Chemical Treatment of Stabilized Mineral-Aggregate Roadway Surfaces

OTMAR W. ZACK, *County Engineer,*
Butler County, Iowa

PAPER deals with Chemical Treatment of Stabilized Mineral Aggregates for Roadway Surfaces, on the Farm to Market road system, in Butler County, Iowa, and covers field operations only. Every area has many characteristics that have vital bearing on the choice of materials used, the methods employed, and the results obtained in such construction.

● BUTLER County is located in the north central part of Iowa and has an area of 576 square miles. This county has a gently rolling to hilly terrain, and is mostly in the Iowan drift area with the southwest portion in the Mississippi loess area. The climate definitely has four seasons. During the winters, frost penetrates to 3 ½ feet. During the spring, the ground thaws, frost boils develop, and normally a considerable rainfall occurs. The summer months of July, August, and September are usually hot and dry. October and November can be perfect construction weather or sloppy cold.

Butler County has a well developed general farming industry. It has a number of small towns but it is without industrial centers or large towns. The total population in 1950 was 18,000.

The governing body consists of a board of county supervisors consisting of three members elected by districts. The county board of supervisors employs a county engineer. The board and the engineer are jointly responsible for the construction and maintenance of the county road system under the general supervision of the Iowa State Highway Commission.

The traffic counts of 1950 on these roads show that those with the least traffic have 120 vehicles per day and those with the greatest traffic have 520 vehicles per day. A recount this next year is expected to show a sizeable increase in each of these values.

The course aggregate available for roadway surface material consists of white limestone of good quality accessible with a 12-mile haul to any part of the county. The finer aggregates of clean course sand and gravel are located in deposits along the rivers. The main deposits of gravel are in the northeast area and the finer materials in the southwest portion.

Two clay pits containing the type of clay most desirable and having a minimum of oversize rock have been opened. One clay pit which is located in the south central area contains material of an olive-grey color, having 74 percent passing a No. 200 sieve, a P.I. of 18, and a dry weight of 72 pounds per cubic foot. The other clay deposit which is in the northwest part of the county is of brownish color, having 74 percent passing a No. 200 sieve, a P.I. of 24, and a dry weight of 63 pounds per cubic foot (Table 1 for further mechanical analysis of materials).

The several aggregates are produced by contractors from privately leased quarries, from county owned quarries, gravel pits, and clay pits.

The limestone is crushed to 100 percent passing ⅝ in. screen. The fines passing a No. 8 sieve are controlled at or near 40 percent with the extreme limits of 35 to 45 percent of the total dry weight of aggregate. The gravel is pit run and crushed to a maximum size of ⅝ inches. The clay is delivered on the road without processing.

After the various materials have been processed and delivered on the road, the county crews take over. Generally, the gravel is delivered first, followed by the limestone and clay in order. A dozer windrow evener is used to distribute the aggregate uniformly along the road. The motor graders divide the material in two equal windrows. After the gravel and limestone have been divided and windrowed, the clay is delivered on the center of

TABLE 1
Mechanical Analysis

Lab. No.	Identification of Sample No.	Avg. Dry Wt. per Cu. Ft.	Percent Passing										
			⅝ in.	⅜ in.	No. 4	No. 8	No. 10	No. 40	No. 100	No. 200	L.L.L.	L.P.L.	P.I.
1609	Clay 24-90-17	72		100			99	93	80	74	35	17	18
1610	Gravel 22-90-18	106	100	95	88	78	75	33	7.1	4.7		N.P.	
1611	Limestone 21-91-18	92	100	73	49	36	33	23	19	17	21	17	4
AAD4 1735	20% 1609 Clay 25% 1611 Limestone 55% 1610 Gravel		100	91	81	72	70	43	25	22	20	13	7
1612	Clay 6-93-17	63					100	94	86	74	40	16	24
1613	Limestone 8-93-17	105	100	73	49	35	33	22	18	15		N.P.	
1614	Gravel 30-93-16	102	100	96	89	77	73	16	3.6	2.7		N.P.	
AAD4 1736	15% 1612 Clay 25% 1613 Limestone 60% 1614 Gravel		100	90	81	70	67	29	19	17	20	14	6

the road where it is dried and broken down as fine as reasonably possible by using motor graders, seaman mixers, and a flat surface roller. Then, the clay is divided equally and mixed with the gravel and limestone and left in the two windrows until the chemicals are applied. The chemicals used are sodium chloride and calcium chloride. The first projects laid in Butler County were two short stretches in the spring of 1952. One was one-half mile, and the other was three-fourths of a mile in length. In these projects, 11 pounds of calcium chloride was used per ton of soil stabilized mineral aggregate. Both projects were on roads that have a 500 vehicle per day count and on which the usual unstabilized aggregate had had not been satisfactory.

In these projects, 1000 tons per mile of the chemical treated soil stabilized aggregate was placed on the previously surfaced roads. At that time there was no equipment available for applying calcium chloride in solution for surface treatment. As a result, the projects received a surface application of dry calcium chloride after the spring rains of 1953. The fall of 1953 was so short of moisture that an application of dry calcium chloride would have been of no value, and as a result received no surface treatment.

