrade soil is variable but the heave was caused mainly by very fine sand and silt.

Profile levels were taken at center and 9' R. & L. of center on November 21, 1944, January 19, 1945, and March 6, 1945.

A comparison was made between the treated section and the adjacent untreated section. The treatment was ineffective in reducing the amount of heaving.

Brighton North Location
US-23, 3.8 miles North of Junction with US-16 Near
Brighton, Livingston County

This heave occurs in a concrete pavement. It is approximately 35 feet in length. The maximum amount of heave is 2.5 inches. The east half of this heave was treated in September, 1945. Holes (6" diameter) were drilled through the pavement on 3 foot centers. Holes in the subgrade were enlarged to 8 inches in diameter and 12 to 15 inches in depth. Twenty-five pounds of calcium chloride (solution form) were added to each on September 13, October 3, and November 1, 1945. The holes were then filled with gravel and covered with cold patch material.

Profiles of the subgrade soil were determined by auger borings along each edge of the slab (10' R. & L. of ℄). The soil is variable but the heave is caused mainly by very fine sand and silt.

Profiles levels were taken 5' R. & L. of ℄ at 10' intervals on September 7, 1945, February 25, 1946, and May 22, 1946. By comparing the treated section with the adjacent untreated section, we note that the treatment was ineffective in reducing the amount of heaving. Soil samples were taken during May, 1946, to determine the extent of migration of calcium chloride. From the test data, we note that the desired migration of calcium chloride has not taken place or that a greater part of the material has leached away.

CONCLUSIONS

From the information assembled in this work, we conclude that calcium chloride has not been effective in reducing frost heaving and that the desired migration of calcium chloride has not taken place or that a greater part of the material has leached away.

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Our experiments cover "Permanence of Calcium Chloride in Subgrade and Stabilized Bases and Its Effectiveness on Base Course Densities."

Calcium Chloride is mixed into the base course of a road primarily to obtain and maintain a more or less favorable moisture content and, as a result, obtain a relatively high density. The purpose of this work was to determine the base course densities of several bituminous roads thus treated, after several years of use, and to determine how much of the calcium chloride originally placed there still remains.

Two samplings have been made--the first in the summer of 1942 and the last in the summer of 1946--to determine the changes of density and chloride content with time. Information on the original conditions of density and chloride content of the roads is in some cases so meager and unreliable that conclusions as to changes from the original conditions of the roads cannot be made. However, changes from the time of first sampling to that of the second have been measured and are reported.

Five roads are sampled: Hiwassee Dam Access Road, N. C., built in 1938; Dietrich-Montrose Road, Illinois, 1937; Muscatine County Road C, Iowa, 1939; Lawton-Marcellus Road, Michigan, 1938-39; and Kuttawa-Fredonia Road, Ky., 1941. Base course densities were measured by the sand method. Samples of base-course and subgrade material were analyzed for hygroscopic water content, and for chloride content

TABLE 1

DENSITIES OF BASE COURSES TREATED WITH CALCIUM CHLORIDE

Road	Year Sampled	Hole	Reported $CaCl_2$ used	Dry Density	Moisture Content	True Sp. Gr.	Maximum [a] Theoretical Dry Density
			lb. per sq. yd.	lb. per sq. yd.	%		lb. per cu. ft.
Hiwassee	1942	1	2.7	151 [a]	2.4	2.75 [c]	161
"	1942	2	2.7	144 [b]	2.6	2.75 [c]	160
"	1942	3	2.7	147 [b]	2.5	2.75 [c]	161
"	1946	1	2.7	150	2.3	2.70	158
"	1946	2	2.7	142	1.9	2.76	163
"	1946	3	2.7	141	2.3	2.80	164
Dietrich	1942	1	1.7	159 [d]	4.0	2.76 [c]	155
"	1942	2	1.7	147	3.3	2.76 [c]	158
"	1942	3	1.7	155	1.8	2.76 [c]	164
"	1946	1	1.7	163 [d]	4.6	2.76	153
"	1946	2	1.7	148	3.4	2.80	159
"	1946	3	1.7	137	2.8	2.72	158
Muscatine	1942	1	1.5	152	2.8	2.68 [c]	156
"	1942	2	1.5	153	2.8	2.68 [c]	156
"	1942	3	1.5	156 [d]	3.0	2.68 [c]	155
"	1946	1	1.5	134	3.5	2.70	154
"	1946	2	1.5	132	2.3	2.65	154
"	1946	3	1.5	145	1.7	2.70	161
Lawton	1942	1	1.1	146	5.0	2.80 [c]	153
"	1942	2	1.1	146	4.3	2.80 [c]	156
"	1942	3	1.1	145	4.5	2.80 [c]	155
"	1946	1	1.1	151	4.5	2.79	155
"	1946	2	1.1	146	2.2	2.77	162
"	1946	3	1.1	143	3.4	2.84	162
Kuttawa	1946	1	2.7	146	5.8	2.70	146
"	1946	2	2.7	137	6 7	2.71	145
"	1946	3	2.7	143	5 7	2.71	147

