PROGRESS REPORT ON STABILIZED TURF SHOULDERS CONSTRUCTED ON LONG ISLAND

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SYNOPSIS

In order to test various factors relating to the growth of turf on earth shoulders several areas along highways on Long Island were mechanically stabilized in 1945, 1946 and 1947. On these a range of soil preparations, seeds and seeding methods have been tested and previously reported./1 This is the 1947 status report, together with a report on new tests relating to traffic loads and shoulder "build up."

Based on the local conditions on Long Island it is indicated that the presence of finer soil fractions are of importance to stabilization and plant growth. Maintenance fertilizing and mowing are likewise important for the turf. The resulting effects of different shoulder materials, compaction, amendments, mulches, kinds and rates of seed and season and methods of seeding are again reported to show changes to date. Most of these variables have had surprisingly small effect on the resulting turf.

Traffic tests were made on the turf-covered stabilized shoulders to determine the degree of stability. The observations to date are affirmative. Grades on roadside areas have been determined at four periods during one calendar year without sufficient change in elevation to indicate trends due to recognizable causes except winter heaving.

The New York State Department of Public Works District Office on Long Island, J. J. Darcy, District Engineer, is continuing the study of establishment and maintenance of turf on mechanically stabilized soil shoulders subject to occasional traffic.

Investigation of the projects previously constructed and reported to the Highway Research Board in 1945 (1)* and 1946 (2)* and of new projects has been extended to include tests of the bearing value of the shoulders and the study of the cause of "build up" in the study of the integration of the requirements for shoulder stability with those for the establishment and maintenance of turf.

/1 - This paper is a continuation of the 1946 progress report on pages 258 to 268 of the Proceedings for the Twenty-sixth Annual Meeting of the Highway Research Board. The conclusions as published on page 268 indicate results of observations of tests through 1946.

*Numbers in parenthesis refer to the list of references at the end of the paper.

Description of Projects - **Project 8444 is a test shoulder 3,000 ft. in length and 12 ft. wide built in the spring of 1945 of soil low in fines mechanically stabilized, except that about 700 ft. was chemically treated and that two small sections were built of granular materials. Projects 8438 and 8440 totaling approximately** 2,600 lineal ft. of 12 ft. wide shoulder built in the spring of 1946 are of sandy material, a small amount of fines having been added to the existing unstable sandy soil. Project 1841, 3,000 ft. of 10 ft. shoulder was built in the spring of 1946. The original top soil contained some 60 percent of silt and clay and was unstable when wet. Sand was added to make a soil material which is higher in fines than are those of the other projects. In the spring of 1947 additional sections of shoulders were built on projects 8438 and 8440 of material somewhat heavier than those built in 1946. These shoulders were constructed of a stabilized course approximately 6-in. deep of the designed mixed material compacted at approximately optimum moisture content. A standard treatment of fertilizer, lime, seed, mulch, etc., was used throughout each project except for the variation of one of these factors in each section or bed.

Table 1 gives the data of typical samples of the soils.

It is important to understand that the soils with which we have worked are sandy materials, that even the soil material of the shoulder of project 1841 containing a comparatively high percentage of silt and clay has a very low plasticity index or is non plastic and has relatively high percentages of voids when compacted.

Maintenance - Fertilizer was applied on all the established stabilized turf shoulders in the spring of 1947. The application made in early May was at the rate of 35 to 40 lbs. of nitrogen, 60 to 80 lbs. of phosphorous and 30 to 35 lbs. of potash per acre.

Mowing was done with sickle bar type mowers during 1945 and 1946, not more often than once a month. In 1947 mowing was done whenever growth became 5 or 6 in. high with a reel type mower set to cut $3\frac{1}{2}$-in. high, except that on projects 1841, 8438 and 8440 the sickle bar type was used after the middle of July.

Traffic Tests - Conditions: On May 6, 1947 traffic tests were made on all of the stabilized turf shoulders. It had been planned to make these tests at the time frost was coming out of the ground when conditions were the most unfavorable for stability. In past years, cars riding on the unstabilized shoulders at this time of year on project 1841 caused very deep ruts. This condition did not prevail in the spring of 1947 possibly due to the fact that snow removed from the pavement after a late snowstorm remained on the shoulder until late in the season. Therefore, a day following several days of rain was chosen for the tests on which day conditions seemed to be the worst of the spring up to that time.

Method: A loaded truck was used for the test. One of the dual right rear wheels was removed so that the unit pressure of the remaining right rear wheel was increased. This wheel was equipped with a standard make of 8-ply, heavy duty, 6.50 x 20 tire which was practically new and which was inflated to 80 lb. pressure. The load was increased to a point at which the reading on the scales used for measurement of the weight on this wheel was 5,970 lb. An imprint of the tire tread was made by jacking up the loaded wheel, placing a piece of Presdwood on the bituminous pavement under the wheel and a piece of linen paper on the Presdwood, applying printer's ink to the tire and lowering the wheel slowly with the jack until the full load was on the wheel. (See Figures 1, 2 and 3). The wheel was then raised and the print removed. A photograph of one of the imprints is shown in Figure 4. The size of this tire print is 12 x 4-3/4 in., which represents a load of 104.7 lb. per sq. inch. The legal limit of loads for pneumatic tires on New York State Highways is 800 lb. per in. width of tire. The load used on the above 6½-in. tire gave 919 lb. per in. width of tire.

The traffic test truck was operated at between two and three miles per hr. with the test wheel running from three to four ft. off the edge of pavement on the shoulder. At one location on 1841 the truck was driven over the same track a second and a third time and the resulting depression measured each time.

Measurements of the maximum depression caused by the load were made by placing a straight edge set on wood blocks of known size each side of the track of the wheel on undisturbed soil and measuring from the straight edge. (Figure 5). Measurements were made at all locations where the depression was greater than ½-in.

Moisture determinations were made on the same day near the track of the test vehicle at several points.

Two stabilized shoulder projects (8438 and 8440 of 1947) had just been constructed but not yet seeded on this date. Traffic tests were made on these projects.

The ruts caused by the test vehicle "healed over" naturally and could not be seen in November 1947.

Results: The measured depressions in the shoulders and the moisture determinations are given in Table 2.

