ECONOMICS OF STABILIZATION WITH CALCIUM CHLORIDE

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SYNOPSIS

In this symposium George L. Farnsworth, related how LaSalle County, Illinois saved on maintenance of gravel roads by constructing 3 inch compacted stabilized gravel surfaces 20 feet wide at a cost of $2321.00 per mile. Prior to treatment, annual costs of maintenance had averaged $106.00 per mile for blading and $300.00 for gravel loss. Only half as much blading is now required. Three applications of calcium chloride per year cost about $265.00.

A. L. Brown notes several types of calcium chloride stabilization in use in Michigan. Base stabilization with 10 to 15 pounds of calcium chloride per ton of aggregate frequently precedes a bituminous surface treatment. Plant mixing of the material is usually preferred. Widening of the narrower paved roads is often accomplished by a 2-foot strip of stabilized gravel, 6 inches deep on each side of the road. The treatment costs about $650.00 per mile and is usually topped with a bituminous surface treatment.

The Missouri maintenance department has been experimenting with calcium chloride stabilization of clay gravel surfaces as a means of eliminating dust nuisance and improving the riding qualities of the surface. Rex M. Whitton described three recent projects, concluding that these objectives have been achieved and that the results justify continuation of the experiment to determine more definite conclusions both from a physical and economic standpoint.

W. F. Abercrombie of the Georgia Highway Department described road-mixing methods of stabilization using about 1.5 pounds of calcium chloride per square yard as an admixture and 0.5 pound later as surface treatment. Uncompacted soil was placed between 9-inch forms at a cost of from 8.4 to 9.6 cents per square yard. Calcium chloride cost 2.8 to 3.8 cents per square yard. The stabilized section was 19 feet wide with a compacted depth of 6 inches.

Francis L. Brown reported on the efforts of Washington County, New York, to take care of a large unpaved mileage by means of calcium chloride. Savings were realized in maintenance costs, $153.00 per mile for 1939 being the lowest yearly figure in the records.

Paul E. Glasgow described methods used in Wayne County, Ohio, in constructing a 21-mile section. Work included cleaning ditches, furnishing graded aggregate, binder soil and calcium chloride (1.5 pounds per square yard admixture and 0.5 pound surface treatment) and mixing. The complete course was 18 feet wide and 3 inches deep and total cost was about $2500.00 per mile. Mixing was accomplished with a traveling pugmill type machine. Covering the base with a bituminous treatment is the contemplated second step of this program.

According to James E. Moreland the road building activities of the T. V. A. are first, to provide access roads to construction sites; and second, to replace roads flooded by backwater from dams. A calcium chloride stabilized base will permit the placing of a bituminous surface treatment immediately after placing, which is of great importance if construction schedules for the dams are to be kept. Plant mix methods are usually preferred, except on small jobs. Costs of base stabilization varies from $1.38 per square yard for a 9-inch section, to $0.47 for a 6-inch section.

There are approximately 2,300,000 miles of unimproved secondary or "low-cost" roads in the United States, representing 80 per cent of the total road mileage. Considering traffic densities, however, expenditure for high type surfaces on the largest part of these roads is not practical. But, since these roads are vitally important to local educational, social, and business needs, there has been an increasing demand for the development of a low cost road construction program that would include their improvement. The applicability of calcium chloride treatment for this purpose is indicated in the following statements by the contributors to this symposium.

Glasgow: Approximately 45 per cent of the 50,000 population of Wayne County, Ohio is spread over the rural agricultural areas. Of the 1200 miles of roads in the County, 500 are on the county system, 500 on the township system, and 200 on the state system. The 500 miles on the county system consist of 440 miles of traffic-bound gravel, stone or slag roads, and but 60 miles of hard surface roads. We have found no satisfactory way of keeping the ordinary traffic bound roads in decent shape, regardless of cost, when the traffic gets up to 300 or more vehicles per day. Approximately 150 miles of our traffic bound roads are carrying from 150 to 500 or more vehicles per day. Our most pressing problem is, therefore, limited to this mileage. Following preliminary experiments during 1937, a contract for constructing 21 miles of calcium chloride stabilized base was let during 1939.

