SOIL CONTROL IN CONSOLIDATED MAINTENANCE

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SYNOPSIS

The Michigan State Highway Department uses a uniform maintenance procedure for the consolidation of loose floating cover on the gravel trunkline system, based on the economical use of local aggregates and binder soils. In some cases specialized equipment had to be designed before it was possible to secure or maintain smooth riding road surfaces free from the hazards of dust, loose gravel or slipperiness caused by improper applications of clay binder soil.

The development of a uniform system of regional maintenance requires knowledge and use of the following factors: (1) The location of sources of local materials normally used in stabilized aggregate mixtures (2) A simplified method of design which permits uniform application of binder soil or corrections in the gradings of loose surfacing materials which result from winter maintenance operations (3) Aggregate specifications flexible enough to permit the use of the better grades of material occurring in the vicinity of the road system yet rigid enough to insure the production of uniformly graded aggregates for road use. (4) Centralized control for maintenance operations with periodic field checks from the central control point to enforce the instructions issued to the various sections of the State.

These items are discussed in detail. The background on which the Michigan method was developed is presented to aid other States contemplating surface consolidation Although the maintenance procedure has been presented for Michigan climate and materials, the findings can be modified to secure a centralized control for the use of binder soil in consolidated surfaces.

Before briefly discussing the Michigan practice of using binder soil for uniform consolidation of gravel road surfaces it is necessary to furnish a background of the information accumulated prior to adopting a direct control of maintenance from a central control point. This basic information is necessary before regional maintenance can be planned systematically for a 2,161 mile gravel trunkline system.

MATERIAL INVENTORIES

A comprehensive survey has been made for most of the local materials used for stabilized gravel road surfaces. Over 1,500 separate sources of aggregates have been catalogued under code numbers, cross-indexed with legal descriptions, owner's names and laboratory test data. The code numbers consist of the county number accompanied by a number which designates the order in which the sources were located in each county. The assigned number designates the source, and any information concerning production, grading or other physical characteristics is filed under pit number. In a similar manner over 800 of the sources of binder soils used for surface consolidation have been catalogued and cross-indexed using a numerical designation of sources.

Both material inventories have been tabulated and copies distributed to contractors preparing aggregates by portable crushing and screening plants. Copies are also furnished the engineers controlling maintenance operations in each district These inventories are supplemented by errata and addenda at periodic intervals depending upon the number of new sources found by the contractors or soils engineers. Usually new sources are located in areas where the existing supplies are depleted or lacking.

This accumulated information enables the central office economically to secure local materials for all sections of the state since the contractors furnishing materials from local sources have detailed knowl-

edge of local deposits and are more apt to bid on each gravel contract. In addition to the lower cost possible through competitive bidding, the state engineers have considerable design data available for each source of material.

Figure 1. Distribution of Local Binder Soil Deposits, 1941

Figure 2. Distribution of Local Aggregate Deposits, 1941

Figures 1 and 2 show the approximate locations of materials used in Michigan for surface consolidation. In the northern part of the State the local pits are usually in close proximity to the gravel trunklines. It has been found economical to spend maintenance funds for the initial location and testing of material deposits in areas which lack suitable materials for stabilization. Deposits located nearer to the point of use will furnish materials at a lower cost to the State. Over a period of years the savings from this fact alone more than pay for the cost of locating the materials.

The Testing Division has developed a detailed map showing local deposits and test results grouped within certain limits by means of colored pins. This information is used to set up specifications to secure materials from all parts of the state. This practice permits the use of the local supply of aggregates and binder soil and reduces the initial cost of maintenance materials through the reduction in the distance of haul.

SPECIFICATIONS

The essential purpose of specifications for the maintenance of low cost surfaces is to secure uniformly graded materials for correcting deficiencies in grading which have been caused by traffic wear or loss from winter snow plowing when the roads are not treated with binder soil. Normal maintenance operations during stabilization with binder soil will not permit applications to be made during winter maintenance, consequently there is a gradual loss of soil fines as well as disintegration of soft stones into sand and silt. This behavior of the surfaces during the winter results in a loose cover of surface aggregate in the spring which is high in sand and low in clay and silt.

A special grading specification is used for initial spring maintenance material that is low in sand and high in stone (retained on No. 10 sieve). A blend of one part of this material with one part of surface material will furnish two parts of aggregate which is ideal for stabilizing with binder soil.

Table 1 indicates the grading specifications (Col. 1) for spring breakup maintenance aggregate, the grading limits (Col. 2) for loose surface aggregate resulting from the loss of fines by traffic during maintenance, the grading limits (Col. 3) of a 50-50 blend of these two materials and the grading limit for stabilized mixtures desired for summer maintenance. Columns 3 and 4 show that the blend requires only an addition of binder soil to produce ideal materials for surface consolidation.

