EXPERIMENTAL SHOULDER STABILIZATION
US 23 North of Alpena (Mn 04032, C6)
First Progress Report

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Synopsis

This report describes the construction of experimental shoulder sections on US 23 just north of Alpena. Admixtures of sodium chloride, portland cement, asphalt emulsion, and slow curing asphalt were added, in different quantities, to in-place aggregate. The resulting mixtures (with two exceptions) were surfaced with a single seal coat. An untreated area surfaced with a double seal was used for comparative test purposes.

The sodium chloride (salt) sections were the easiest to construct and had the highest densities. Several problems encountered in the asphalt sections slowed construction time.

Preliminary roughometer and Benkelman beam tests were made to evaluate the "as constructed" condition of the test areas. These and other evaluation tests will be continued at periodic intervals until the relative effectiveness of the different treatments is determined.

Economical maintenance of gravel shoulders in a satisfactory condition has long been a problem for highway agencies. Patrol maintenance is time consuming, expensive, and a continuing task. On many major highways, the problem has been solved by bituminous surfacing of aggregate shoulders. In order to determine if a more economical but equally satisfactory method could be developed for improving aggregate shoulders now in place, upgrading their performance, and reducing maintenance operations and costs, a research project involving experimental shoulder construction was established by a memorandum from W. W. McLaughlin, Testing and Research Engineer, dated July 1, 1962, at the request of the Office of Maintenance. The Research Laboratory Division was directed to design the mixtures to be used (with the exception of the asphalt sections), to prepare reports on the project, and to evaluate the sections, for an evaluation of various soil stabilizing materials as applied to gravel shoulders under Michigan's traffic and weathering conditions. All the materials used in the study are readily available, relatively low in price, and have histories of successful use in roadbuilding operations. The project was constructed by the Office of Construction, with Research Laboratory Division personnel coordinating and directing the work.

Project Description

Four stabilizing agents were used on this project: sodium chloride (rock salt), portland cement, asphalt emulsion, and slow curing asphalt. The test areas consisted of the east and west shoulders of a 9.2-mile section of US 23, north of the city limits of Alpena. The width of treatment was 4 ft. The length and layout of each test section is shown in Fig. 1. Quantities of each admixture were varied between opposite

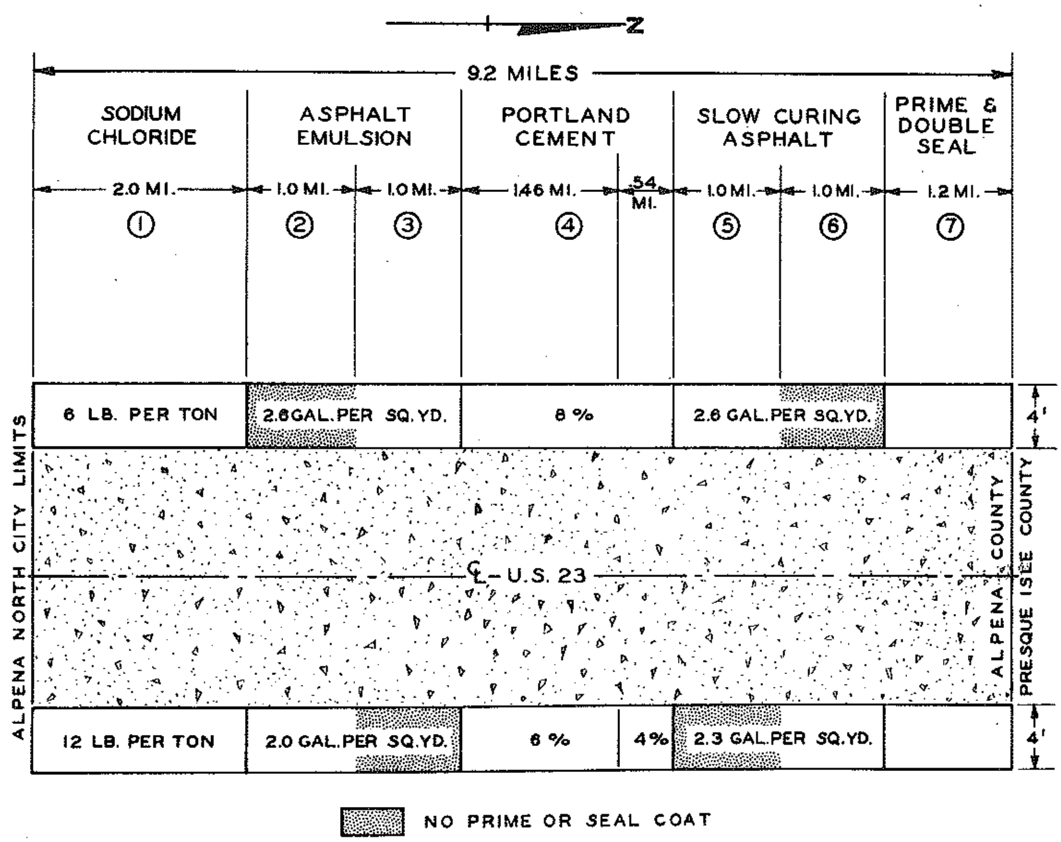


Figure 1. Layout of the test sections.

shoulder sections, and it should be noted that the asphaltic treatments were divided, half of each section receiving no seal coat. A 1.2-mile section of untreated aggregate, surfaced with a double seal coat, was included for comparative purposes. Quantities and costs with general requirements for construction are listed in Table 1.