Whitton: In Missouri there has been for a number of years a growing demand for the elimination of dusty roads together with an increasing number of complaints about rough gravel roads through the dry summer months; especially is this true on those routes which carry a heavy traffic for this type of surface. At the present time there are 8,646 miles of gravel or crushed stone surfaced highways in Missouri under State maintenance. It is, of course, economically inadvisable and financially impossible to provide a dustless type surface for this entire mileage of gravel or crushed stone roads, but it is highly desirable to eliminate the dust on a part of it. It is, therefore, the general feeling in Missouri that there is a definite need for a low cost dustless surface.

Farnsworth: LaSalle County, located in the heart of Illinois's richest industrial and agricultural area is faced with the problem of developing a highway system which will enable both farmer and industrialist to market his products. In the past our policy was to link together the most important centers with hard-surfaced year-around roads, but once this was accomplished, the problem was what to do with the rapidly increasing mileage of secondary roads. Although the majority of these were gravel surfaced, the increased use of high-speed automobiles made the loose surface impractical and the next step was to decide upon an improved dustless low-cost type of surfacing which would include the major portion of our road system, and yet could be maintained within our present budget. After careful study of the various types available, we decided that the calcium chloride soil stabilized gravel road best fitted our conditions.

A. L. Brown: Michigan's climatic conditions are extremely varied, with temperature extremes ranging from −50° to 0° F. during the winter and 100° to 32° F. during the summer; and rainfall records show average monthly precipitations varying from 0.87 to over 4 in. Within this area are approximately 3000 miles of gravel trunkline roads which have traffic densities ranging from

over 1400 to less than 200 vehicles per day. Interspersed with the commercial truck traffic, local traffic and the usual inter-county traffic is a large tourist traffic which, according to the Public Roads Administration, expends over $300,000,000 annually in this State. This makes the tourist industry the second largest in the State, exceeded only by automobile manufacturing and means that special consideration must be given to the highway system in order to insure the continuation of this industry.

F. L. Brown: In Washington County, New York, up to 1937 a work relief program had decreased the ratio of paved to unpaved highways until it was evident that unless a reverse procedure was instituted, a serious drain on normal maintenance budgets might cause impairment to the service. Undertaking a year of maintenance in 1938, we set forth to attain two objectives: (1) to place all mileage in such a condition that it could be easily maintained until financial conditions would allow the return of a normal ratio of paved to unpaved mileage; and (2) to adapt our program to the public demand for smooth, dustless roads at a minimum of expense. To accomplish the objective with regard to gravel surfaces, a program of calcium chloride stabilization was adopted.

Moreland: The program of the Tennessee Valley Authority involves the construction of access roads to various dams under construction and the relocation or reconstruction of roads which are to be flooded by back-water from the dams. The policy of replacing with equivalent facilities dictates the type of surface on replacement roads, and the transportation demands determine the type of access roads. In both classes there are numerous projects on which it is permissible to use bases constructed of local materials such as crushed stone and gravel. This introduced the problem of utilizing these materials in an economical manner and producing a base of adequate strength which can receive a bituminous surface immediately after placing, since the construction schedules of work do not permit stage construction with long intervals during which traffic may consolidate the base and develop any weakness which may occur. Naturally a mixture of materials having a high density is called for, and our studies indicated that the methods of designing which are generally associated with the use of calcium chloride would be the most suitable.

Calcium chloride soil stabilization has been applied to base stabilization, partial surface stabilization, and complete surface stabilization. Accordingly it is necessary to discuss the economics of the various types of calcium chloride stabilization separately. Broadly, however, the general topic may be divided into two fields—base and surface construction; in the first case the ultimate surface will probably be a bituminous mat or concrete pavement, while in the latter case the calcium chloride stabilized surface constitutes the roadway wearing course. Several of the contributors to this symposium have offered discussions relating to both phases, while other contributors, due to prevailing local conditions, have confined their discussions to either one or to the other. The economic factors of the two construction types, as effected by calcium chloride are discussed as follows:

ECONOMY OF CALCIUM CHLORIDE IN STABILIZED BASE CONSTRUCTION

Subgrade

Moreland: In all of the T. V. A. projects precautions were taken to secure a sound, well drained subgrade. Wet spots were corrected by ditch or by tile under-

drains. Unsuitable materials were either replaced or treated to improve the quality. It is of course essential that the subgrade be firm and unyielding for any type of base to be successful. The stabilized base, when properly constructed, will retain its form, and will transfer superimposed loads to the subgrade, but it certainly cannot be expected to function satisfactorily if the subgrade is unstable.