In July of 1953, two more projects were constructed. This time 10 pounds of sodium chloride was used per ton of aggregate. One project was ½ mile and the other was 1½ miles in length.

The conditions under which the second two projects were constructed were the same as those of the first two. Although the fall of 1953 was comparatively dry, all projects stood up remarkably well and already had saved the county more than the cost of the chemicals. From visual observation, no material difference was noted between the calcium chloride treated aggregate and the sodium treated aggregate.

The cost to Butler County for the calcium chloride was $25 per ton in bulk car shipment, and the sodium chloride cost was $13.50 per ton. Because of the difference in cost, it was decided that sodium chloride would be used for stabilizing the soil bound aggregate and that calcium chloride would be used for surface treatment in subsequent work. Sodium chloride was shipped in flat bottom gondola cars and unloaded with a clam shell bucket and spread over the aggregate on the road with a truck lime spreader.

Before the chemicals are applied, the mixed aggregates are spread uniformally over the road surface. It is very desirable to have the materials in a moist condition as it prevents the aggregate from separating and helps to dissolve the chemicals. The seaman mixers follow the sodium spreader to mix the chemicals with the aggregate. Then the material is well compacted by rolling before any blading is done to prevent segregation. The writer believes that a dense well graded material will give better results with chemicals than will a loosely graded aggregate. To obtain a dense material, the help of the Iowa State Highway Commission laboratories was obtained and their recommendations were very helpful.

The mixture used in the 92,000 tons of treated aggregate placed on 35 miles for resurfacing and 20 miles of newly constructed roads consisted of 60 percent gravel, 27 percent limestone, and 13 percent clay to which was added 8 lb. to 10 lb. of sodium chloride. The rate of application was 1,500 tons of mixed aggregate per mile for maintenance work and 2,200 tons per mile for new construction.

The cost of the material delivered on the road by the contractors was $0.89 per ton for gravel, $1.66 per ton for limestone, and $1.26 per ton for clay giving an average cost of $1.146 per ton for the mixed aggregate or $2521.20 per mile on new construction work.

The cost of sodium chloride was $13.50 per ton f.o.b. Butler County and using 8 lb. per ton of aggregate gave a cost of 5.4 cents per ton or $118.80 per mile. The average cost per mile of hauling the sodium chloride, mixing, and laying all materials by the county crews was $378 per mile. The cost of supervision, inspection, and checkers was $52 per mile. The total cost per mile of new construction was, therefore, $3074 (see Table 2).

TABLE 2
AVERAGE COST PER MILE OF CONSTRUCTION

	Percent of Total	Cost per Ton	Cost per Ton Mixed Aggregate	Quantities per Mile	Cost per Mile
		$	$	*tons*	$
Gravel	60	0.89	0.534	1,320	1,174.80
Limestone	27	1.66	.448	594	986.04
Clay	13	1.26	.164	286	360.36
Aggregate cost	100	—	1.146	2,200	2,521.20
Salt	8 lb.	13.50	.054	8.8	118.80
Total cost of material			1.200	2,200	2,640.00
Supervision and checkers					56.00
Labor cost					138.00
Equipment cost					240.00
Total cost per mile					3,074.00

In the spring of 1954, a 1,500-gallon water tank was purchased to use in applying calcium chloride in solution. A gasoline motor and pump were placed on a rear platform and connected so that water could be pumped from a supply to fill the tank, to circulate the water within the tank or to supply water to the 8-foot spray bar. At the top of the tank a sunken dome was constructed with a No. 8 copper screen. The piping was so arranged to circulate the water thru the dome. The calcium chloride was placed in the dome and dissolved by the circulating water. Some corrosion in the tank was caused by the chemicals. It seemed that a strong solution caused more corrosion. Because of this and of the nearby water supplies, a weak solution of 1.60 pounds of calcium chloride was used per gallon of water or 1 ton of calcium chloride to 1,200 gallons of of water. This amount was considered enough to cover 1½ miles, 16 feet wide and figures 0.67 ton of calcium chloride per mile per application. Such applications were made throughout the year when conditions seemed to justify additional calcium chloride.

The maintenance of chemically treated road surfaces is not as serious as was first believed. A slow rain will soften the surface enough to allow a blade to get material to fill pot holes. Whenever too much binder has been lost, the course material can be rebound by using limestone dust.

The benefits from the use of chemicals which are being observed are threefold: physical benefits to the public, economical benefits, and the benefits as a base for future bituminous surface.

The benefits to the public are a dust free road which results in safer highways, and is more pleasant to the traveling public and the housewives along the highway. The economical benefits are the saving of aggregate. It is found that there is not the large amount of aggregate over the shoulders and in the ditches caused by blades, snowplows, and speeding vehicles.

It is too early from our experience to make a statement on the maintenance costs. We do, of course, know it has cut down on the amount of blading, but how much of this saving is offset by the cost of chemical treatments has not been determined.

The Iowa Highway Research Board and the Iowa Highway Commission have authorized a Research Project No. H.R.-33 to study the Characteristics of Chemically Treated Road Surfaces. This study should also determine the possibilities of stage construction for a base course to bituminous surfaces.

The Board of Supervisors has been very cooperative and helpful in planning our operations and has indicated that we would proceed in the use of chemicals and to improve our our facilities for their handling.