TABLE 1
CONTRACT COSTS FOR THE TEST SECTIONS

Section No. and Shoulder Type	Quantity and Unit	Item	Unit Price	Net Total Less Tax
	104 Stations	Machine grading	$ 5.00	$ 520.00
	9,386 sq yd	Single-pass machine stabilization	.35	3,285.10
Section 1	14 tons	Sodium Chloride Type 1 (cost plus 10 percent)	13.73	192.22
Sodium	4,081 gal	Bituminous material AE-3 applied	.20	816.20
Chloride	117 tons	Cover material 31-B applied	6.00	702.00
	36 units	Water, 1000-gal per unit	10.00	360.00
	1,363 gal	Bituminous prime coat MC-1 applied	.20	272.60
		Total		6,148.12
	104 Stations	Machine grading	5.00	520.00
Sections 2 & 3	9,386 sq yd	Single-pass machine stabilization	.35	3,285.10
Asphalt	22,333 gal	Asphalt emulsion (cost plus 10 percent)	.169	3,774.28
Emulsion	2,084 gal	Bituminous material AE-3 applied	.20	416.80
	82 tons	Cover material 31-B applied	6.00	492.00
		Total		8,488.18
	104 Stations	Machine grading	5.00	520.00
	9,386 sq yd	Single-pass machine stabilization	.35	3,285.10
Section 4	967 bbl	Portland cement (cost plus 10 percent)	4.90	4,738.30
Portland	3,987 gal	Bituminous material AE-3 applied	.20	797.40
Cement	120 tons	Cover material 31-B applied	6.00	720.00
	53 units	Water, 1000 gal per unit	10.00	530.00
	2,128 gal	Bituminous prime coat MC-1	.20	425.60
		Total		11,016.40
	104 Stations	Machine grading	5.00	520.00
Sections 5 & 6	9,386 sq yd	Single-pass machine stabilization	.35	3,285.10
Slow Curing	23,272 gal	Slow curing asphalt SC-3 (cost plus 10 percent)	.142	3,304.62
Asphalt	2,109 gal	Bituminous material AE-3 applied	.20	421.80
	66 tons	Cover material 31-B applied	6.00	396.00
		Total		7,927.52
	63 Stations	Machine grading	5.00	315.00
Section 7	1,450 gal	Bituminous prime coat MC-1 applied	.20	290.00
Untreated	4,159 gal	Bituminous material AE-3 applied	.20	831.30
Base	70 tons	Cover material 31-B applied	6.00	420.00
	84 tons	Cover material 26-B applied	6.00	504.00
		Total*		2,360.80
		GRAND TOTAL		$35,941.02

* Not including cost of single-pass machine stabilization.

The shoulders to be treated had been in service since 1958 and appeared to be in good condition. However, there was an obvious lack of binder material, causing loose gravel at the surface. A composite grain size analysis of the aggregate (Fig. 2) showed it closely to approximate 23-A specifications. The fines were non-plastic and the gravel contained no chlorides. Thickness of the gravel varied from 3 to 9 in., with 6 in. an approximate average. The subgrade beneath the aggregate varied from a dense fine sand containing small silt pockets, to a dense, uniformly graded medium sand. Most of the subgrade contained numerous boulders up to 1 ft in diameter. In general, the subgrade was stable and appeared adequately drained, although drainage conditions did vary within the test sections. Borings indicated that soil fines from the shoulder aggregate had leached into the sand subgrade.

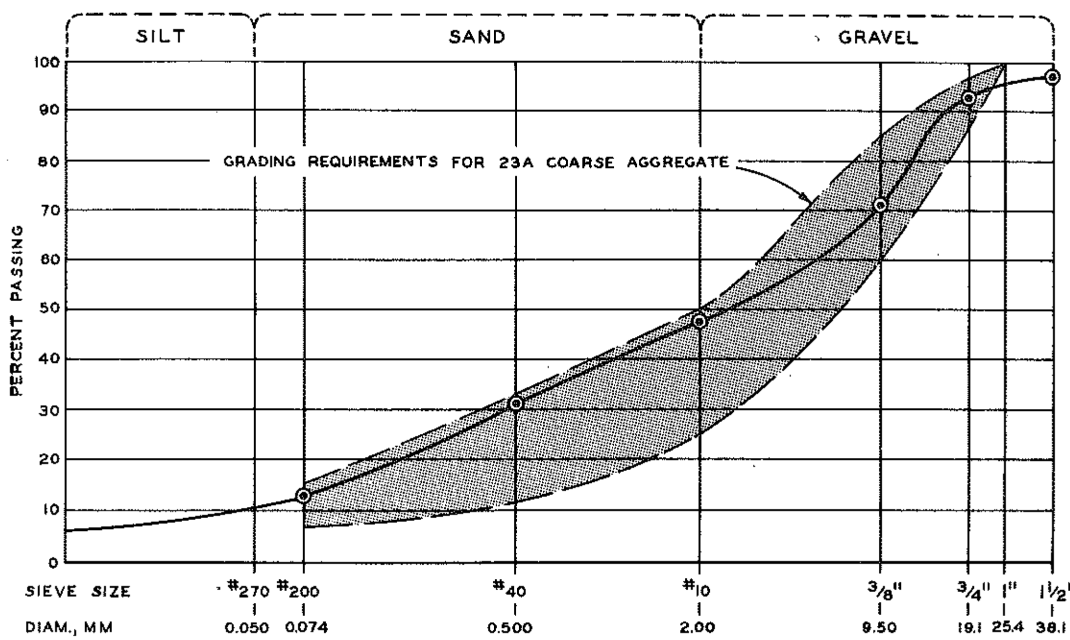


Figure 2. Composite grain size distribution curve for shoulder aggregate.

Physical properties of the surfacing aggregate in each test area are shown in Table 2. In general, there is little significant difference among the materials of each section so that the average values, also shown, should be characteristic of the project as a whole.