Compaction

Moreland: In addition to the advantages of uniform and prearranged gradation of stabilized mixtures over water-bound or traffic-bound types of construction, the value of the incorporation of calcium chloride is also to be considered. An incorrectly proportioned mixture cannot be turned into a satisfactory one by the addition of calcium chloride, but it is undoubtedly true that the addition of calcium chloride to a well designed mixture will add to the density, stability and strength, and this additional value is obtained at a very low cost per square yard. Calcium chloride has been added to well maintained traffic-bound roads with good results, since the continuous moist condition caused by the presence of calcium chloride permits traffic to compact the surface effectively. The benefits derived from calcium chloride are more noticeable when it is incorporated in a well designed mixture during the process of construction. A base of satisfactory gradation to which calcium chloride has been added during construction, when properly compacted has a hardness and density which can only be explained by the fact that the presence of calcium chloride in the mixing water promotes compaction and increases the density. This is because the addition of this material increases the surface tension of the liquid, and permits soil particles to be moistened by thinner films of water. In *Public Roads* May, 1936, Messrs. Hogentogler and Willis make this statement: "Treatment with calcium chloride . . . . effects a decrease in the volume change and an increase in the density and stability of graded road mixtures." A progress report of the Project Committee on Stabilized Soil Road surfaces, issued by the Highway Research Board in 1935, contains the following statement: "The moisture film cohesion furnished by calcium chloride is more stable than that furnished by plain water, due to the combined effect of lower vapor pressure and hydroscopic property."

Clemmer: The research reported by the Public Roads Administration in the November, 1939 issue of *Public Roads* refers to outdoor circular track experiments in which various aggregates and admixtures all were used in the construction of base courses; which, following compaction, were covered with a light bituminous surface. The completed sections, as in the case of the bases, were subjected to distributed traffic wheel loadings, with the general surface conditions being noted periodically. The experiments were conducted in such a manner that it was practicable to control the water elevation and thus study the performance of the base under varying degrees of saturation.

With reference to compaction prior to application of the bituminous surfacing the following is quoted: "Compaction was continued on the top layer (of a two course base)until no further subsidence was noted and all sections were in suitable condition for testing. . . . . The effect of the chemical admixtures on the compaction of the graded materials is shown by the behavior of the test sections during the initial compaction period. Track 1, which contained calcium chloride, reached a condition considered suitable for starting the test at

somewhat less than one-third the wheel trips required to produce a similar condition in track 3 of the plain mixture." The numbers of trips were 18,200 for the calcium chloride track and 60,000 for the plain track.

A. L. Brown: The admixture of 10 to 15 lb. of calcium chloride per ton of gravel conserves the moisture and makes possible a greater density under compaction.

Surface Stability of Bituminous Mats

Clemmer: Quoting from the November 1939 issue of *Public Roads* . . . . "After this phase (testing of the respective bases without a bituminous surface) of testing had been completed, the sections were reshaped and trimmed smooth. A prime consisting of 0.3 gal. per sq. yd. of light tar was applied and allowed to cure. A surface treatment consisting of 0.4 gal. of hot bituminous material and a covering of 50 lb. per sq. yd. of stone of ¾ in. maximum size was constructed. The treatment was consolidated by additional distributed traffic until the surface was well sealed and showed no movement." "New initial or zero displacement readings were taken after the application and compaction of the bituminous surface and the record from that time on or from 171,200 wheel-trips to the end of the test indicates the behavior of the calcium chloride treated materials when acting solely as base courses."