Fall 1947 - On October 23, 1947, after one month of practically no precipitation a similar test was run using a truck similarly loaded and with one of the dual right rear wheels removed. The remaining wheel was equipped with a standard make of heavy duty, 8-ply, 7½ x 20 tire which had a good tread, inflated to 80 lb. pressure. The weight on the test wheel was 6,470 lb. An imprint of the tire was taken in the same way as in the spring. The size of this tire print is 13 in. x 5-3/4 in. representing a pressure of 86+ lbs. per sq. inch. This test vehicle (Figure 6) was run over the shoulders of projects 1841, 8438 and 8440. There was no measurable depression on any of the stabilized shoulders; there was a depression made on the unstabilized shoulder on project 1841 which, however, was less than ½-in.

"Build Up" Study - The possible reasons for "build up" have been variously stated as frost action, plant growth, silting, swell of fine soils, loosening of stabilized material by traffic (3) accretion of wind blown material, etc. Various methods have been suggested to eliminate or reduce "build up". If it were possible to determine the most important causes, control might be facilitated. To this end our study has been directed.

Method: Elevations were taken on twelve typical sections of two of the stabilized turf shoulder projects. Three of these cross sections are at a curve

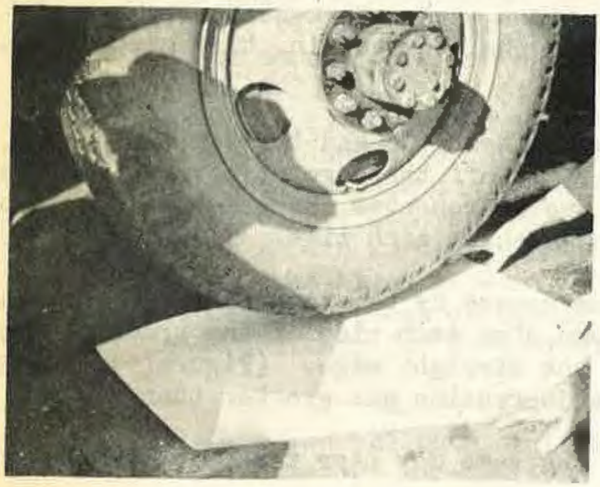

Figure 1. Ready to Make Imprint of Tire of Test Truck

Figure 2. Making Imprint of Tire of Test Truck

Figure 3. Removing Imprint

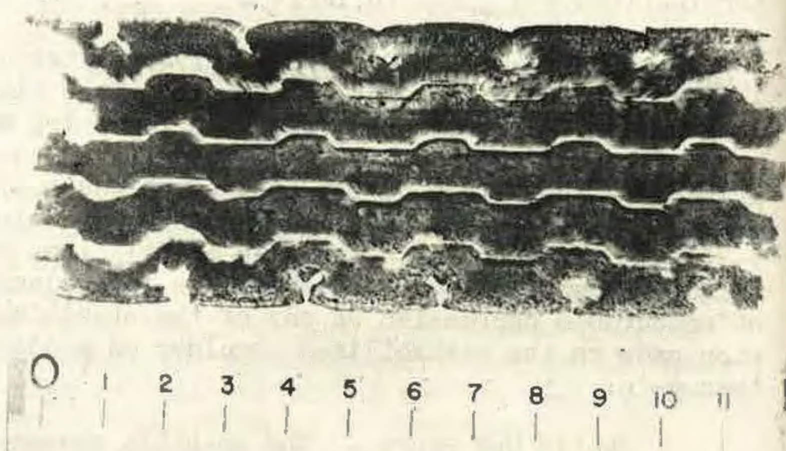

Figure 4. Imprint of Test Track Tire (Spring Test) - with 1-ft. Scale

where the pavement slopes away from the shoulder. These elevations were taken in September 1946 to hundredths of a foot at the pavement edge and at 2 ft. intervals on the shoulders and backslopes. Elevations were taken at the same locations in March, May and October 1947. It is intended to continue similar readings in the future. The average changes in elevation at the points used for the readings were determined by sealing directly from the plotted cross sections and results are given in Table 3.

The elevations taken on the shoulder at the edge of pavement were not included in this summary as it seemed there would be changes due to traffic at these points which would not be characteristic of the entire shoulder.

Density determinations (Table 1) taken November 1946 and July 1947 and to be taken in the future may help in this study.

Vegetation as Affected by Factors of Study*- Compaction: Good turf is growing where a dry density of the top four inches of soil is as great as 120.2 lb. per cu. ft. with a void content of 26.7 percent. These tests were made in July 1947. (Figure 7). The dry density at this location in November 1946 was 130.0 lb. per cu. ft. and the voids 19.9 percent and the turf good.

Type of Shoulder: There is a satisfactory turf growth on all of the mechanically stabilized soil shoulders previously reported where these shoulders are subjected to occasional traffic only. Weeds which were growing vigorously on project 8444 in 1945 and on project 1841 in 1946 are conspicuously reduced. There are (and were in 1946) few weeds on project 8438. On the shoulders built on project 8444 of stone and cinders with 1-in. of top soil on top in 1945, there is a growth of Red Fescue, Redtop, and Clover which is rated poor near the pavement and fair on the outside. (Figure 8.)

Amendments.- There is no conspicuous difference in the condition of turf due to variation in the amounts and kinds of organic materials, fertilizer, and lime incorporated in construction.

In one section of 8444 large amounts of various chemicals were incorporated in separate beds in the 6 in. stabilized course primarily to determine their effect on density. Although not a part of the turf shoulder test this section was seeded. The turf is poor or fair on the three feet adjoining the pavement in all the beds except the bed where 150 lb. of calcium chloride was incorporated in 240 sq. ft. where the rating is good. Table 4 gives the various treatments and the average rating of growth over each bed.

Mulches: There is no conspicuous difference in the condition of turf due to various types of mulches used or to omission of mulch.

Variety of Plant: Red Fescue, Redtop, Yarrow, Smooth Brome, Wild White Clover, and Birdsfoot Trefoil are the dominant plants in the areas of general seeding while in the test of variety of seed the following are best on the sandier soils: Red Fescue, Perennial Rye, Orchard, Smooth Brome, Meadow Fescue, Redtop, Erect Brome, Yarrow, Birdsfoot Trefoil, Alfalfa, Wild White Clover and on the heavier soil of project 1841 Red Fescue, Colonial Bent, Redtop, and Orchard are best.