TABLE 2
AGGREGATE PHYSICAL PROPERTIES

Section Control Number	Shoulder Type	Grain Size Distribution, cumulative percent passing following sieves							AASHO Textural Classification					T-99 Compaction	
		1-1/2 in.	3/4 in.	3/8 in.	No. 10	No. 40	No. 200	0.005 mm	Gravel	Coarse Sand	Fine Sand	Silt	Clay	Maximum Dry Density, pcf	Optimum Moisture, percent
1	Sodium Chloride	100.0	98.0	75.0	47.3	30.3	12.0	5.9	52.7	17.0	18.3	6.1	5.9	134.3	8.3
2 & 3	Asphalt Emulsion	96.4	93.8	71.0	47.0	30.1	13.2	4.9	53.0	16.9	16.9	8.3	4.9	134.2	7.8
4	Portland Cement	96.1	92.1	69.3	47.6	34.9	17.8	5.2	52.4	12.7	17.1	12.6	5.2	135.0	8.3
5 & 6	Slow Curing Asphalt	96.4	90.8	69.8	46.5	22.1	12.7	4.7	53.5	14.4	19.4	8.0	4.7	134.6	7.4
7	Untreated Base	98.2	94.0	72.6	51.9	38.7	13.2	4.9	48.1	13.2	25.5	8.3	4.9	133.2	7.5
	AVERAGE	97.4	93.7	71.5	48.1	31.2	13.8	5.1	52.0	14.8	19.4	8.7	5.1	134.3	7.8

Equipment Used

The two primary pieces of equipment used in constructing the test sections were the Duo-Stabilizer and Duo-Pactor, manufactured by Seaman Motors of Milwaukee, Wisconsin.

The Duo-Stabilizer (Fig. 3) is a self-propelled combination scarifier, pulverizer, mixer, and liquid distributor which provides preliminary compaction. Separate power plants are provided to propel the equipment, drive the mixing motor, and operate the distributor pump. The scarifier is located at the front and can be adjusted for any desired depth up to 8 in.

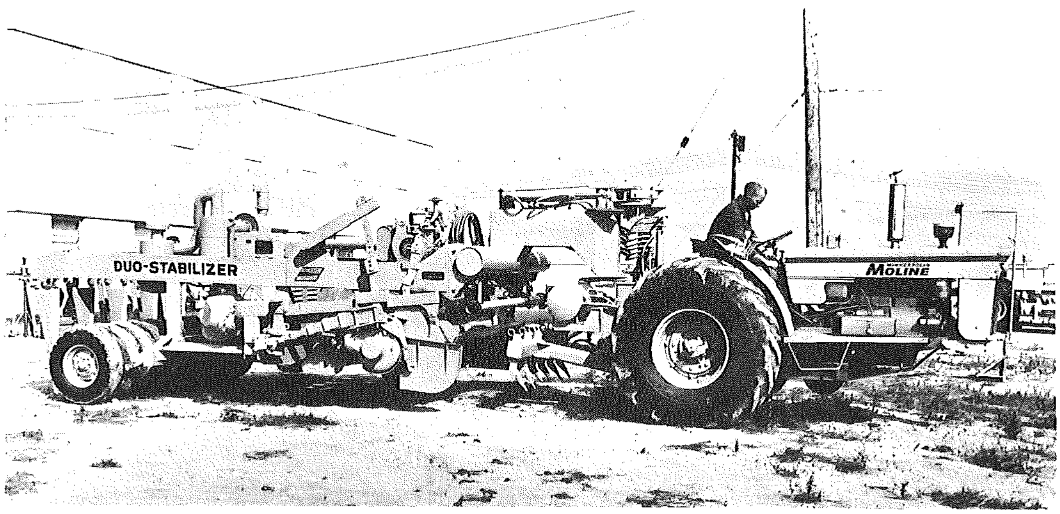


Figure 3. Seaman Duo-Stabilizer.

Just behind the scarifier is the mixing rotor assembly and chamber used for pulverizing and mixing surface materials. The rotor has a positive depth control to insure a uniform depth of mixing through a range of 8 in. The mixing tines can be removed so that any width of surface can be mixed up to a maximum of 7 ft for each pass of the equipment. The hood of the mixing chamber can be raised to aerate or dry out the soil. The spray bar for the distributor is located in front of the rotor assembly with its spray directed ahead of the mixing tines. In this way water or other liquid materials can be added and uniformly mixed with the soil or aggregate. The rate of application can be controlled by the operator. A row of six rubber tires are located at the rear of the Duo-Stabilizer. These are used to pulverize large clay lumps and to provide preliminary compaction to the material being placed.

The Duo-Pactor is a companion piece of equipment to the Duo-Stabilizer and serves as a water wagon and as a rubber tired and steel wheeled compactor. By filling the large ballast tank with water it is possible to obtain a wide range of compactive loads. The rubber tired rollers are closely spaced and can be used to obtain high initial density. The steel rollers can be raised or lowered to provide a smooth finished surface. Water can be added to the surface through a valve-operated spray bar at the rear of the ballast tank. The equipment thus can be used to compact and add water during a pass of the equipment. However, in this case the water is added behind the compacting wheels.

Construction Procedures

All work on this project was conducted in accordance with the 1960 Standard Specifications for Road and Bridge Construction. Except for a grader used for trenching, shaping, and finished grading, all work on these sections was performed by the Duo-Stabilizer and Duo-Pactor. The procedures were not quite the same for the different test sections because of the nature of the additives involved. Construction procedures for each will be discussed separately. The contractor was Yockey Brothers of Alpena, and construction took place in July and August 1962.

Sodium Chloride Sections

As Fig. 1 indicates, two quantities of rock salt were applied: 6 and 12 lb per ton of aggregate. Detailed construction operations were as follows:

1. In-place shoulder material was scarified and mixed by one pass of the Duo-Stabilizer.

2. Bulk salt was uniformly applied to the prepared surface by means of a mechanical fertilizer spreader which could be adjusted to any desired rate of application.