"The materials in all sections of track 1 (calcium chloride) gave good service and showed little movement as base courses even under the very severe test conditions imposed by maintaining the water elevation at 2½ in. At 261,200 wheel-trips, or 90,000 wheel-trips after the start of concentrated traffic and 60,000 wheel trips after the water had been raised to the 2½ in. level, the average vertical displacement of the surface on all the calcium chloride sections was less than 0.05 in. and the maximum amount of rutting was 0.09 in."

Glasgow: The first step in our plan is to convert the traffic bound surfaces on our heavier travelled roads, into low-cost stable bases; the second step is to apply a 1½ to 2-in. bituminous treatment of the roadmix type. During 1937, we placed with our own forces a calcium chloride stabilized base on a two mile section of a county system road having a daily traffic of approximately 500 vehicles. The plasticity index for the final mix on this section was above 10. This base came through the winter of 1937-38 in excellent shape and was bituminous surfaced in 1938. The finished section, while developing a few failures (possibly on account of the high plasticity index of the base) during the winter of 1938-39 encouraged us to let a unit price contract for the construction of the 21 miles of various sections of county system roads.

Figure 1. Uniform spreading of Calcium Chloride, Wayne County, Ohio

Moreland: *Hiwassee Access Road.* This road extends from Hiwassee dam site to the nearest railroad twelve miles away. It was designed for the transportation of all equipment both permanent and temporary, all materials except the concrete aggregates, and a large percentage of the labor. The cement was transported over this road in vehicles holding 60 bbl., or approximately 12 tons of cement. The heaviest individual load was estimated to be 60 tons. The aver-

age traffic during construction has been approximately 1,000 vehicles per day. The base was built in two layers to a total thickness of 9 in. and immediately after construction was given a bituminous prime and seal coat of hot asphalt, with 50 lb. of stone chips rolled into the asphalt. The base material which was composed of crushed stone, local soil, water and calcium chloride, was mixed in a concrete mixer. There have been no failures of the base except a minor one at a point where the subgrade was not well drained.

Alabama State Highway No. 1. A section of this highway, four miles in length, was built to replace an existing road which has since been flooded. The road replaced was composed of a crushed stone and gravel base, with a bituminous prime and mixed in place surface. The traffic on this section was 1,000 or more vehicles per day, including heavy truck traffic. The road which we constructed to replace this was composed of a stabilized base 6 in. thick, with a bituminous prime and 1 in. mixed in place bituminous surface. The base was of crushed stone, local soil, calcium chloride and water, mixed on the subgrade in two layers with a heavy grader. No failures were encountered during the past winter, which was the first winter after construction.

Chicamaugua Access Road. This road extends from Chicamaugua dam site to Tennessee Highway 58, one mile away, and is used almost entirely for passenger traffic to the dam consisting of approximately 1200 vehicles per day. On this road we constructed a stabilized base 5 in. thick, and applied the bituminous prime and hot bituminous seal with 50 lb. of stone chips per square yard. This base is composed of crushed stone, local soil, calcium chloride and water, mixed in place in two layers. The road has been in use for three years with no base failures, and only moderate maintenance on the surface.

Kentucky Access Road. This road extends from the site of the Kentucky dam near Gilbertsville, Kentucky, to U. S. Highway 68, seven miles away. It is being constructed to provide transportation for labor and visitors to the dam during construction. The traffic will probably be 1200 vehicles per day. The base course is 6 in. thick, with a bituminous prime and hot bituminous seal coat. The materials of the base are bank gravel, sand, calcium chloride and water. The base was mixed in place with a heavy grader in two layers. It has only recently been finished so there is no record of the maintenance.

Watts Bar Access Road. This road extends from the site of Watts Bar dam to the nearest serviceable road two miles away. It will provide transportation for part of the labor used on the dam, and for supplies to the construction camp. The traffic will be some 800 vehicles per day, including a fair proportion of trucks. The base is of stabilized material 6 in. thick, with a bituminous prime and hot bituminous seal coat added. The materials in this case are gravel, calcium chloride and water. The base was recently completed, and has had no maintenance cost.