[a] Formula used: vol. soil (cu.ft) + vol. water (cu. ft) = 1 cu. ft. (assuming complete saturation)

let x = dry wt. (lb.); since vol. given as 1 cu. ft.

x = dry density (lb. per cu. ft.)

$$\frac{x}{(\text{true sp. gr.})\ (62.4)} + \frac{(\%\ M.C.)\ x}{(100)\ \ (62.4)} = 1;$$

$$x = \frac{[\,(6240)\ (\text{true sp. gr.})\,]}{100 + (\%\ M.C.)\ (\text{true sp. gr.})}$$

[b] Determined by Bernard Thomas.

[c] Average of 1946 values for same road.

[d] Impossible value; experimental error.

by the Mohr titration method. Chloride values from roadside blanks were subtracted from the amounts found under the pavements.

Table 1 lists the densities of the base courses sampled. The values labelled "Maximum Theoretical Dry-Density at M. C. Found" were calculated to determine whether the density values found are possible values (most of the values are so high, approaching those of concrete that doubt might be expresed as to their possibility).

Figure 2 shows the calcium chloride contents of the base courses and subgrades, calculated from the chloride found. Nothing is known of the calcium ion, or the manner in which the chloride is present, except that it is water-soluble. All depths represent distances down from the bottom of the pavement. Values of calcium chloride are expressed as the dihydrate, the commercial form in which the chemical is usually used in road work. All percentages are based on the dry weight of the soil.

The horizontal lines across the graphs represent the total calcium chloride applied (as reported), calculated as though it were mixed evenly throughout the 36 inches below the pavement, including base course and subgrade. In these calculations, an average density of 100 pounds per cubic foot was assumed for the entire 36 inches. In the Muscatine graph it is obvious that more chemical was used than was reported, perhaps for dust control in the years preceding pavement.

In a few years the 1946 values are slightly higher than the 1942 values. This might be caused by changes in ground-water conditions since the vertical migration of chloride is sensitive to rise and fall of water, but the difference, are too small to be significant in any case.

The density values found are unusually high, but there are no blank values (from untreated sections) for comparison. After a period of five to ten years, one-third to one-half of the chloride originally placed still remained. Almost the entire loss occurred during the first five years.

COMMITTEE SUMMARY

The work of the committee to date has been confined largely to the experimental treatment of existing frost heaves with calcium chloride. Figures 3 to 8, which follow, show typical procedures and records. Results have not been particularly encouraging since, in most instances, there has been no diminishing of the original amount of the heave. In contrast, however, some reports indicate some benefit and, in one instance, a complete cure. Since laboratory experiments have indicated that a moderate concentration of calcium chloride in the soil will practically eliminate frost heave, it is the committee's opinion, which is based in part on experimental data, that adverse water conditions have leached the chemical from the soil thus making the treatments ineffective in some instances.

The committee has not expanded its activities to include the treatment of subgrades in general, for the purposes of seeing whether or not the frost line can be lowered in the subgrade and thus decrease the amount of pavement spring break-up.