3. Salt was mixed into the aggregate with one pass of the Duo-Stabilizer.

4. Water was added to the mixture with one pass of the Duo-Pactor.

5. A second mixing pass was made with the Duo-Stabilizer, which improved the mix.

6. Moisture content was brought to the desired optimum with a second pass of the Duo-Pactor.

7. A third mixing pass was made with the Duo-Stabilizer, which improved the mixture slightly.

8. Shoulders were compacted by the Duo-Pactor fully loaded with water.

During this test it was found (as in previous work on M 46 near Newaygo) that salt and aggregate mixtures compacted most readily at moisture contents about 2 percent below laboratory optimum (T-99), so water application was adjusted accordingly. Field observation and laboratory tests indicated that three passes of the Duo-Stabilizer gave optimum uniformity of mixture.

Densities were high and could be easily obtained, partly due to the moisture retention characteristics of the salt. No curing time was required for the salt-aggregate mixture, and this type of construction can be handled in practically the same way as normal aggregate base construction.

Portland Cement Sections

Originally two different quantities of portland cement were to be used, 6 and 8 percent by weight, but later it was decided also to study a 4 percent by weight treatment. Fig. 1 shows the location of these sections.

Construction procedures were as follows:

1. In-place shoulder material was scarified and mixed by a single pass of the Duo-Stabilizer and moistened by one pass of the Duo-Pactor.

2. Bagged portland cement was spotted along the shoulder in the required quantity, broken open, and hand spread as uniformly as possible over the surface (Fig. 4).

3. The aggregate and cement were mixed to a depth of 6 in. by the Duo-Stabilizer using one, two, or three passes. This preliminary mixing varied, depending upon the availability of the water wagon. In its absence, mixing was continued (Fig. 5). Due to preliminary moisture application there was very little dusting during this operation.

4. Water was added by the Duo-Pactor to bring the moisture content to the desired amount. The mixture handled best when the moisture was 1 or 2 percent above optimum. The Duo-Stabilizer continued mixing operations during the addition of water.

5. The soil-cement mixture was trenched away from the edge of the concrete road with a motor grader and replaced during subsequent mixing. This was done to assure well-mixed soil-cement immediately in contact with the edge of the metal.

6. The surface was shaped and compacted with the Duo-Pactor until at least 95-percent T-99 density was attained.

7. The surface was kept moist until primed by adding water from the Duo-Pactor to the finished surface.

No particular problems were encountered during this portion of the construction. At least three passes of the Duo-Stabilizer were required to obtain uniform mixing for any given condition. More passes were made if the Duo-Stabilizer was available while waiting for the return of the water wagon.

Due to the setting action of soil-cement, density tests must be made before the mixture hardens. Sufficient time, therefore, should be allowed if additional compaction should be thought necessary. Once soil-cement hardens, the density must be accepted as it is or the section torn out and replaced. The surface of the soil-cement must be kept moist until primed to allow proper curing.

The portland cement sections were in good shape at the time of sealing. However, as shown in Fig. 6, there were many loose stones on the surface at this time. Fig. 7 shows a general view of the 6-percent soil-cement section after two days of moist curing.

Asphalt Sections

Two forms of asphalt were used on this project: asphalt emulsion (AE-3) and a slow curing asphalt (SC-3). Because construction procedures and the problems encountered were generally the same for all the asphalt sections the two types may be discussed together. The asphalt sections proved to be much more difficult to construct than were those with the dry additives (salt and portland cement). Much of the difficulty was caused by poor quantity control of the asphalt application, balling and segregation

Figure 4. Placing bagged portland cement.

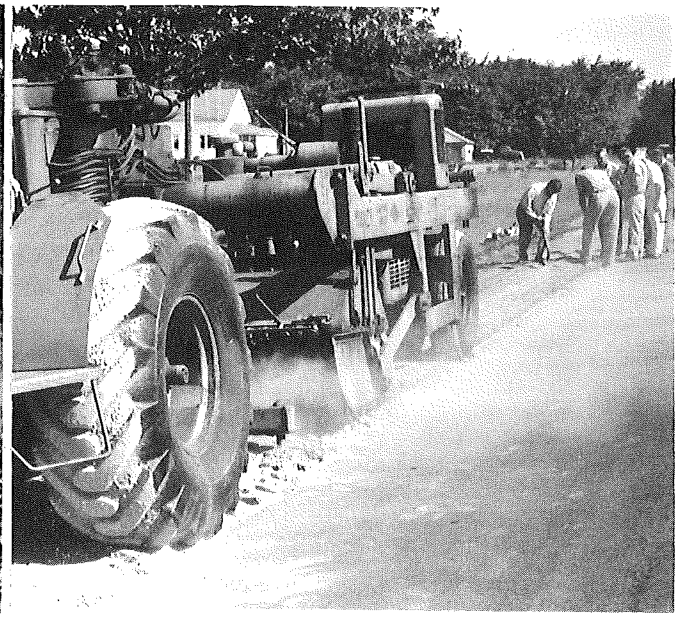


Figure 5. Dry-mixing a soil cement section.

Figure 6. Loose condition of soil cement surface before sealing. Note presence of stones.