A. L. Brown: The Michigan plan for base course construction anticipates the application of a higher type bituminous surface. The final road as designed and as proven by experience, has provided the economical, low maintenance cost type of surface that must be used to keep up with the rapid increase in traffic on the Michigan State highways. If the oil aggregate wearing course is deferred, the gravel road can be treated with a surface application of calcium chloride during the dry periods, which will require a minimum of maintenance for one, two or three years. In some cases it has proved practical to apply a bituminous surface treatment to protect the base for one or

two years, and in this case a prime coat is not used when the oil aggregate is applied.

Summary on Base Stabilization

Moreland: The following benefits are received from the inclusion of calcium chloride in the soil mixture:

1. Greater ease of manipulation, since the mixing water does not evaporate to an inconvenient degree.
2. Greater density and cohesion, resulting in added strength per inch.
3. Insurance against premature drying after completion, with added maintenance costs.
4. An apparent aid to the absorption of bituminous priming materials.

In conclusion, experience has shown that the intelligent use of the accepted criteria and methods for using local materials in a stabilized base will result in real economies on many road projects, and that the addition of the proper quantity of calcium chloride is amply justified by the increased efficiency of the materials used and reduction in maintenance costs during construction.

A. L. Brown: The Michigan State Highway Department, faced with the problem of improving traffic conditions, and of satisfying public complaints; confronted with problems caused by a wide range in maintenance season; faced by a wide change in climatic conditions; forced because of financial conditions to use the available local materials; finding that the increased traffic in industrial areas has made obsolete the recently built hard surfaced roads; can point with pride to the economy and improved conditions resulting from soil-aggregate stabilization with calcium chloride.

ECONOMY OF CALCIUM CHLORIDE IN STABILIZED SURFACE CONSTRUCTION

Many conditions exist where a stabilized surface is by far the most economical type of construction. It should likewise be pointed out that the major portion of all "base" projects serve as surfaces for several years following their construction. Although many of the economic benefits pertaining to bases likewise apply to surfaces, the following section is devoted to economics in the construction of stabilized surfaces as effected by the use of calcium chloride.

A. L. Brown: Any procedure that tends toward saving of material and decreasing of maintenance costs should warrant our earnest attention. Every $10.00 saved in maintenance on each mile of the 3000 miles of gravel road in Michigan's trunk-line system, a total of $30,000, means enough to place 20 miles of bituminous surface treatment on prepared base stabilization.

Farnsworth: LaSalle County, Illinois has 400 miles of gravel roads. To maintain these roads in the past, twelve motor patrol graders were kept at work at an annual cost of $106 per mile. Added to this was the cost of replacing gravel lost as dust, forced into the subgrade and thrown from the road by traffic. The annual loss of material from our principal gravel roads amounted to 200 cu. yd. per mile, based on our total replacement of material every five years. This gravel cost the county $1.50 per cu. yd. or $300 per mile delivered on the road. The total annual maintenance cost for roads which were dusty during the summer season and unstable in the early spring was, therefore, $406 per mile.

Under our present system of maintenance, blading costs have been considerably reduced. Where the principal gravel

roads had to be bladed at least once or twice each week, these roads, stabilized and maintained with calcium chloride, now require blading on an average of only once each month. This means that each patrolman can now maintain a greater mileage of roads and otherwise devote former blading time to other maintenance work.

The replacement of gravel formerly lost has not been measurable and we well feel that this is no longer an important factor with the dust kept in the road as a binder by the moisture supplied through calcium chloride and with a tight surface resulting with no loose gravel.

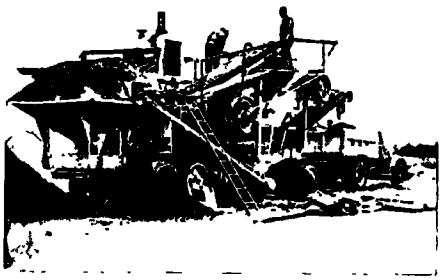

Figure 2. A plant arrangement for preparing stabilized mixtures. LaSalle County, Illinois

With the use of stable gravel maintained with calcium chloride we have almost eliminated the gravel loss, and estimate a 50 per cent saving in blading costs.