*Based on observations made November 1947.

Figure 5. Measuring Depression

Figure 6. Test Truck on Shoulder

Figure 7. At 3-ft. Offset from Pavement at location 1 (see cut), dry density = 120.2 pcf., voids = 26.7%, organic material = 2.2%, 12.5% passing 200 mesh sieve, turf in good condition in fall of 1947

Figure 8. Project 8444 (11/18/47) Beyond location 3 (see cut) shoulder untreated; 2 to 3 cinder shoulder; 1 to 2 stone shoulder; foreground stabilized soil shoulder

Perennial Rye is still the best of the grasses in the test of variety on 8444 and is almost as good as it was the first two years. On 8440 it is not as good as it was in July of 1947 from an overseeding done in October 1946.

Rate of Seeding: There is no apparent difference due to variation of the rate of seeding from 27 to 300 lb. per acre. Check plots not seeded on the project built in 1945 are covered with good vegetation similar to adjoining beds, while those not seeded on the 1946 projects are similarly covered by a poor to fair growth.

Season of Seeding: There is no conspicuous difference due to the various seasons of seeding on projects 8444 and 1841 and only a slightly better turf on 8440 from the seeding of July, August and October 1946, as compared with the seeding of April 1946.

Method of Seeding: There is no conspicuous difference on any of the reported projects due to the various methods of seeding.

Poor results were obtained from the seeding in early May of the projects built this year. Seed had been broadcast without raking the stabilized surface and a mulch of grits applied just thick enough to cover the soil. A good stand of crabgrass developed in the summer.

Soil: Good turf is growing at the location referred to under "Compaction" where the organic content of the top 4 in. of soil is only 2.2 percent and the percent passing No. 200 sieve is only 12.5 percent. An excellent turf is growing where the pH was determined as 4.6 and the organic content 2.7 percent for the top 3 in.

A good turf is growing where the soil contains but 7.7 percent of silt and clay as indicated by a sample taken in November 1946.

Density - Comparison of the dry densities determined in November 1946 and July 1947 (Table 1) indicates no significant general change on projects 8444 and 8438. On project 1841, however, there is indicated a decrease in density of the top 3 $\pm$ in., at all the locations sampled, the average decrease being 13.3 lb. per cu. ft.

Density determinations have not yet been made in the fall of 1947 to determine what change in density, if any, has occurred during the growing season on the projects constructed this year.

There was not much development of plant growth on the sections of projects 8438 and 8440 constructed in the spring of 1947 when the density determinations were made in July 1947. It is seen from Table 1 that the top 3 in. was less dense than the next lower 3 in. at all the locations sampled.

SUMMARY

Stability - With a load almost 15 percent in excess of that permitted by law on New York State highways and at a time of year when conditions were as bad as would obtain during at least 95 percent of the year (4) no damage requiring repair was caused to any of the stabilized turf shoulders by the traffic test. Assuming this performance to indicate stability, the term is so used in the following.

As previously reported (2) there are locations along project 1841 where the shoulder is not adequately drained. It was at these locations that the greatest penetration of the test load occurred in the spring but it should be noted that the moisture contents of that day were more than 50 percent greater than those determined in November of 1946 and July 1947. At the lower moisture contents in the fall there was no penetration of a load 8 percent in excess of the legal limit in the same locations on the projects tested.

Mechanical analysis of the soil of the shoulders indicates a variation from a minimum of 6.7 percent to a maximum of 44.0 percent passing the No. 200 sieve within the area near the test run. The mechanical analysis of these two samples indicates them to be, at least in part, beyond the limits of A.A.S.H.O. specification M56-42 for Type A material, one on the coarse side and one on the fine side. Other samples vary through the range permitted by the specification. Stability was obtained with all of the above.

The shoulder was stable at the various densities and percentages of voids reported. No determination was made of the size of the pore spaces. (5) The lower densities of the top 3 in. as compared with the next lower 3 in. of the stabilized shoulders determined about two months after construction probably indicates the effect of compacting this type of soil rather than the effect of plant growth.

No determination of the bearing value of turf itself has been attempted. Some value is indicated by one reference given (3).

The shear value of turf has been indicated by Figure 8, p. 267 (2) where the tire mark on the pavement made by the spinning wheel of the wrecker which started on the shoulder to pull a car out of the sand of the backslope. It has been suggested that we consider the possibility of turf as a material to confine a sand unstable in itself to produce a stable turf shoulder just as chicken wire laid over sand provides stable landing areas for planes. The problem would then become the determination of the minimum requirements of the soil for turf growth rather than the minimum amount of binder soil to be added to sand to provide stability, although stability during development of the turf would have to be considered. Sodding might be a possibility.

Build Up - A general decrease of density of the top 3 in. of soil and an average increase in elevation of the stabilized shoulder occurred over winter, where determinations were made. This was true of the sections where the pavement slopes away from the shoulder. There was a slight average increase of elevation of both ditch and backslope over winter. From March to May there was a slight average decrease of elevation of shoulder and backslope and from May to October the averages indicate no changes.

Vegetation - The satisfactory turf growing on mechanically stabilized soil shoulders after two to three seasons of growth indicates the relatively lesser importance to plant growth of the various factors in construction such as type and amount of mulch, amendments and, within reasonable limits, rate, season and method of seeding. The condition of turf on the various projects may indicate the importance of the finer soil fractions to plant growth for there seems to be poorer growth generally where the percentage of fines is lower.

The general regression of quality of turf on project 8440, one of the shoulders low in fines is an indication of the need for an intelligent fertilizing program. The improvement in turf on project 8444 this year is due at least in part to the better program of mowing.

Although certain desirable varieties of plants have developed well from seeding and some of these develop naturally there is a need for hardy turf plants which will germinate quickly from seed, develop vigorously to establish a cover of vegetation of low top growth, and be resistant to the adverse conditions of moisture, air movement and traffic.