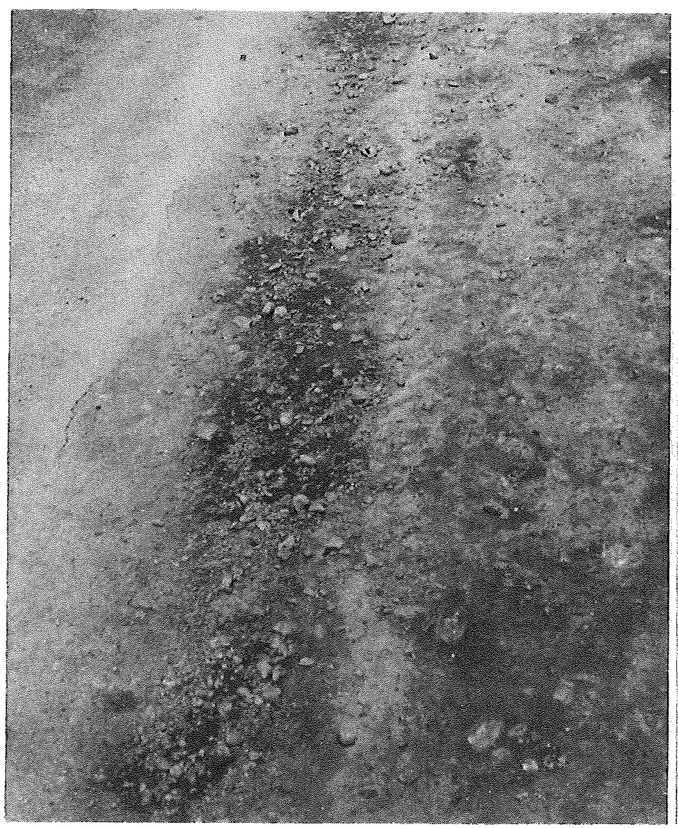
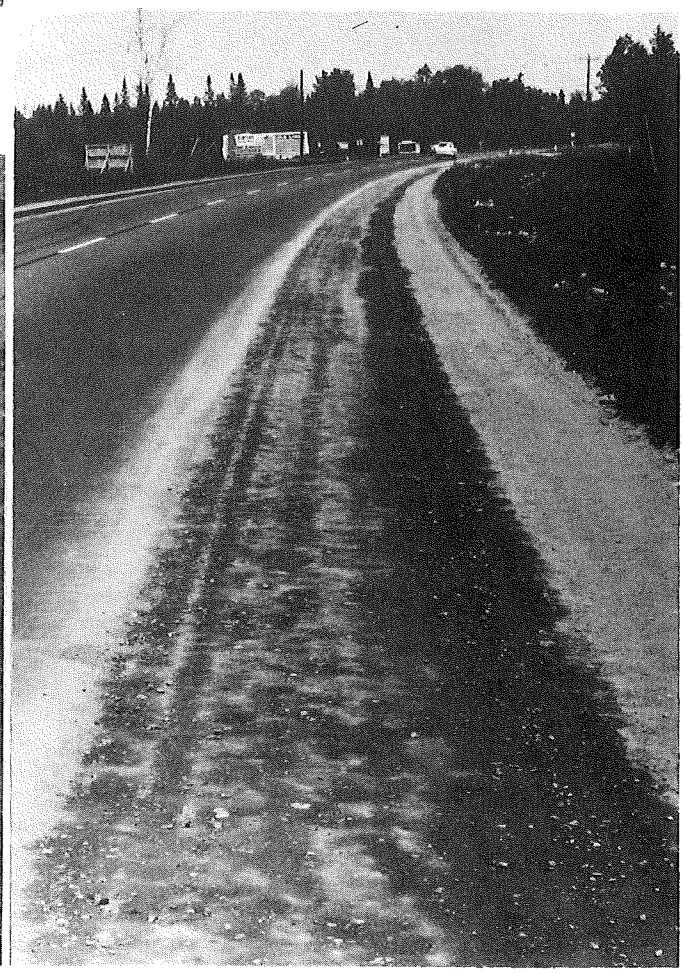


Figure 7. Soil cement treatment after two days of moist curing.



of asphalt and aggregate at the time of processing, and poor compaction characteristics due to insufficient curing at the time of compaction. Some of these problems could be eliminated by more experience in handling these types of materials, and selection of the best form of asphalt stabilizer for the particular job.

The mixes used in this project were compacted to 95 percent of standard T-99 density as determined for the untreated aggregate. Optimum water content used in the field was equal to normal optimum moisture less the percent asphalt added. In other words, the asphalt replaced an equal percentage of water in computing the desired moisture content. This worked well in the field and no difficulty was experienced obtaining desired density--once the asphalt had properly cured. There was no problem using the standard Rainhart method for density control in the asphalt treated aggregate.

Asphalt emulsion sections were constructed using 2.0 and 2.6 gal of asphalt per sq yd; the slow cure sections with 2.3 and 2.6 gal per sq yd.

Although detailed construction procedures were varied to handle processing problems as they arose, the general procedures for constructing all asphalt sections were as follows:

1. Shoulder material was scarified and mixed by the Duo-Stabilizer and moistened lightly with the Duo-Pactor (Fig. 8).

2. The aggregate was trenched away from the edge of the concrete slab to a depth of approximately 4 in., and the surface of the shoulder leveled by the grader. Trenching was done to allow liquid asphalt to coat the edge of the concrete in hope of obtaining a better bond between the stabilized aggregate and the concrete.

3. Asphalt was applied by the Duo-Stabilizer using one or two passes. It was originally planned to apply the asphalt in a single pass, but due to poor control of application a second pass was sometimes required. The application of asphalt and the mixing are shown in Figs. 9 and 10.

4. The asphalt-aggregate mixture was processed by the Duo-Stabilizer until a uniform blend was obtained. In some cases this was not possible until the mixture had cured overnight.

5. The mixture was compacted with the Duo-Pactor until required density was obtained. Unless it was properly cured, the asphalt could not