The cost of our annual calcium chloride treatment, at 10 tons per mile, is $265 which is actually paid for by the savings in gravel replacements and decreased blade maintenance. We also are realizing other advantages gained by this type of surface which are not directly measurable in dollars and cents, such as increased safety, health and public satisfaction.

Whitton: In the summer and fall of 1938, the success of nearby state highway departments with the use of calcium chloride on surface-stabilized clay-aggregate roads was noted, and it was then decided to do some experimenting along the same lines in Missouri. Three widely separated sections surfaced with loose aggregate, and representative of the different conditions encountered in Missouri were selected for the clay-aggregate surface stabilization experiments using calcium chloride on the surface.

The first section is located on State Route 4 in Gentry County in northwest Missouri, and is 6.1 miles in length. This section was selected because it was the only gravel surfaced section on this route for a considerable distance in either direction; and since the average daily traffic count was approximately 250 vehicles, the surface became very dusty and rough during the summer months. The reconstructed stabilized section was composed of existing loose roadway gravel, together with binder soil from the roadway ditches, moisture and calcium chloride, compacted by traffic to a thickness of approximately 4 in.

The second experimental section 4.6 miles in length, is located on State Route 20 in Saline County in west central Missouri, and is a portion of a 29-mile section of crushed stone surface. This section was selected because of the exorbitant crushed stone replacement cost and, also because of the extremely dusty condition of the road at certain periods of the year. The crushed stone replacement cost on this particular section of road for the past four years has been $510 per mile per year, while the average replacement cost for this territory, as a whole, has been $135 per mile per year. The average daily traffic is approximately 200 vehicles. The reconstructed stabilized section consists of crushed limestone mixed with subgrade binder soil of the Marshall soil series, together with moisture and calcium chloride. Following thorough mixing with a Seaman Soil

Tiller and spreading with motor graders, the completed roadway was compacted by traffic.

The third section is located on State Route 53 in Dunklin County in the extreme southeast portion of Missouri, and was selected because of the extremely rough surface conditions which prevailed through the summer months. This condition was caused primarily by the sandy condition of the soil and the lack of proper binder and moisture. During the spring when sand storms occur, sand drifts in from the fields, filling up the ditches and adding additional fines to the surfacing material on the roadway. During the past few years both quantity and speed of traffic have increased very materially, thus resulting in additional difficulties in maintaining a smooth riding surface. The surface of the roadway would become very corrugated, full of pot holes and extremely dusty during dry periods of the year. The average daily traffic on this section is now approximately 150 vehicles. The reconstructed stabilized section consists of added binder soil, roadway gravel free of oversize material, calcium chloride and moisture; which, following thorough mixing, was compacted by traffic.

Considering the three projects as a whole, it is felt that the first year's results have been satisfactory. The dust nuisance has been eliminated entirely on the latter two sections and to a great extent on the first section, and it has been possible to maintain a much smoother surface than had been possible in the past on these sections through the dry periods. Comments from the public have been highly complimentary. Results also seem to justify the continuation of the experiments of these particular sections in order to arrive at more definite conclusions, from an economical as well as a physical viewpoint, based on observations made over a longer period of time.

Abercrombie: The use of calcium chloride stabilization is comparatively new in Georgia. During the late summer of 1937 a two mile experimental section was built, after which, during 1938, three Federal Aid projects were constructed. Two of these latter projects consisted of pebble soil and the third of sand-clay. The typical sections were 19 ft. wide by 6 in. compacted depth. We have been studying two of these projects with respect to soil loss and to date have made two readings. The first reading was made within two months after the projects were finished and the second reading about six months later. These readings showed practically no loss; however, it is felt the time interval is too short to give conclusive results.

F. L. Brown: In Washington County, New York, the normal program of gravel road maintenance in the past has been to patrol the gravel roads with power driven grader patrols using two units. A simple analysis showed quickly the cost involved.