One of the difficult problems of building of stabilized turf shoulders is the development of a turf cover when construction operations are completed at a season unfavorable for seeding. Two methods have been successful for summer seeding in our tests:

1. Seeding and mulching with hay or mowings covered lightly by soil (but this might not be so successful with adverse weather conditions) and

2. No immediate treatment, allowing a natural vegetation to develop in the summer which may be allowed to remain as a mulch when seeding is done in the fall by broadcasting seed without any preparation of seed bed. A project has just been constructed to determine the best methods of surface treatment when construction is completed in the fall too late for seeding. This project includes application of a bituminous emulsion as a mulch.

Conclusions - This paper reports the progress of study of stabilized turf shoulders constructed in the past three years with the sandy soils characteristic of Long Island.

The data reported indicates that under the local conditions turf can be grown and maintained under occasional traffic on mechanically stabilized soil shoulders which are stable under the loads permitted by New York State law when drainage is adequate and the soil material is within the range permitted by A.A.S.H.O. specification M56-42 for Type A material.

The build up study begun in the fall of 1946 must be continued to provide further information from which conclusions may be drawn.

The importance of an effective program for maintenance of turf is stressed, and the problem of out of season seeding is discussed.

Acknowledgments - Acknowledgment is due Dr. John Lamb, Cornell University and Soil Conservation Service and E. B. Coffman, Soil Conservation Service for their continued interest and advice in this work.

REFERENCES

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(3) "Report of Stabilized Soil & Turfing" U. S. Army Airfields in Jacksonville, Fla., District - U.S. Engineer Office, Jacksonville, Fla. August 1944.

(4) "The Climate of Long Island" - Norman Taylor, Cornell University Agric. Exper. Sta., Bulletin 458, March 1927.

(5) "Turf on Stabilized Granular Materials" - G. O. Mott. 1944 Group Meeting Book of A.A.S.H.O.

TABLE 1. SOIL AND CONDITION OF TURF DATA

Project No. 8444 Constructed Spring 1945

December 1945 and November 1946

Station	Offset Ft.	Depth In. (Dec. 1945)	Dry Density Lb/Cu.ft. (Dec. 1945)	Condition of Turf (Dec. 1945)	Station	Offset Ft.	Depth In.	Dry Density Lb/Cu.ft.	Moist. %	% Finer Than Sieve #4	#10	#40	#200	mm. .004	Voids %	Voids Ratio	P.I.	Condition of Turf
458/60	2	0-6	134.7	Poor	458/60L	2	0-3	121.4	7.1	82.6	74.1	40.2	14.4		25.8	0.35	NP	Poor
							3-6.7	132.1	5.1	85.0	72.0	33.5	13.6		16.5	0.20	Np	
							6.7-9.5	130.5	5.0	78.9	67.7	31.8	11.7		21.1	0.27	NP	
	7	0-6	116.0	Poor		7	0-3	109.6	10.8	92.1	83.1	41.9	14.8		32.7	0.48	NP	Good
							3-6.5	128.2	5.8	80.0	71.3	34.9	11.7		22.2	0.29	NP	
							6.5-9	129.5	4.3	84.7	75.4	39.7	10.6		21.7	0.28	NP	
	10	0-6	113.7	Poor		10	0-3	112.7	7.0	89.4	80.3	39.1	13.5		31.3	0.46	NP	Excellent
							3-6.5	123.1	4.7	89.1	82.3	44.8	12.3		25.6	0.34	NP	
							6.5-9	125.7	3.5	90.3	81.2	16.6	10.5		24.3	0.32	NP	
459/48	2	0-6	130.3	Good	459/62L	2	0-3	117.8	9.4	94.9	87.8	51.1	19.4		27.4	0.38	NP	Good
							3-6	132.0	5.3	94.2	84.9	43.1	16.5		19.9	0.25	NP	
							6-9	134.0	6.1	90.7	80.0	46.1	18.8		17.8	0.25	NP	
	6	0-6	124.5	Excellent		6.5	0-3	111.5	9.0	88.9	82.0	44.7	16.6		31.0	0.45	NP	Good
							3-6	130.0	6.5	88.7	80.6	47.2	17.9		21.1	0.27	NP	
							6-9	136.5	5.0	90.1	78.3	47.8	19.6		18.7	0.23	NP	
	11	0-6	115.1	Excellent	459/60L	11	0-3	112.0	7.9	90.5	81.9	44.0	16.7		32.2	0.48	NP	Good
							3-6.5	135.7	5.0	69.6	61.7	37.1	13.7		17.6	0.21	NP	
							6.5-9	133.5	4.5	79.0	76.6	40.2	15.2		20.2	0.26	NP	
467/00L	2	0-6	126.8	Poor (Good from 6' to 12' offset)	467/00L	2	0-3	116.4	7.6	85.8	75.6	36.5	10.4		26.0	0.39	NP	Poor
							3-6	122.9	10.2	90.3	82.4	44.2	20.7		25.0	0.33	NP	
							6-9.3	114.9	12.2	94.3	90.0	47.0	20.0		30.0	0.43	NP	
470/19.5	2	0-6	130.0	Fair	470/19L	2	0-6.5	128.3	5.8	88.1	77.4	37.0	11.1		21.8	0.28	NP	Fair
	6	0-6	118.0	Good		6	0-6	116.9	6.5	88.4	76.1	11.3	7.5		28.5	0.40	NP	Good
	10	0-6	118.0	Excellent		10	0-6.5	116.1	5.7	88.7	78.8	28.0	8.9		29.8	0.42	NP	Excellent
472/50	2	0-6	128.3	Good	472/50L	2	0-6.7	121.9	8.9	85.7	77.6	35.9	11.8		25.2	0.34	NP	Fair
	6	0-6	122.3	Good		6	0-6	123.1	8.7	86.6	78.3	39.8	12.7		25.3	0.34	NP	Fair
	10	0-6	117.4	Excellent		10	0-6	113.1	8.0	84.3	68.8	21.7	1.9		30.8	0.45	NP	Good
483/00 (Not Stabilized)	3	0-6	119.1		483/00L	3	0-6.2	125.1	6.3	86.3	74.9	26.0	7.6		23.8	0.31	NP	