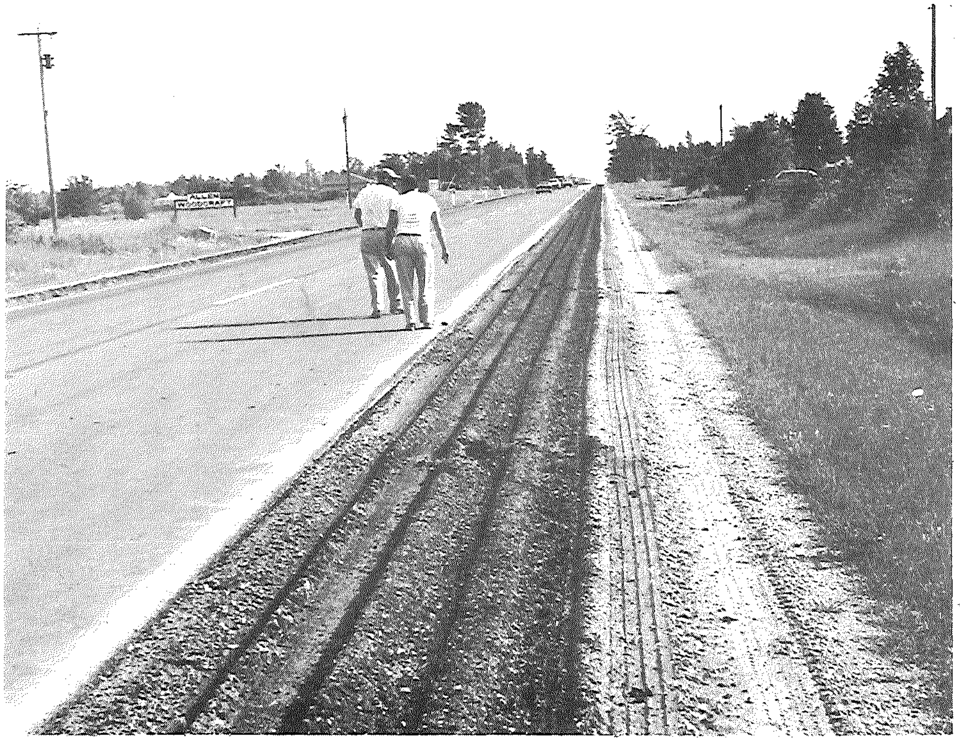


Figure 8. (top left) Moistened shoulder aggregate before application of asphalt for stabilization.

Figure 9. (top right) Application of slow curing asphalt (front view).

Figure 10. (right) Application of slow curing asphalt (side view).

be well compacted and large sections of the mixture were picked up on the rollers. Usually, when it was cured sufficiently for good mixing, the asphalt-aggregate could also be compacted satisfactorily.

6. The finished surface was shaped with the grader.

The Duo-Stabilizer equipment used for applying the asphalt depends upon a positive displacement pump and a constant forward speed to produce a uniform application. Unfortunately, uniform speed could not always be maintained and there were indications that the pump output was erratic. When it became apparent that either too much or too little asphalt was being applied (by observing the liquid level in the truck in comparison with the distance traveled), the pumping rate or the speed of the equipment was changed. The result of such modification is shown in Fig. 11 where a pronounced change is apparent in the quantity of asphalt in the 2.3 percent SC-3 section. This may also be observed in Fig. 12 where molded samples are shown which were obtained in about a 100-ft length of the 2.3 gal section.

All the asphalt emulsion sections appeared to be lean in asphalt content, particularly the 2.0 gal per sq yd areas. Fig. 13 shows a typical section of this treatment. The surface gravel is quite loose. The 2.6 gal per sq yd section contained only small areas where loose stones were present. There was no bleeding in the low emulsion area and only about 5-percent bleeding in the area of higher treatment. Asphalt emulsion did not appear to adhere to the aggregate as readily as did the slow curing asphalt.

For the SC-3 section an asphalt content of 2.3 gal per sq yd appears to be satisfactory. There was some bleeding in about 10 percent of this area. The 2.6 gal per sq yd application appeared to be too high with bleeding occurring over about 50 percent of the treated area.

A potential traffic hazard is created by the long time required for curing of an asphalt shoulder prior to obtaining density. Fig. 14 shows the typical loose condition of the shoulder material during the curing period.

Untreated Sections

The untreated sections were constructed of in-place gravel, scarified and mixed with one pass of the Duo-Stabilizer. After the proper additions of water these sections were compacted to a density of 95 percent of the standard T-99 value. The contractor had difficulty obtaining this density.

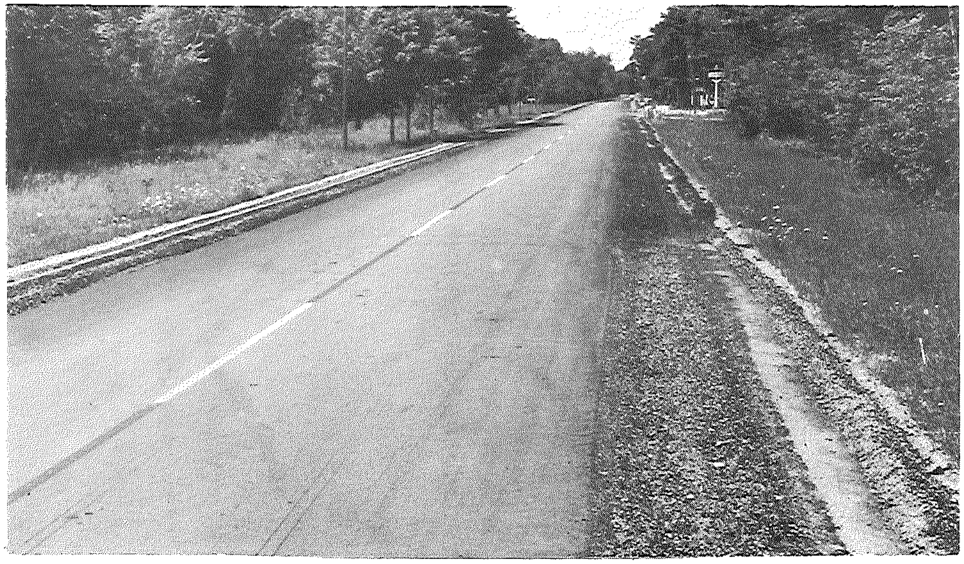


Figure 11. Visible variation in asphalt content in slow curing asphalt section.