The abrasion limits for maintenance aggregates are specified for particular sections of the State to permit the economical use of local aggregates in preparing spring breakup maintenance aggregates. The fraction passing the No. 200 sieve is restricted to less than 10 percent to eliminate undesirable soil fines but provision has been made to increase this fraction to 15 percent provided the soil fines have a desirable plasticity index

TABLE 1

Sieve size	(1) Specification for spring maintenance	(2) Grading limits of surface materials in the spring	(3) 50–50 blend of (1) and (2)	(4) Desired limits for summer maintenance
	% passing	% passing	% passing	% passing
¾-in.	100	100	100	100
⅜-in.	60 – 80	76 – 96	68 – 88	60 – 85
No. 10	20 – 35	54 – 69	37 – 52	40 – 55
No. 40	16[a]– 26[a]	30 – 40	23 – 33	20 – 35
No. 200	0 – 10	6 – 12	3 – 11	5 – 20

[a] Limits specified based on data from normal gravel plant operations.

DETERMINATION OF QUANTITY OF SOIL FINES

The percentage of soil fines required for summer maintenance is controlled by the plasticity index specified for the stabilized aggregate mixture The exact quantity of binder soil added depends upon the grading and physical properties of the final blending of surface aggregates in the windrows along each side of the road; the grading and physical characteristics of the binder soil; and the plasticity desired in the final stabilized mixture.

Tables 2, 3 and 4 are used to determine the percentages of various types of binder soil to add to secure the desired plasticity index in the final mixture. The percentage of binder soil added is based on the weights of the windrows of loose aggregates on the road surface. The weights of loose aggregates are determined by the measurements of the windrows at frequent intervals to obtain the average cross sectional area in square feet from which the cubic yards of loose gravel per mile can be computed. The quantity of binder soil in cubic yards per mile required for proper stabilization can be determined by using conversion factors based on the weights of aggregates and binder soil.

EXAMPLE

USE OF DESIGN CHART FOR STABILIZATION OF LOOSE FLOATING COVER

Given:

Windrow Gravel
- Passing No. 40—28%
- Passing No 200—12%
- Plastic Index—3

Binder Soil
- Passing No. 40—99%
- Passing No. 200—80%
- Plastic Index—16

From Table 4, the mix must have less than 15% passing the No. 200 sieve, 100 — 99 = 1% of binder soil retained on No. 40 sieve; from Table 3, R = 1 01.

TABLE 2

Design Chart for Stabilization of Loose Floating Cover

Conversion Factor (K) for Various Mix and Windrow Plasticity Indexes for 10 to 40 P. I. Binder Soils