July 1947

Station (Dec. 1945)	Offset Ft. (Dec. 1945)	Station	Offset Ft.	Depth In.	Dry Density Lb/Cu.ft.	Moist. %	% Finer Than Sieve #4	#10	#40	#200	mm. .002	Specific Gravity -4	Voids %	Voids Ratio	pH	Organic %	November 1947 Condition of Turf	May 1947 Stability
458/60	2	458/62	2	0-3	121.6	9.8	76.8	69.0	38.0	14.1		2.58	24.5	.32	6.3	2.9	Poor	Excellent
				3-6	134.5	4.7	80.4	66.2	30.9	14.3		2.64	18.3	.22	6.4	1.0		
				6-9	137.1	5.2	77.2	63.3	27.6	8.6		2.66	17.4	.21	6.6	1.0		
	7																Fair	Excellent
	10																Good	Excellent
459/48	2	459/64L	2	0-3	120.3	4.9	92.6	84.4	44.1	19.7	4.0	2.63	26.7	.36	6.8	2.1	Fair	Excellent
				3-6	130.7	5.1	87.1	78.7	37.3	12.7		2.64	20.7	.26	6.2	1.2		
				6-8-3/4	130.6	6.1	80.3	69.1	37.2	19.6	5.0	2.64	20.7	.26	5.8	1.6		
	6																Good	Excellent
	11																Excellent	Excellent
467/00L	2	467/03	2	0-3¼	118.9	5.6	80.1	70.1	30.0	7.6		2.58	26.2	.36	6.9	2.0	Poor (Good from 6 to 12' offset)	Excellent
				3¼-6¼	121.8	9.7	90.3	83.5	40.9	19.1		2.68	27.1	.37	6.6	2.2		
				6¼-9	126.7	8.2	80.6	75.1	38.2	16.9		2.60	21.9	.28	6.7	2.8		
470/19.5	2	470/13	3	0-3	114.4	2.6	76.0	69.0	30.6	6.7		2.60	29.4	.42	6.2	2.9	Poor	Excellent
				3-6	132.8	2.3	72.4	64.4	28.6	6.7		2.62	18.8	.23	6.4	1.2		
				6-6¼	126.6	1.8	89.9	79.3	31.2	4.5		2.61	22.3	.29	6.2	0.6		
	6																Good	
	10																Excellent	
472/50	2	472/54	4	0-3½	113.4	3.9	90.3	82.8	53.7	30.1	4.0	2.61	30.4	.44	6.4	3.4	Fair	Excellent
				3½-6	132.5	3.9	76.3	68.1	32.8	12.0		2.64	19.6	.24	6.8	1.8		
				6-8¼	128.1	3.9	94.8	85.8	40.6	11.8		2.66	22.8	.30	6.4	0.9		
	6																Fair +:	
	10																Good.	
483/00 (Not Stabilized)	3	482/98	4	0-3	117.2													
				3-6	127.7	3.1	79.5	73.8	40.3	10.5		2.58	27.2	.37	6.4	2.2	Poor	Excellent
				6-9	128.1	6.5	70.3	63.2	38.3	17.1		2.61	21.6	.28	7.0	1.9		
						6.4	74.9	64.1	29.4	11.3		2.59	20.8	.28	6.8	2.3		

Project No. 1841 Constructed Spring 1946

November 1946

Station	Offset Ft.	Depth, In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	mm. .004	Voids %	Voids Ratio	Liquid Limit %	Plastic Limit %	P.I.	Condition of Turf
155/02R	3.5	0-3	122.5	9.9	91.9	86.8	55.4	33.8	7.8	24.4	0.32	26.9	20.4	6.5	Excellent
		3-6	123.5	11.3	92.3	88.3	51.5	31.1		23.8	0.31	30.1	22.6	7.5	
		6-10	119.0	10.9	94.0	89.3	54.4	29.2		26.6	0.36			NP	
158/95R	3.0	0-3.7	124.2	7.5	90.1	82.3	43.1	26.1		23.5	0.31	27.7	21.4	6.3	Excellent
		3.7-6	127.3	6.8	93.2	84.9	47.1	22.5		21.5	0.27	25.1	19.3	5.8	
		6-8.5	129.6	3.4	91.8	79.8	37.1	10.5		20.2	0.25			NP	
164/03R	3.3	0-3	117.4	9.2	98.8	93.4	61.8	35.2		27.6	0.38	29.7	21.5	8.2	Good
		3-6	119.2	11.1	94.1	89.8	61.2	35.7		27.0	0.37	25.6	18.2	7.4	
		6-8.5	120.2	8.5	91.0	87.5	56.2	27.7		25.9	0.35			NP	
170/23R	7	0-3.3	122.7	8.8	90.5	85.1	52.4	31.7		24.5	0.32	30.5	21.8	8.7	Good
		3.3-5.6	117.8	12.0	93.0	87.1	58.9	39.0		27.5	0.38	23.9	18.4	5.5	
		5.6-9	119.0	14.8	97.6	94.9	86.0	44.5		26.6	0.36			NP	
170/31R	2	0-3.5	125.3	9.5	90.3	82.5	52.4	32.1		28.6	0.29			NP	Good
		3.5-6	119.2	11.4	87.1	80.5	52.0	35.1		27.0	0.37			NP	
		6-9	122.0	14.0	93.1	86.8	80.9	43.8		24.9	0.33			NP	
173/82R	2.5	0-3	120.6	11.7	89.9	88.3	55.1	37.1		25.7	0.35			NP	Good
		3-6	125.7	10.4	91.9	84.1	54.1	34.7		22.6	0.29			NP	
		6-9	119.2	14.6	92.8	85.7	52.4	31.7		27.0	0.37			NP	
180/00R	5	0-3	120.8	11.1	94.6	90.6	62.9	41.9		25.6	0.34			NP	Good
		3-6	124.3	11.9	91.2	87.5	59.5	40.1		23.4	0.31			NP	
		6-9	121.2	11.6	94.7	91.3	62.2	40.4		25.3	0.34			NP	