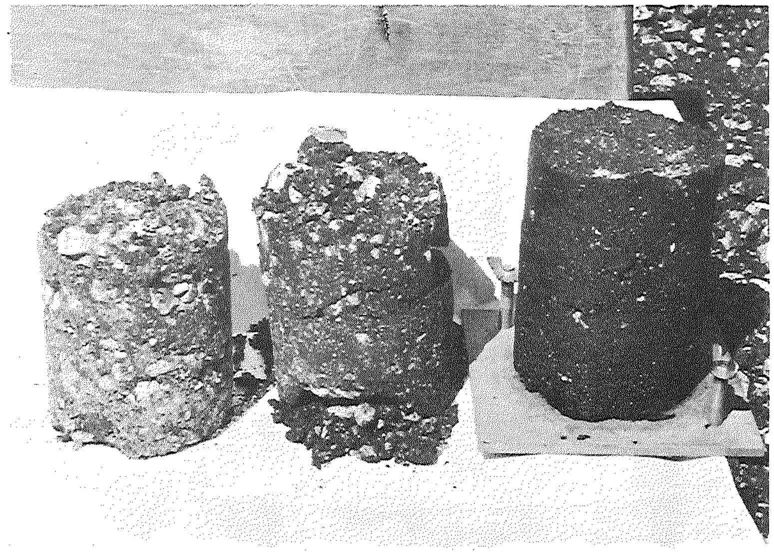


Figure 12. Molded samples showing variable asphalt content in slow curing asphalt section.

Figure 13. Appearance of the 2-percent asphalt emulsion section.

Figure 14. Loose shoulder material during curing of asphalt-aggregate mixture.

After completion, the salt and portland cement sections were surfaced with a prime and seal consisting of MC-1 prime coat, AE-3, and 31-B cover material. Half of each asphalt section was left unsurfaced, and the other halves covered with AE-3 and 31-B material. Fig. 15 shows a typical sealed shoulder at the completion of the project. The untreated section was covered with MC-1 prime and a double seal surface of AE-3 plus 31-B and 26-B.

Figure 15. Typical sealed shoulder at completion of operations.

Preliminary Testing (Fall 1962)

Inspection of all the test areas shortly after completion of the project indicated that they were in very good condition. Roughometer tests were run September 7, 1962 and yielded the values included in Table 3. The most extreme roughness was found in the 4-percent cement and in the 2.6 gal per sq yd SC-3 unsealed section. Other roughness values showed no particular trend at that time.

Relative deflections of the test sections under a given load were measured by means of a Benkelman beam. This procedure not only gives

TABLE 3
SUMMARY DATA FOR SHOULDER PROJECT

Section Control Number	Shoulder Type		Field Density		Roughness, accumulated in./mi (7-29-62)	Appearance Before Sealing	Uniformity of Mixture	Cost Index	Curing Time	Special Problems
			Total Tests	Avg pcf						
1	Sodium Chloride	6 lb per ton	18	137.3	343	Hard, dense, few loose stones	Excellent	1.0	None required	None
		12 lb per ton	16	135.4	352	Hard, dense, some loose stones	Excellent		None required	None
2 & 3	Asphalt Emulsion	2.0 gal	13	132.6	391 (seal) 421 (no seal)	Lean mix with many loose stones	Uneven	1.4	2 days	Obtaining uniform mixtures. Time required for curing
		2.6 gal			418 (seal) 398 (no seal)	Well proportioned mix with some loose stones	Uneven		3 days	
4	Portland Cement	8 percent	16	133.4	455	Hard & dense with some loose stone on surface	Excellent	1.8	5 to 6 hr to set up	Manpower required to apply cement
		4 & 6 percent	13	130.6	517 (4%) 463 (6%)	Hard & dense with some loose stone on surface	Excellent		5 to 6 hr to set up	Rapid setting of the cement
5 & 6	Slow Curing Asphalt	2.3 gal	10	132.9	413 (seal) 418 (no seal)	Very rich in spots with some bleeding	Very uneven	1.3	3 or 4 days	Obtaining uniform mixtures. Time required for curing
		2.6 gal			395 (seal) 548 (no seal)	Very rich with excessive bleeding	Uneven		4 days or more	
7	Untreated Base	---	8	132.4	402 NB 328 SB	Fairly dense with some loose stones	---	0.64*	None	Obtaining density

* Does not include cost for single pass machine stabilization.

a comparative test among the sections but can be used periodically to measure changes in stability of the different bases. Fig. 16 shows the placement of the Benkelman beam prior to a deflection reading, using a county truck to furnish a 5300-lb dual wheel load.

Figure 16. Benkelman beam measuring surface movement under dual wheel load.

Results of these tests are shown in Table 4. The data show only general trends at present because surface movement in all sections was very slight and much of it could have been due to movement of the seal coat rather than to an actual deflection of the base. With the small deflection measurements obtained, any irregularities in the test method or in surface movement could have a significant influence on the values. An example of how the shoulders reacted to the dual wheel load is shown in Fig. 17. The flexible surface (and in some cases, the base also) was squeezed upward between the wheels as shown at Point A. This raised surface, at the point where the Benkelman beam measurements were made, prevented accurate determination of relative deflections among the different sections. Because of this plastic movement, deflection values cannot be considered alone, but must be evaluated together with their corresponding rebounds. Thus, the Benkelman beam values shown in