P I. of binder soil	Desired plasticity of mix																												
	P I = 7							P I = 6						P I = 5					P I = 4				P. I = 3			P I = 2		PI=1
	Windrow P. I							Windrow P I						Windrow P I.					Windrow P I				Windrow P I			W P I		WPI
	0	1	2	3	4	5	6	0	1	2	3	4	5	0	1	2	3	4	0	1	2	3	0	1	2	0	1	0
10	2 33	2 00	1 67	1 33	1 00	0 67	0 33	1 50	1 25	1 00	0 75	0 50	0 25	1 00	0 80	0 60	0 40	0 20	0 67	0 50	0 33	0 17	0 43	0 29	0 14	0 25	0 13	0 11
11	1 75	1 50	1 25	1 00	0 75	0.50	0 25	1 20	1 00	0 80	0 60	0 40	0 20	0 84	0 67	0 50	0.33	0 17	0 57	0.43	0.29	0 14	0 38	0 25	0 13	0 22	0 11	0.10
12	1 40	1 20	1 00	0 80	0 60	0 40	0 20	1 00	0 84	0 67	0 50	0 33	0 17	0 72	0 57	0 43	0 29	0 14	0 50	0 38	0 25	0 13	0 33	0 22	0 11	0 20	0 10	0.09
13	1 17	1 00	0 84	0 67	0 50	0 33	0 17	0 86	0 72	0 57	0 43	0 29	0 14	0 63	0 50	0 38	0 25	0 13	0 44	0.33	0.22	0 11	0 30	0 20	0 10	0 18	0 09	0 08
14	1 00	0 86	0 72	0 57	0 43	0 29	0 14	0 75	0 63	0 50	0 38	0 25	0 13	0 56	0 44	0 33	0 22	0 11	0 40	0 30	0 20	0 10	0.27	0 18	0 09	0 17	0.08	0 08
15	0 88	0 75	0 63	0 50	0 38	0 25	0 13	0 67	0 56	0 44	0 33	0 22	0 11	0 50	0 40	0 30	0 20	0 10	0 36	0.27	0 18	0 09	0 25	0 17	0 08	0 15	0.08	0.07
16	0 78	0 67	0 56	0 44	0 33	0 22	0 11	0 60	0 50	0 40	0 30	0 20	0 10	0 46	0 36	0 27	0 18	0 09	0 33	0 25	0.17	0 08	0 23	0 15	0 08	0 14	0 07	0 07
17	0 70	0 60	0 50	0 40	0 30	0 20	0 10	0 55	0 46	0 36	0 27	0 18	0 09	0 42	0 33	0 25	0 17	0 08	0 31	0 23	0 15	0 08	0 21	0 14	0 07	0 13	0.07	0 06
18	0 64	0 55	0 46	0 36	0 27	0 18	0 09	0 50	0 42	0 33	0 25	0 17	0 08	0 39	0 31	0 23	0 15	0 08	0 29	0 21	0.14	0 07	0 20	0 13	0 07	0 13	0 06	0 06
19	0 58	0 50	0 42	0 33	0 25	0 17	0 08	0 46	0 39	0 31	0 23	0 15	0 08	0 36	0 29	0 21	0 14	0 07	0 27	0 20	0 13	0 07	0.19	0 13	0 06	0 12	0 06	0 06
20	.0 54	0 46	0 39	0 31	0.23	0 15	0 08	0 43	0 36	0 29	0 21	0 14	0 07	0 33	0 27	0 20	0.13	0 07	0 25	0 19	0 13	0 06	0.18	0 12	0 06	0 11	0.06	0.05
21	0 50	0 43	0 36	0 29	0 21	0 14	0 07	0 40	0 33	0 27	0 20	0 13	0 07	0 31	0 25	0 19	0 13	0 06	0 24	0 18	0 12	0 06	0 17	0 11	0 06	0 11	0 05	0 05
22	0 47	0 40	0 33	0 27	0 20	0.13	0 07	0 38	0 31	0 25	0 19	0 13	0 06	0 29	0 24	0 18	0 12	0 06	0 22	0 17	0 11	0 06	0 16	0 11	0 05	0 10	0 05	0 05
23	0.44	0 38	0 31	0 25	0 19	0 13	0 06	0 35	0 29	0 24	0 18	0 12	0 06	0 28	0 22	0 17	0 11	0 06	0 21	0.16	0 11	0 05	0 15	0 10	0 05	0 10	0 05	0 05
24	0 41	0 35	0 29	0 24	0 18	0 12	0 06	0 33	0 28	0 22	0 17	0 12	0 06	0 27	0 21	0 16	0 11	0 05	0 20	0 15	0 10	0 05	0 14	0 10	0 05	0 09	0 05	0 04
25	0 39	0.33	0 28	0 22	0 17	0 11	0 06	0 32	0 27	0 21	0 16	0 11	0 05	0 25	0 20	0 15	0 10	0 05	0 19	0 14	0-10	0 05	0 14	0 09	0 05	0 09	0 04	0 04
26	0 37	0 32	0 27	0.21	0 16	0 11	0 05	0 30	0 25	0 20	0 15	0 10	0 05	0 24	0 19	0 14	0 10	0 05	0 18	0 14	0 09	0 05	0 13	0 09	0 04	0 08	0 04	0 04
27	0 35	0 30	0 25	0 20	0 15	0 10	0 05	0 29	0 24	0 19	0 14	0 10	0 05	0 23	0 18	0 14	0 09	0 05	0 17	0 13	0 09	0 04	0 13	0 08	0 04	0 08	0 04	0 04
28	0 33	0 29	0 24	0 19	0 14	0 10	0 05	0 27	0 23	0 18	0 14	0 09	0 05	0 22	0 17	0 13	0 09	0 04	0 17	0 13	0 08	0 04	0 12	0 08	0 04	0 08	0 04	0 04
29	0.32	0 27	0 23	0 18	0 14	0 09	0 05	0 26	0 22	0 17	0 13	0 09	0 04	0 21	0 17	0 13	0 08	0 04	0 16	0 12	0 08	0 04	0 12	0 08	0 04	0 07	0 04	0 04
30	0 31	0 26	0 22	0 17	0 13	0 09	0 04	0 25	0 21	0 17	0 13	0 08	0 04	0 20	0 16	0 12	0 08	0 04	0 15	0 12	0 08	0 04	0 11	0 07	0 04	0 07	0 04	0 04
31	0 29	0.25	0 21	0 17	0.13	0 08	0 04	0 24	0 20	0 16	0 12	0 08	0 04	0 19	0 15	0 12	0 08	0 04	0 15	0 11	0 07	0 04	0 11	0 07	0 04	0 07	0 04	0 03
32	0 28	0 24	0 20	0 16	0 12	0 08	0 04	0 23	0 19	0 15	0 12	0 08	0 04	0 19	0 15	0 11	0 07	0 04	0 14	0.11	0 07	0 04	0 10	0 07	0 04	0 07	0 03	0.03
33	0 27	0 23	0 19	0.15	0.12	0 08	0.04	0 22	0 19	0 15	0 11	0 07	0 04	0 18	0 14	0 11	0 07	0 04	0 14	0.10	0 07	0 04	0 10	0 07	0 03	0 07	0 03	0 03
34	0 26	0 22	0.19	0.15	0.11	0 07	0 04	0.21	0 18	0 14	0 11	0 07	0 04	0 17	0 14	0 10	0 07	0 04	0.13	0 10	0 07	0 03	0 10	0 07	0 03	0 06	0 03	0.03
35	0 25	0 21	0 18	0.14	0.11	0 07	0 04	0.21	0.17	0 14	0 10	0 07	0.04	0 17	0 13	0.10	0 07	0 03	0 13	0 10	0 07	0 03	0 09	0 06	0 03	0 06	0 03	0.03
36	0.24	0.21	0.17	0 14	0.10	0 07	0.04	0 20	0 17	0 13	0 10	0 07	0 03	0 16	0 13	0 10	0.07	0 03	0 13	0 09	0 06	0 03	0 09	0 06	0 03	0 06	0 03	0 03
37	0 23	0 20	0 17	0 13	0.10	0 07	0.03	0 19	0 16	0 13	0 10	0 07	0 03	0 16	0 13	0 09	0 06	0 03	0 12	0 09	0 06	0 03	0 09	0 06	0 03	0 06	0 03	0 03
38	0 23	0 19	0 16	0 13	0 10	0 07	0 03	0 19	0 16	0 13	0 09	0 06	0 03	0 15	0 12	0 09	0 06	0 03	0 12	0 09	0 06	0 03	0 09	0 06	0 03	0 06	0 03	0 03
39	0 22	0.19	0 16	0 13	0 09	0 06	0 03	0 18	0 15	0 12	0 09	0 06	0 03	0 15	0 12	0 09	0 06	0 03	0 11	0 09	0 06	0 03	0 08	0 06	0 03	0 05	0 03	0 03
40	0 21	0.18	0 15	0 12	0 09	0 06	0 03	0 18	0 15	0 12	0 09	0 06	0 03	0 14	0 11	0 09	0 06	0 03	0 11	0 08	0 06	0 03	0 08	0 05	0 03	0 05	0 03	0.03