July 1947

Station (Nov. 1946)	Station	Offset Ft.	Depth In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	mm. .002	Specific Gravity -4	Voids %	Voids Ratio	pH	Organic %	November 1947 Condition of Turf	May 1947 Stability
155/02R	155/05	4	0-3¼	108.7	5.6									5.4	4.4	Good	Excellent
			3¼-6¼	126.9	8.6	95.2	86.0	51.5	34.1	8.0	2.61	22.1	.29	5.7	3.5		
			6¼-9	120.0	7.7	89.2	82.3	47.2	24.0	7.0	2.60	26.0	.35	5.8	2.6		
158/95R	156/97	5	0-3	107.2	3.5	65.7	76.5	50.0	30.7		2.66	35.4	.55	5.8	4.0	Good	Good
			3-6¼	119.0	4.5	70.3	63.9	40.9	25.0		2.62	27.2	.37	5.8	3.7		
			6¼-9	122.2	3.8	78.3	70.4	35.8	14.3		2.60	24.6	.33	6.0	1.9		
164/03R	164/20	4.5	0-3½	105.2	3.7	96.1	90.9	62.5	44.0	10.0	2.57	34.9	.52	6.0	4.2	Good	Good
			3½-6	117.9	3.9	93.6	87.6	56.3	26.9		2.57	26.5	.36	5.8	2.7		
			6-9	119.2	5.2	86.8	79.9	44.5	22.2	6.0	2.63	27.3	.37	6.2	2.2		
170/23R	170/20	6	0-3½	110.6	14.3	95.5	87.2	54.5	35.9	9.0	2.57	31.0	.45	5.6	4.2	Good	Good
			3½-6	123.6	10.8	87.3	81.7	50.5	31.0		2.58	23.2	.30	6.2	4.2		
			6-9	118.1	12.1	89.6	85.5	60.1	39.1	10.0	2.57	25.4	.36	6.2	4.1		
170/31R																Good	Good
173/82R	173/80	3.5	0-3	113.8	11.4	70.6	65.2	36.2	19.0		2.62	30.4	.44	5.6	3.4	Good	Fair
			3-6	121.1	9.0	97.0	90.9	53.6	30.2	9.0	2.61	25.7	.35	6.0	3.2		
			6-9	111.2	12.4	89.0	86.0	55.3	34.0		2.58	31.0	.46	5.4	4.2		
	178/48	3.5	0-3		11.7	86.5	80.1	46.0	26.5	6.0	2.60			4.6	2.7	Excellent	Good
			3-6	101.9	10.5	93.0	86.0	65.5	30.6	10.0	2.60	37.1	.59	5.8	3.5		
			6-8½	130.6	7.1	56.3	52.5	32.6	14.5		2.64	20.6	.26	5.4	2.4		
180/00R	180/00	3.4	0-3½	102.9	14.2	93.5	88.7	61.0	41.7	12.0	2.61	36.9	.58	5.4	4.2	Excellent	Good
			3½-6	122.6	10.9	90.0	82.8	54.7	36.7		2.60	24.4	.32	6.0	3.7		
			6-8½	130.2	8.9	84.5	80.3	51.1	29.1	9.0	2.63	20.6	.26	6.8	2.3		

TABLE 1, Continued

November 1946

Project No. 8438 Constructed Spring 1946

Station	Offset Ft.	Depth In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	.004	Voids %	Voids Ratio	P.I.	Condition of Turf
181/88L	2.5	0-4	130.0	5.0	80.0	68.3	30.9	10.9		19.9	0.25	NP	Good
		4-7.5	132.0	3.4	84.8	71.0	28.8	7.9		18.6	0.23	NP	
		7.5-9	132.8	3.6	83.0	68.8	27.9	9.2		18.1	0.22	NP	
181/88L	5.5	0-3.5	128.2	5.3	79.7	66.3	29.2	11.7		20.9	0.26	NP	Good
		3.5-7.5	135.5	3.2	79.8	62.9	19.0	8.3		16.5	0.20	NP	
		7.5-9.5	129.5	2.4	80.9	65.8	16.8	5.5		20.1	0.25	NP	
183/52R	2.0	0-3	119.5	9.7	79.4	69.3	39.2	19.8		26.4	0.36	NP	Poor
		3-6	128.8	7.1	79.6	67.6	37.9	18.1		21.9	0.28	NP	
		6-9	135.0	4.2	78.0	65.4	30.0	10.6		16.8	0.20	NP	
187/06R	2.5	0-3	119.1	11.1	90.1	82.3	49.4	26.1		26.5	0.36	NP	Good
		3-6	114.1	14.8	95.3	91.6	60.6	38.5		29.5	0.42	NP	
		6-9	128.0	6.2	86.3	74.0	37.6	17.9		21.0	0.27	NP	

Project No. 8440 Constructed Spring 1946

Station	Offset Ft.	Depth In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	.004	Voids %	Voids Ratio	P.I.	Condition of Turf
238/49R	2.8	0-3	123.0	6.8	86.3	79.2	46.4	16.6		24.1	0.32	NP	Good
		3-6.5	128.0	4.0	77.7	68.1	35.3	7.5		21.0	0.27	NP	
		6.5-9.5	123.8	4.4	90.6	81.1	39.0	7.1		23.5	0.31	NP	
239/62R	2.5	0-3	129.2	6.5	82.4	76.5	41.3	15.3		20.3	0.25	NP	Not Seeded
		3-6.5	135.0	5.7	86.0	79.6	41.8	14.1		16.8	0.20	NP	
		6.5-9.5	125.8	3.1	87.6	78.3	34.3	7.1		22.5	0.29	NP	
241/97R	8.5	0-3.5	116.9	4.2	85.9	76.6	33.8	7.7		28.0	0.39	NP	Fair
		3.5-6.3	120.0	4.5	82.2	72.9	32.9	7.7		26.0	0.35	NP	
		6.3-9	108.7	5.9	87.1	76.9	32.0	7.9		33.0	0.49	NP	
242/12R	8.5	0-3.8	120.7	7.2	69.0	80.4	27.1	17.4		25.6	0.34	NP	Fair
		3.8-6.3	124.3	4.1	77.7	66.2	29.7	6.5		23.4	0.31	NP	
		6.3-8.5	122.5	5.5	75.2	64.1	27.3	8.3		18.4	0.23	NP	