2 motor patrols at $2.70 per hr., each ..... $43.20 per 8-hr. day
For a normal 5-day week, 7 months season..... $6480.00 per season
Cost per mile per year (on approx. 95 mile basis).... $68.20

This service guaranteed that the roads would be leveled off about once a week, however, it took only a day or two until "washboarding" and other evidence of roughness appeared. In addition, dusty roads were ever present.

The cost of gravel blown off the road is another item of expense which may run as high as 300 cu. yd. per mile per year.

In considering Washington County's program of stabilization it should be noted that roads having gravel surfaces are classified roughly as follows:

1. Well graded surfaces to be paved shortly.

2. Well graded surfaces suitable if stabilized.
3. Poorly graded surfaces to be reconstructed.
4. Poorly graded surfaces, reconstruction not justified.

Groups 1 and 2 deserved the most immediate attention. The use of large quantities of calcium chloride in Group 1 was not thought to be justifiable but Group 2 deserved all possible care. To Groups 1 and 2 enough material was added to allow grading to a parabolic crown from edge of shoulder to edge of shoulder. From 3 to 8 tons per mile of calcium chloride was added. Roads in Group 2 were treated with at least 8 tons per mile, after which rolling was initiated and continued until consolidation was effected. No water was added; natural rains were depended upon to maintain the moisture ratio at the optimum amount at the time of application of calcium chloride. To Group 3 calcium chloride was applied only as a dust layer. An attempt was made with Group 4 to remove high shoulders and establish adequate drainage before gravel was added to construct a suitable crown. Immediately thereafter the roads were treated similarly to Groups 1 and 2.

The economy of this program is illustrated in Table 1, which may be best emphasized when it is noted that in 1939, the second year of the program, blading and graveling costs were cut in half. In addition to this, a dustless, smooth road serves the farmer to his better satisfaction, while he awaits the day of the hard surfacing of his road.

Summary on Surface Stabilization

A. L. Brown: We have saved the loss of wearing material from the road surface and eliminated a large part of costly hand patching. We have greatly reduced the need for costly blading. And we have lowered the traffic count on the main highways by diverting traffic to the secondary roads where the motorist can now travel in safety and comfort.

Indirect economic results as obtained for our motorists are:

1. Increase of safety and prevention of accidents by eliminating dust and loose material hazards.
2. Financial and health saving to property owners adjacent to the road.
3. Saving on the upkeep of automobiles through improved stabilized roads.
4. Early lifting of weight restrictions.

Farnsworth: The program of LaSalle County has proved satisfactory and we

TABLE 1 (F. L. BROWN)
COST OF GRAVEL ROAD MAINTENANCE

	1934	1935*	1936*	1937	1938	1939
Blading cost per mile per year	81.50	40.50	48.50	79 00	54.50	38.20
Gravel replacement per mile per year	136.00	55.50	84.80	168.00	87.50	36.10
Calcium chloride treatment per mile per year	.....	.....	.....	.....	128.00	79 50
Total	217.50	96.00	133.30	247.00	270.00	153.80

* The slump occurring in 1935 and 1936 was the result of an economy move by the Board of Supervisors who reduced greatly all normal appropriations and devoted much of the year's program to work relief. The normal program was resumed in 1937.

have increased the original 21.5 miles constructed in 1937 to approximately 70 miles of stabilized calcium chloride roads and we plan to add to this mileage each

Figure 3. An inexpensive method of securing uniform distribution, of stabilized mixture. LaSalle County, Illinois.

year. Thus we feel that we are accomplishing our original purpose; to develop a highway system that is economically sound, spreading improved highway benefits over a large area and yet maintaining them with our present maintenance budget.

F. L. Brown: The conclusions to be drawn from our program may be summarized as:

1. Calcium chloride stabilization will give to properly graded gravel roads a smooth, hard, dustless surface.
2. Calcium chloride stabilized roads will reduce normal maintenance costs for this class of road.
3. There is a distinct reduction in blading and gravel replacement costs after stabilization. Before stabilization the cost of blading ran about $68.20 per mile per year. This was reduced so that graders were in use on maintenance for less than half the working season, freeing these machines for construction operations.