Binder soil to be added (%) = KR × % of material in windrow passing No 40 sieve For values of R see Table 3

From Table 2, for binder soil of P. I. 16, desired mix P. I. 5, windrow P. I. 3, the correction factor K = 0.18.

Binder soil to add = K R × % in windrow passing No 40 sieve = 0.18 × 1.01 × 28 = 5%.

Blend equals 0 95 from windrow + 0.05 binder soil.

Passing No. 40 = 0 95 × 28 + 0.05 × 99 = 27 + 5 = 32%.

Passing No. 200 = 0.95 × 12 + 0 05 × 80 = 11 + 4 = 15%.

Ratio, per cent passing No. 200 to per cent passing No 40 in Blend = $\frac{15}{32}$ = 0.47.

The analysis of windrow gradations, the computation of aggregate blends and the determination of the required amount of binder soil and the texture classification of the subgrades are determined by the soils engineers in the field for each maintenance project. Figure 3 shows how the windrows are prepared for measurement and selection of samples for grading analysis.

After the design quantities of aggregate and binder soil have been determined by the soils engineer the normal maintenance operation is followed during mixing, shaping, and consolidating the road surfaces.

MAINTENANCE OPERATIONS

As previously stated, uniform maintenance requires centralized control in the issuance of instructions and type of equipment best suited for maintenance operations. The information may be issued to the base of operations by means of special instruction letters timed to coordinate the various stages of maintenance required during a successful season. The following information has been excerpted from circular letters issued during the past year to coordinate the maintenance of gravel roads:

STATION MARKING

Marker stakes 1 in by 3 in. by 2 ft. should be colored by dipping in maintenance paint. The color of the stakes should coincide with the color scheme shown on the soil survey map (which has been prepared by the soils engineer) as follows: (1) Yellow for sand. (2) Orange for loam (3) Red for clay. (4) White for swamp or muck areas. The station numbers should be burned into the stakes prior to painting.

The properly identified stakes should be located on the right of way at ½ mile intervals A suggested position is near the property fence line. However, the exact location will have to be determined in the field The stake should be driven into the ground, where possible, to a depth of 16 in. The stakes should be numbered consecutively from the P O B. (point of beginning) of gravel sections within a county. The P.O B. shall be the east or the south county line. Each trunkline road shall have assigned consecutive station numbers at ½ mile intervals throughout the entire county. However, only gravel sections require marker stakes A gravel section maintained by one county organization may extend into the adjacent county, or counties and in such cases a new P.O B. will be made at the adjacent county line. These stakes will be numbered in the manner outlined above.

TABLE 3

VALUES OF CORRECTION FACTOR R FOR BINDER SOIL

$$R = 1 + \frac{\%\text{ of Binder Soil Ret. on No 40 Sieve}}{\%\text{ of Binder Soil Pass No 40 Sieve}}$$

Ret No 40 %	R	Ret No 40 %	R	Ret No 40 %	R
0	1 00	8	1 09	16	1 19
1	1 01	9	1 10	17	1 20
2	1 02	10	1 11	18	1 22
3	1 03	11	1 12	19	1 23
4	1 04	12	1 14	20	1 25
5	1 05	13	1 15	21	1 27
6	1 06	14	1 16	22	1 28
7	1 08	15	1 18	23	1 30

TABLE 4

DESIGN DATA

Plasticity index of binders	Recommended mix limits, passing No 200 sieve
10 to 16	14 to 18
16 to 25	12 to 15
Above 25	10 to 12

The ratio of the percentage passing the No. 200 sieve in the stabilized mix to the percentage passing the No. 40 should be less than 0 67.