July 1947

Station	Offset Ft.	Depth In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	mm. .002	Specific Gravity -4	Voids %	Voids Ratio	pH	Organic %	November 1947 Condition of Turf	May 1947 Stability
181/87L	3	0-4	120.2	8.3	68.6	59.5	31.7	12.5		2.63	26.7	.36	6.5	2.2	Good	Excellent
		4-6½	135.8	5.3	67.1	56.0	25.1	7.8		2.63	17.4	.21	6.2	1.6		
		6½-9	134.2	4.5	79.8	65.4	28.5	16.8		2.64	18.5	.23	6.8	1.0		
															Excellent	Excellent
183/50R	2.5	0-2¾	118.9	11.6	61.0	54.0	28.1	13.4		2.57	25.9	.35	6.7	3.7	Fair	Excellent
		2¾-6¾	135.4	5.4	68.8	60.1	31.8	17.3		2.58	15.9	.19	6.8	3.0		
		6¾-8½		4.4	52.1	45.8	20.1	6.3		2.63			6.6	0.9		
187/10R	3	0-3	117.3	9.4	95.5	87.9	48.6	24.7		2.63	28.5	.40	6.6	2.9	Good ✓	Excellent
		3-6	121.8	9.9	85.6	79.3	45.1	23.4	6.0	2.63	25.8	.35	6.4	2.8		
		6-8¾	138.3	6.5	92.7	86.4	51.6	23.8	8.0	2.66	16.7	.20	5.8	1.5		
															Fair	Excellent
															Fair	Excellent
															Good	Excellent
															Good	Excellent

Project No. 8458 Constructed Spring 1947

July 1947

Station	Offset Ft.	Depth In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	mm. .002	Specific Gravity -4	Voids %	Voids Ratio	pH	Organic %	Condition of Turf June '47	November '47	May 1947 Stability
198/25R	2	0-3½	122.6	3.4	92.1	85.5	48.8	19.9	5.0	2.60	24.4	.32	6.0	2.1	Fair	Crabgrass Good	
		3½-6	134.6	3.9	60.9	54.0	28.6	9.2		2.62	17.7	.22	6.6	1.2			
		6-9	127.6	7.3	74.9	68.6	38.4	15.9		2.64	22.6	.29	6.4	1.7			

Project No. 8440 Constructed Spring 1947

Station	Offset Ft.	Depth In.	Dry Density Lb./Cu.Ft.	Moist %	% Finer Than Sieve #4	#10	#40	#200	mm. .002	Specific Gravity -4	Voids %	Voids Ratio	pH	Organic %	Condition of Turf June '47	November '47	May 1947 Stability
A251/50L	4	0-3	111.8	6.5	87.0	81.6	47.4	15.2		2.66	32.7	.49	5.7	1.9	Poor	Crabgrass Good	Poor
		3-6	122.9	6.7	86.2	81.9	43.0	12.0		2.60	24.2	.32	5.4	1.7			
		6-9	122.7	7.1	93.5	90.4	48.7	15.7		2.60	24.3	.32	5.3	2.2			
A251/20R	4	0-3	119.8	1.8	90.7	85.6	51.0	16.2		2.62	24.9	.33	6.0	1.9	Good	Crabgrass Good	Good
		3-6	124.1	3.6	94.3	86.1	46.6	11.0		2.62	24.1	.32	6.5	1.3			
		6-9	134.0	3.3	89.3	82.5	39.1	8.4		2.68	19.8	.25	6.2	0.9			
218/90R	3	0-3	119.6	1.5	88.2	80.8	43.7	13.6		2.72	29.6	.42	5.7	1.4	Fair	Crabgrass Good	Good
		3-6	134.7	2.5									6.0	0.8			
		6-9	125.4	1.6	63.9	59.5	34.6	8.0		2.64	23.3	.30	6.5	0.4			
221/58R	3	0-3½	111.9	7.5									5.2	2.8	Fair ✓	Crabgrass Good	Fair
		3½-6	127.3	7.6	93.2	85.9	51.6	23.3		2.60	21.5	.28	5.4	2.7			
		6-9	127.2	4.1	81.4	71.3	35.4	10.9		2.64	22.8	.30	5.8	1.2			
A252/20R (Not Stabilized)																	3" Depression

TABLE 2. TRAFFIC TEST DATA MAY 6, 1947*

Project	Station	Depth of Rut Inches	% Moisture at Depth (In.) 0-1"	0-3" 1-3"	3-6"	6-9"	Notes
8444 (Built 1945)		No measurable depression					
8440		No measurable depression					
(Built 1946)	238+50R	1/4		8.6	5.5	4.6	
8440	219+00R	1/2 ±		8.7	6.5	5.6	
(Built 1947)	A249+56R	3/4					
	A252+00R	3					Unstabilized shoulder
8438 (Built 1946)		No measurable depression					
8438 (Built 1947)	198+25R	1 ±					
1841	153+90	7/8					
(Built 1946)	155+10	1/4	.	17.1	13.9	16.8	
	157+62	1/2					
	159+70	1		16.2	13.8	15.2	
	163+38	7/8					
	164+25	1/2					
	172+00	1/2	18.0	14.0	12.7	13.3	
	173+60	1					
	176+40	1-1/4		18.9	14.4	13.6	
	178+00	7/16					After 1st pass
	"	3/4					" 2nd "
	"	5/8					" 3rd "
	179+00	1/4 ±	19.6	15.7	14.7	10.9	
	142± to 149±	3/4					Unstabilized shoulder

*All depressions not shown by a dimension were less than approximately 1/2 inch.

TABLE 3

BUILD UP STUDY ANALYSIS OF SECTIONS

Average differences between original elevations of 9/17/46 and those on dates shown. (Feet)

Project and Station	Shoulders 3/13/47	Shoulders 5/9 to 19/47	Shoulders 10/8 & 9/47	Ditch 3/13/47	Ditch 5/9 to 19/47	Ditch 10/8 & 9/47	Backslope 3/13/47	Backslope 5/9 to 19/47	Backslope 10/8 & 9/47
1841									
162+50/1	+.02	+.01	+.04	+.06	+.02	+.04	+.02	-.02	-.02
163+75/1	+.04	+.02	+.02	+.01	+.03	+.03	+.00	.00	+.02
165+00/1	+.04	+.03	+.02	-.02	+.01	+.02	-.04	.00	.00
170+50	+.03	+.01	.00	+.05	+.02	+.02	.00	-.02	-.03
171+75	+.03	.00	+.01	+.02	+.01	+.05	+.03	+.01	+.02
173+30	+.04	.00	+.01	+.03	+.01	+.03	+.01	-.02	-.02
8438									
180+00L	.00	.00	+.01	+.02	-.01	-.01	+.03	.00	+.02
182+00L	+.02	-.01	.00	-.03	+.01	+.01	+.01	.00	-.01
184+00L	+.03	+.01	+.03	-.03	-.01	-.03	.00	-.02	.00
180+00R	+.03	+.02	.00	+.02	+.02	+.01	+.01	.00	.00
182+00R	+.01	+.01	+.01	+.03	+.02	+.01	+.01	+.02	+.01
184+00R	+.02	+.03	.00	+.03	+.05	+.02	+.03	+.02	+.02
Averages	+.03-	+.01+	+.01+	+.02-	+.02-	+.02-	+.01-	.00	.00

/1 - Notes: Pavement slopes away from shoulder.