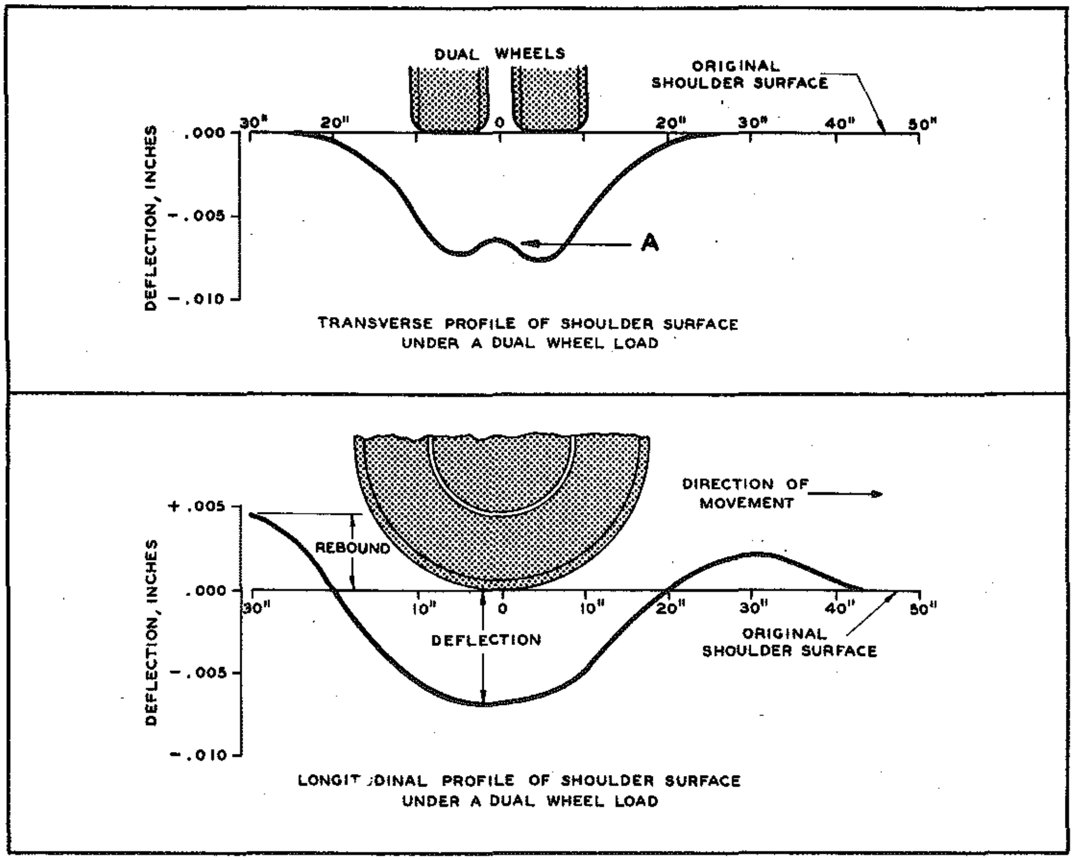


Figure 17. Typical surface distortion for asphalt-treated gravel under dual wheel load of 5300 lb.

TABLE 4
SUMMARY OF BENKELMAN BEAM DATA

Section Control Number	Shoulder Type	Number of Tests	Mean Average Movement, in.		Standard Deviation, in.		Relative Surface Movement, in. *
			Deflection	Rebound	Deflection	Rebound	
4	Portland Cement, 4 & 6 percent	24	.008	-.003**	.005	.003	.005
4	Portland Cement, 8 percent	20	.012	-.003**	.003	.002	.009
2 & 3	Asphalt Emulsion, 2.0 gal per sq yd	21	.001	.008	.002	.005	.009
1	Sodium Chloride, 12 lb per ton	15	.017	-.004**	.011	.005	.013
5 & 6	Slow Curing Asphalt, 2.3 gal per sq yd	27	.008	.007	.005	.007	.015
2 & 3	Asphalt Emulsion, 2.6 gal per sq yd	24	.004	.012	.004	.004	.016
1	Sodium Chloride, 6 lb per ton	16	.014	.003	.004	.002	.017
7	Untreated Base	18	.012	.006	.010	.003	.018
5 & 6	Slow Curing Asphalt, 2.6 gal per sq yd	24	.007	.015	.009	.015	.022

* Difference between mean average deflection and mean average rebound.

** Negative values indicate rebound below original shoulder surface elevation.

Table 4 are expressed as total surface movement represented as the difference between average mean deflection and average mean rebound. By this interpretation, the more rigid soil-cement sections appeared to have the least surface movement.

Results indicate that the Benkelman beam test was not too successful in differentiating among the small deflections found immediately after construction of the test sections. The values obtained, however, provide a base with which future deflection measurements can be compared. It is believed that Benkelman beam test results might be more meaningful if significant differences in the supporting power of the test sections develop during the life of the project.

Conclusions

The following conclusions to date involve only construction operations and preliminary observations; performance of the different test sections will be determined conclusively only with time.

1. The equipment used to construct the shoulders was satisfactory and could be used in other forms of construction. Increased use of the equipment would assure its more efficient operation. Application of the asphalt material by the Duo-Stabilizer was erratic.

2. The sodium chloride sections were the easiest to construct and looked as well or better than the other sections. Densities were higher and easier to obtain than were those of the other sections.

3. Portland cement sections required careful moisture control and careful planning to assure complete mixing and compaction prior to hardening of the cement. Further, an unusually large number of men were required to distribute the cement over the shoulders.

4. Asphalt stabilization required an unusual amount of mixing and aeration in order to place the asphalt in a proper manner. The time required for curing, prior to compaction, was excessive and during this time the uncompacted shoulders were a potential traffic hazard. The use of a more rapid curing asphalt might help improve this situation.

5. General observations on this project indicated the following relative costs of the sections: salt (1.0), untreated double seal (0.64), asphalt emulsion (1.4), slow curing asphalt (1.3), and portland cement (1.8). Other methods of operation and more experience with the specific treatments might alter this relationship considerably.

6. Standard density could be obtained more easily for the sodium chloride shoulder than for those of similar untreated aggregate. Highest densities were obtained in the sodium chloride section.

7. Preliminary roughometer tests showed some differences in the riding quality of the sections. The sodium chloride and untreated sections were the smoothest.

8. Benkelman beam tests showed the least surface movement to be in the portland cement sections. Deflections of all sections at this time were small, however.

9. Periodic inspection and testing will continue with emphasis on conditions during the spring breakup period.