The grass should be kept trimmed around the stake during routine maintenance operations in order that the stake may be observed from the road. Delineator or guide stakes made from saplings approximately 2 in in diameter may be placed as an aid in locating the station stakes.

body blade trucks (preferably four wheel drive), multiple blade maintainer, water tanks and a York stone rake.

Procedure: Loose material on the road surface should be bladed off the edge of the metal. The center of the road should be scarified deep

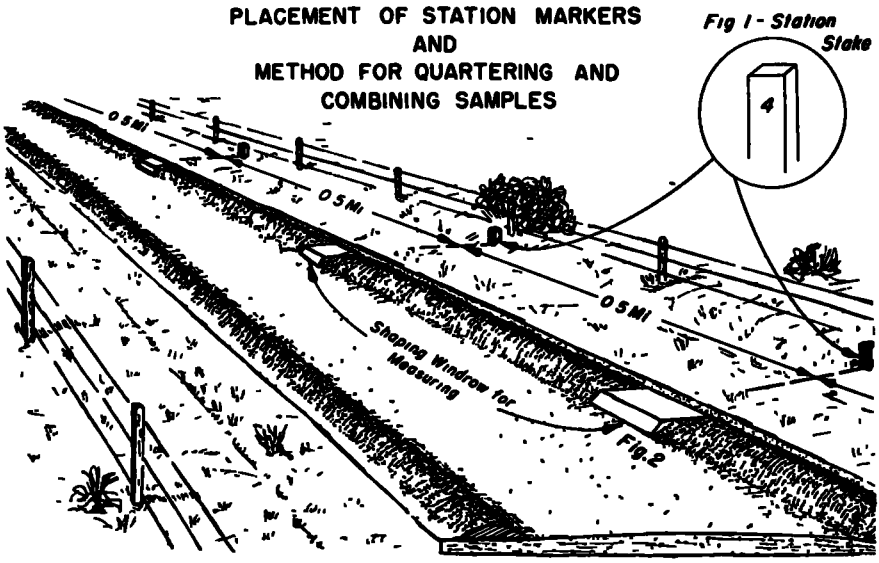

FIG 2. Method for Quartering and Combining Samples.

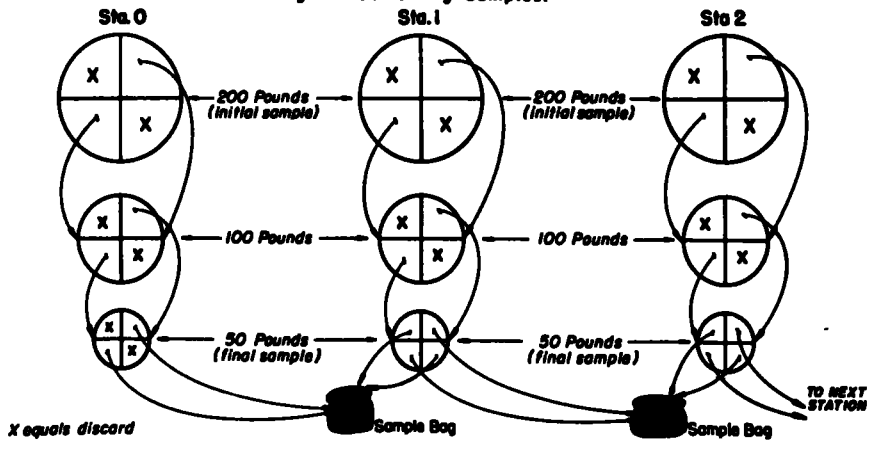

Figure 3

RESHAPING GRAVEL ROADS

Reshaping gravel roads for removal of irregularities or oversize material after the spring breakup or for preparing for resurfacing should follow a definite procedure. Under normal conditions this operation can be accomplished with a power grader equipped with scarifier, underenough to break up the existing metal but never to disturb the subbase. The scarifying should proceed progressively from the centerline toward the sides to the desired width. If the road surface is hard and dry, water should be applied before scarifying. If a stone rake is available, the scarified material should be raked and the

oversize stones removed. If a rake is not available, the oversize stones should be forked out by hand. These stones may be used for filling borrow pits, eroded sections or for widening shoulders. A power grader should then be used to trench out the scarified material and windrow it on the shoulders with the original loose material. Irregularities in the grade or in the alignment of the subbase should be corrected. Small quantities of undesirable subbase or frost heave material should be removed and replaced with suitable borrow material. This repair operation should be limited to the amount which can be torn up and reconditioned during the day. Sufficient clay to insure compaction should be added to the windrows at this time and the material thoroughly mixed. Instructions from this point on are the same as the final steps described under the heading "Stabilization of Gravel Roads."

GRAVEL SURFACING WITH PRE-STABILIZED MATERIAL

The equipment required for this type of maintenance consists of a water tank, underbody blade truck or grader, multiple blade maintainer and, if necessary, light trucks for hauling materials.