TABLE 4

EFFECT ON TURF OF CHEMICALS INCORPORATED IN 1945
ON PROJECT 8444

Material in Bed	Tons per Acre	Condition of Turf-Nov.'47 F* G**
None	–	F+
Calcium Chloride	0.5	F+
Sodium Nitrate	2.7	
+ Calcium Hydroxide	9.0	F
Sodium Chloride	18.2	F+
Aluminum Sulphate	3.2	F+
Ammonium Sulphate	3.0	F+
Ammonium Sulphate	3.0	
+ Calcium Hydroxide	9.0	F+
Sodium Chloride	3.2	F+
Sodium Chloride	3.2	
+ Calcium Chloride	3.2	F+
Sodium Chloride	3.2	
+ Calcium Hydroxide	4.5	F+
Sodium Nitrate	2.7	F
Sodium Nitrate	2.7	
+ Superphosphate	3.2	F
Sodium Nitrate	2.7	
+ Calcium Hydroxide	18.2	F+
Sodium Nitrate	2.7	
+ Cyanimid	3.5	F+
Sodium Nitrate	2.7	F-G
+ Aluminum Sulphate	3.2	
Sodium Nitrate	2.7	
+ Superphosphate	3.2	G
+ Potassium Chloride	3.2	
Superphosphate	4.5	G

Material in Bed	Tons per Acre	Condition of Turf-Nov.'47 F* G**
Cyanimid	7.2	G
Calcium Chloride	13.5	G+
Calcium Hydroxide	7.5	F+
+ Calcium Chloride	7.2	
Calcium Hydroxide	21.7	F+
Calcium Hydroxide	43.5	F+
Cement	6.0	F+
Cement	27.0	F+
Calcium Hydroxide	7.5	
+ Potassium Chloride	3.2	F+
Calcium Hydroxide	7.5	
+ Superphosphate	4.5	F+
Calcium Hydroxide	7.5	
+ Superphosphate	1.7	
+ Cyanimid	4.5	F+
Calcium Hydroxide	7.5	
+ Cyanimid	8.2	F+
Calcium Hydroxide	7.5	
+ Aluminum Sulphate	3.2	F+
Potassium Chloride	3.2	F+
Potassium Chloride	3.2	
+ Superphosphate	4.5	F+
Potassium Chloride	3.2	
+ Calcium Hydroxide	9.0	F+
Potassium Chloride	3.2	
+ Cyanimid	3.7	F+
Potassium Chloride	3.2	
+ Aluminum Sulphate	3.2	F+
Ammonium Sulphate	0.5	F+
Ammonium Sulphate	5.5	F+
None	–	F+

*F-Fair
**G-Good

DISCUSSION OF PROGRESS REPORT BY IURKA

Mr. Iurka was asked the following questions:

It is generally recognized that close mowing is not beneficial to turf, but has there been any study of the question of whether closer or more frequent mowing would reduce build-up?

Mr. Iurka: No such observations have been made.

Was the test truck operated fast enough? It would seem that a higher speed would be desirable to be more comparable to actual traffic use.

Mr. Iurka: No opinion to express on this question.

What do you consider the best method of measuring the bearing value of a shoulder with a test truck; pounds per sq. in.; pounds per inch width of tire; or total pounds?

Mr. Iurka: We should accept the recommendations of the soils engineers as to method and the method should be designed for our particular purpose. Mr. McAlpin of our Soils Bureau is present and can answer that question better than I.

Mr. McAlpin: It seems necessary to better define the types of soils being considered. A sand is different than a fine grain soil. For example, confined sands are stable; a mat of turf over sand would confine the sand. Clay soils are not so resistant to vertical loads. In testing stabilized shoulders it is necessary to consider not only wheel load but also the shearing stress. Traffic tests would seem to be the best method as they provide durability tests as well as tests of bearing capacity. In any case, these tests are in the realm of soils mechanics and should be referred to the local Soils Mechanics Bureaus.

You mention a turf mat confining sand and giving stability. An experience with "blow" sand showed a mat of turf confined the sand and gave a stable shoulder until the turf mat was broken in one small place. Thereafter there was a rapid disintegration of a considerable shoulder area. It would seem that such a condition would be hazardous insofar as permanent stability is concerned.

Mr. McAlpin: A clay loam, or perhaps better, another sand could be added to the sand for better gradation to provide stability. It is of course important to have the shoulder stand up during the period of germination and establishment of turf.

Do the reported slight depressions caused by the test truck in turf shoulders lead to destruction of stability?

Mr. McAlpin: Depressions in sandy shoulders such as those reported are not significant because such a porous soil holds so little water.

Included in the report is a table of chemical amendments used. What conclusions have you made in reference to the use of these materials?

Mr. McAlpin: No conclusions have been reported. The data is presented because it seemed of interest that large amounts of chemicals including complete fertilizers (applied in amounts much greater than under agricultural practices,) salt, calcium chloride and even cement did not produce an effect on the turf as observed after three growing seasons, such as would have been expected. The best growth at the time of observation reported was in the bed where calcium chloride was applied at the rate of $13\frac{1}{2}$ tons per acre. My opinion is that this data indicates the extent of leaching in our soils.

The report indicates the relatively lesser importance to plant growth of certain factors such as type and amount of mulch, amendments, rate, season and method of seeding. Does this mean that these factors are of no importance?

The question provides the opportunity to stress that this statement is made on the basis of an inspection two or three seasons after construction. These factors have more or less immediate effect; for example, application of fertilizer on the surface resulted in quicker development of growth immediately after germination than did the incorporation of fertilizer in the 6 in. depth of stabilized materials. Other factors have obscured these differences since then.