The road surface should be properly shaped and prepared with a crown somewhat less than the standard The higher the application rate of prestabilized gravel, the flatter the crown of the subbase. The subbase should be thoroughly soaked and the new prestabilized gravel should then be spread and smoothed by using a power grader and underbody blades to a width of not more than 20 ft. The standard 5-in. crown for a 20-ft. roadway is worked into the new gravel during the shaping operation. Compaction is secured by traffic during the spreading operation. Final finishing should be accomplished with the multiple blade maintainer.

DESIGN OF STABILIZED MIXTURE

Road Mix Method

For the present, the mixture design will be made by the Soils Engineer in accordance with the following requirements: In general, the stabilized mix shall be designed for plasticity indices of 5 over clay base, 6 over loam or muck base, and 7 over a sand base. If the material passing the No. 200 sieve in the computed mix is in excess of the limits specified in Table 5, redesign the mix using a lower plasticity index to lower the amount of binder soil added. If the material passing the No. 200 sieve in the computed mix is less than the limits in Table 5, additional binder soil should be added to the computed amount until the minimum requirement in the table is reached

The Maintenance Engineer should be notified in writing, with a copy to the State Highway Laboratory, in case the fraction passing the No. 200 sieve is greater than two-thirds the fraction passing the No. 40 sieve in the final mix.

STABILIZATION OF GRAVEL ROADS

The equipment required for this operation consists of power graders, underbody blade trucks, water tanks, multiple blade maintainer and a gravel compactor, and a multi-pneumatic-tire roller.

Preliminary Procedure: In both types of stabilization (salt and calcium chloride) the preliminary procedure is similar. The loose material on the surface should be bladed to the shoulders of the road and windrowed If sections of the road require additional gravel, 23-A gravel should be added to the windrows as needed. The necessary percentage of clay, of proper plasticity index, should be determined under the supervision of the soils engineer and should be added to the windrows. The amount of binder soil spread on the windrows should be in proportion to the variation in the amount of loose material. More binder may be added later if necessary since it is much easier to add binder soil than to add aggregate to correct an excess of binder soil in the final mixture. The binder should be allowed to dry thoroughly and should then be pulverized as completely as possible by the use of a gravel compactor, or some other pneumatic tired equipment.

TABLE 5

P. I. Range of binder soils	Passing No 200 sieve limits in stabilized windrow
10 – 16	14 – 18
16 – 25	12 – 15
Above 25	10 – 12

The windrow material should then be bladed away from the ditch line to the edge of the traveled roadway by the use of an underbody blade truck having only the right half section of the blade attached Care should be observed during this operation to avoid blading any of the mixture to the traveled portion of the roadway. The material should then be rebladed toward the outside edge of the shoulder by the use of an underbody blade truck having a full cutting edge. If the windrowed material is too heavy to be handled by a blade truck, the power graders or drawn type graders should be used. The dry mixing should be continued until the

pulverized binder soil has been thoroughly incorporated into the aggregate mixture.

Final Procedure (First Method—Salt): If an admixture of salt is to be used, the salt should be added to the windrow after pulverizing the binder soil at the rate of one ton per mile per inch of depth of stabilization, and thoroughly mixed with the surfacing material by blading. After blading, the mixture is windrowed and stored along each side of the road.

The road surface is thoroughly wetted and any alignment irregularities cut with a power grader or underbody blade unit. The resulting loose material should be distributed evenly over the surface. The windrows of material on the shoulders are bladed back on to the road in ½-in. to 1-in. layers. These layers should be taken alternately from the windrow on each shoulder by means of a power grader followed by a blade truck distributing the material across the full traveled road width. Continuous wetting of the material during manipulation is essential to good compaction, care being taken to avoid exceeding the optimum compaction moisture. In salt stabilization, the final shaping should be done by successive trips with a multiple blade maintainer. This final smoothing should be followed by a surface application of calcium chloride, at the rate of two tons per mile as soon as the surface shows signs of dusting.

Final Procedure (Second Method—Calcium Chloride): If an admixture of calcium chloride is to be used, the windrows of material on the shoulders should be bladed back on to the road in ½-in to 1-in. layers. These layers should be taken alternately from the windrow on each shoulder. This should be done with a power grader followed by a blade truck distributing the material across the full traveled road width. Each layer should be thoroughly wetted to provide good compaction, care being taken not to exceed the optimum compaction moisture.

The calcium chloride should then be spread on the road surface at the rate of 2 tons per mile and thoroughly worked into the top of the metal to a depth of 1 to 2 in by the use of a multiple blade maintainer. Additional calcium chloride, at the rate of 2 tons per mile, should be applied to the finished surface as soon as the surface shows signs of dusting. Water tanks may be required to moisten the surface before making the final application of chloride.

BLADING OF GRAVEL ROADS

Blading During Normal Weather: Any loose accumulation of material which develops on the road surface during dry spells should be brushed by light blading to the side of the road If considerable loose material accumulates on the side of the road, binder soil should be spread, pulverized, and windrowed with the accumulation of floating cover. The quality, type and quantity of binder soil necessary is determined by the soils engineer. Water tank trucks should be available for preparing and compacting this material on the road surface. Previous to spreading and compacting the stabilized mixture, the road surface should be bladed with an underbody blade or grader to remove all irregularities The surface of the road should be sufficiently moistened to permit some cutting. All cutting of the surface should be from the center of the road towards the sides.

The resulting material from this blading is added to the windrow on the roadside. The entire accumulation of material should now be bladed to the road surface and compacted under proper moisture conditions controlled by water tanks. Shaping and finishing operations are carried on with underbody blades and multiple blade maintainers.

Occasionally it is necessary to employ more drastic measures to improve certain sections of road to prevent development of serious ravelling, pot holes, transverse and/or longitudinal ruts, etc. These sections should be repaired in advance of normal road blading by the use of heavy blading and/or scarifying equipment.

Blading During Wet Weather: When light rains occur, sufficient to moisten the road surface, fairly light blading with underbody units from the center of the road toward the sides should be carried out to eliminate chatter bumps, pot holes, and other minor irregularities. After the rain, while the road surface and accumulated material at the side is still moist but not enough to make the road surface muddy or slippery for traffic, the loose material should be bladed back into the road and shaped for proper crown, etc Final blading and finishing should continue with multiple blade maintainers while the surface is compacting under traffic.

When heavy rains occur, sufficient to cause the road surface to become muddy and slippery for traffic, the unstable material on the surface should be bladed to the sides and left there. Do not blade from the outside toward the center of the road while rain continues or when the surface is inundated or extremely wet. As soon as this material has dried enough to recompact, it should be bladed back on to the surface and properly shaped Final blading and finishing should be continued with multiple blade maintainers while the surface is compacting under traffic.

Procedure: The surface consolidated road, like all other types, will give more satisfactory service if it is properly drained The "Modified A" or "Straight Line" crown is most satisfactory. Parabolic type crowns are apt to develop

pot holes along the road center where water will stand after rains. When the center of the blades wears down first, making it difficult to shape a "straight line" crown, the blades should be reversed on the moldboard. Subsequent blading will then cut off the arch in the road crown and wear the blades to a straight line.

The "Modified A" type crown with about one-half inch slope per foot of width, that is, a 5-in. crown on 20 ft. roadway, provides a well drained, smooth surface. Figure 4 shows the type of templet used to check the crowns of gravel roads.

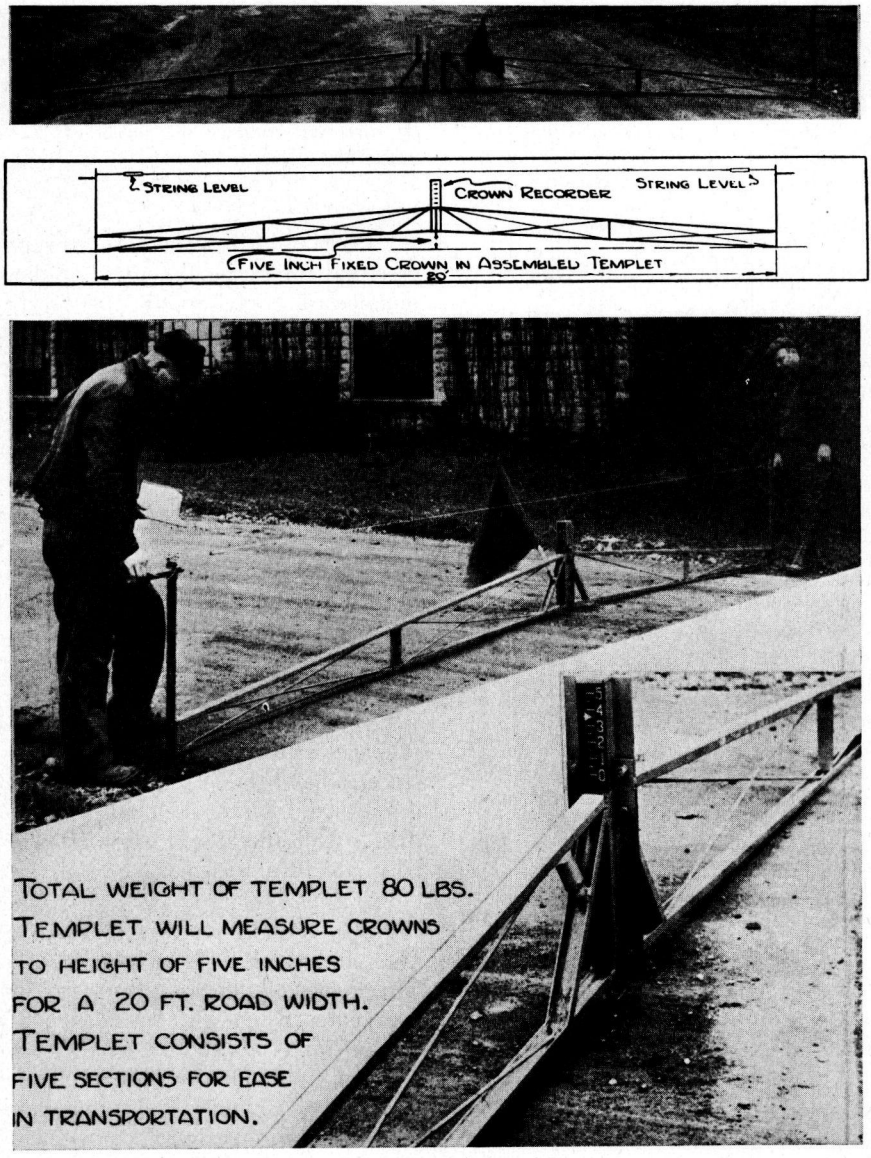

Figure 4. Portable Templet for Measurement of Road Crown

The crown should vary slightly with the grade—being slightly lower on sharp grades and greater on flat grades. Super-elevation on

curves should be maintained as originally constructed Blading culvert and bridge approaches to prevent an irregularity in the shape of the approach requires lifting and reshifting the blade while crossing the structure

Trucks equipped with underbody blade attachments, having curved moldboards, are generally adequate for all routine blading Multiple blade maintainers are best for final smoothing. This maintainer with its several edges and long wheel base should be used only as a finishing tool and only when the surface is moist.

DUST PALLIATIVES

The application of dust palliatives serves two purposes—the elimination of dust and the preservation of the stabilized surface In general, the gravel surface should have been shaped and consolidated prior to the initial applications of dust palliatives However, even if the work as outlined under previous instructions concerning gravel road maintenance has not been completed prior to Decoration Day, a light application of dust palliatives (1 to 2 tons per mile) should be made to allay the dust for the holiday traffic. After Decoration Day, subsequent applications of two tons per mile per month are made throughout the summer season. However, precipitation and volume of traffic have a direct bearing on the quantities used Judgment should be used with respect to areas which have a natural high water table. In these areas lighter applications should be made as the conditions warrant. During dry periods the road should be sprinkled with water to preserve the chloride content and maintain moisture in the road surface This sprinkling should be done at night during periods of low traffic densities.

Procedure for Chloride Application: Road sections should be thoroughly wetted prior to the application of the dust palliative. Loose material that does not consolidate with the metal should be swept to the edge of the traveled roadway. The chloride should be applied by mechanical means in a true and even manner on the traveled portion of the highway. Frequent checks of quantities and length of spread should be made during the process of application to insure uniform application of chlorides.

FALL STABILIZATION

Stabilization work is intended to be performed during the spring and summer months and should be completed by September 1st. Emergency stabilization after this completion date consists of extended disintegration of the stabilized surface with an accumulation (300 tons or more per mile) of loose material which cannot be consolidated with the road surface except by adding binder soil. Small accumulations (300 tons per mile or less of loose material) may be flattened on the shoulder until spring stabilization. In case of a fall emergency, substitute the following modified design of mix: A plasticity index of 3 over clay base and 4 over loam or muck base, and 5 over sand base. This plasticity index requirement reduces the quantity of binder added in the stabilized mixture and reduces the possibility of excess slipperiness during the wet season of the year.

SUMMARY

(1) Standardization of operations is essential for regional control of the maintenance of gravel roads.

(2) By proper use of binder soil traffic hazards such as loose floating cover, dust and slipperiness during wet weather will be avoided.

(3) Aggregates used to compensate for gravel loss should be coarser than the gradation desired in the stabilized mat; i.e., when the loose floating cover is used as a part of the wearing course.

(4) The plasticity index for the wearing course should be varied to compensate for the soil texture found on the gravel road shoulders.

(5) The use of maintenance funds to prepare material inventories is justified since it has been proved that the savings in future maintenance costs will more than offset the initial cost of preparing adequate inventories.

(6) The specifications for maintenance aggregates should stress uniform gradations and be flexible enough in other requirements to permit the use of inferior aggregates whenever it is not economical to haul materials from an outside source. Uniform maintenance operations are possible when materials having uniform gradings are used to compensate for gravel lost by traffic abrasion.

(7) The design of stabilized mixtures should be simplified to the point where it can be readily used in the field to determine the proper application rate of binder soil.

(8) Centralized control of maintenance

operations is necessary when uniform road consolidation is placed on a regional basis.

(9) The crown, for best results, should be of the A type not the parabolic type. The crown should be at least ½ in. per foot or 5 in. in a 20-ft. road width to minimize the amount of pitting caused by traffic during periods of heavy rainfall.

(10) The proper use of dust palliatives will decrease maintenance costs by conserving soil fines and subsequent loss of aggregate from the road surface.

(11) A smooth riding stable surface will reduce the amount of blading required for proper road maintenance.

CONCLUSIONS

Although the maintenance procedure has been presented for Michigan climate and materials, it is felt that the general principles which have been given, will cover problems which are encountered in many other states. Deviation from Michigan standards and specifications are expected, for progress in any locality is made by modifying existing standards or methods to meet specific needs.

The Michigan method of central control may be more rigid and extensive than that used by other states; but experience with both central and local methods for surface consolidation has shown that the quality and performance of the road surface constructed under central control will offset any immediate savings derived from less rigid systems for the control of binder soil in consolidated road surfaces.