GRAVEL STABILIZED SHOULDERS for TURF as USED on the NATCHEZ TRACE PARKWAY

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GENERAL

In November 1954, the first section of road on the Natchez Trace Parkway with stabilized shoulders for turf was completed. Since then, in November 1955, and December 1956, two other sections of parkway road with stabilized shoulders for turf have been completed.

These projects are located in separated areas having different climates, soils, vegetation, and available sources of gravel metal for use as the stabilizing agents in the shoulders. The southernmost of the three projects is of interest primarily because of the loess soil that is characteristic of the region.

These projects, the locations of which are shown in Figure 1, are:

1. Project 1H6-1J9-2A11, length 34 miles, Wayne County, Tenn. and Lauderdale County, Ala., completed in November 1954.
2. Project 3K3-3L7, length 15 miles, Choctaw and Attala Counties, Miss., completed in November 1955.
3. Project 3W5-3W6, length 12 miles, Jefferson and Adams Counties, Miss., completed December 1956.

In all instances the shoulders were stabilized and planted in conjunction with, and under the same contract for, the construction of a hot-asphalt-concrete pavement. The contract for the construction of the pavement and the stabilized shoulders for turf was the last of a series of construction contracts on staged construction.

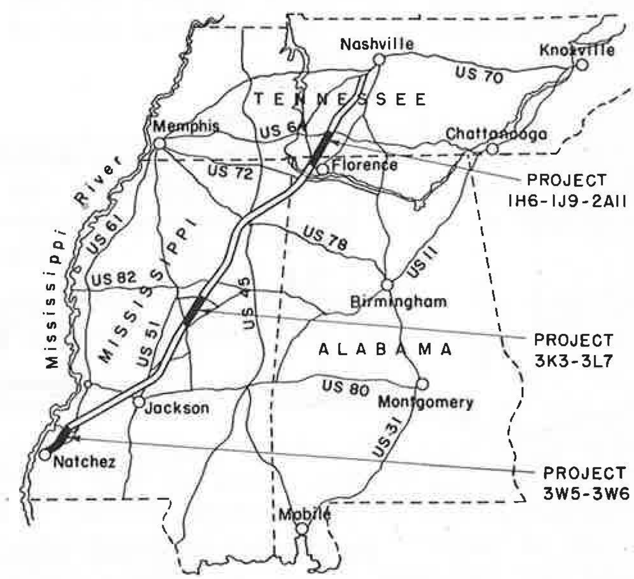

Figure 1. Natchez Trace Parkway.

GEOLOGY AND CLIMATE

Project 1H6-1J9-2A11 is in the Tennessee River Basin. The HRB Soils Classifications run from A-2 to A-7. In some areas a considerable amount of gravel was naturally present in the roadbed material. Agriculturally, the soil could be considered poor or submarginal. All the ingredients for the stabilized shoulders, including the mineral aggregate, were available locally. The mineral aggregate included bank-run and stream-bed gravel. Both materials were in ample quantity and were naturally within the limits specified for physical properties. The climate is continental and warm temperate with a mean average rainfall of 50 in. The heaviest precipitation is in the winter and early spring months.

Project 3K3-3L7 is in the Gulf Coastal Plain area. The soils are unconsolidated clays, A-7-5 and A-7-6, with occasional areas of A-2-4 and A-2-6 sands. The gravel metal was imported from commercial sources, involving freight and truck hauls totaling approximately 75 miles. Sand and loamy filler were available locally. The climate is characterized by short, mild winters and long, hot summers with an average rainfall of 50 in. Both weather and soils are conducive to a good growth of vegetation.

The soils of Project 3W5-3W6 are loess, HRB Classification A-4, and unconsolidated sand, gravel, and clay having HRB Classifications of A-7-5 and A-7-6. Streambed gravel, sand, and silt-loam were locally available. The area has a warm temperate, humid climate characterized by long summers and short, mild, damp winters. The mean average rainfall is about 50 in.

DESIGN

The plans, specifications, and estimates for this and other construction work on the Natchez Trace Parkway were prepared by the Bureau of Public Roads and reviewed and approved by the National Park Service. The inspection of construction was by personnel of the Bureau of Public Roads. Through both the planning and construction stages the landscape and other esthetic features have been carefully appraised by landscape architects of the National Park Service.

The preparation of the plans, specifications, and estimates for the pavement and the shoulder work for the three projects presented but few problems. The typical cross-sections specified a width of pavement of 22 ft in all instances and widths of shoulders of 5 to 6 ft, depending on the available width of the existing roadbed (Fig. 2).

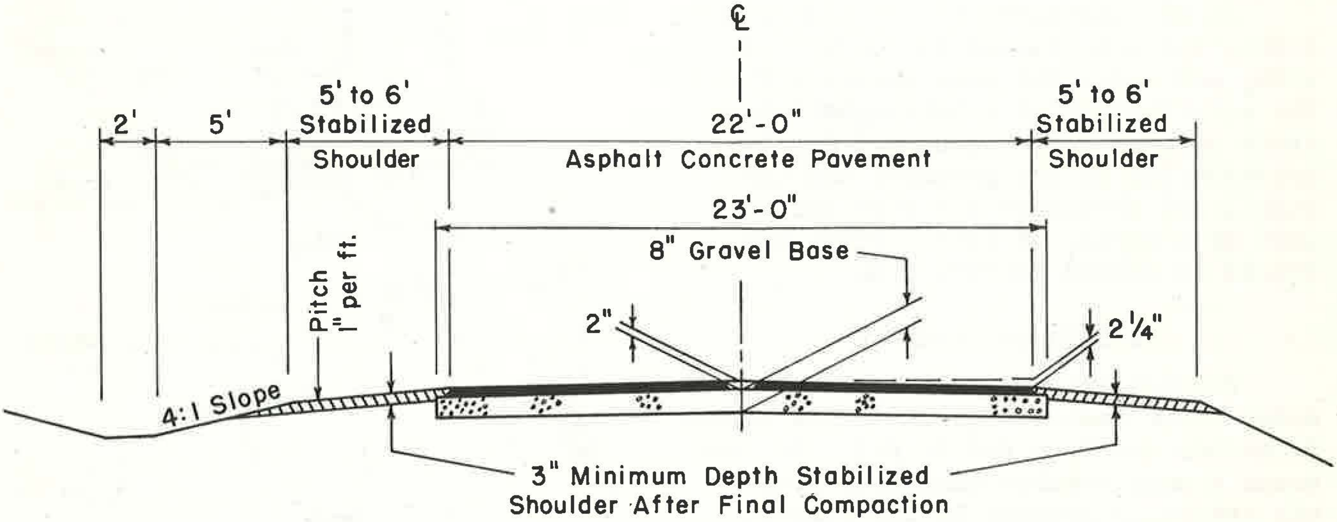

Figure 2. Typical section, Natchez Trace Parkway.

The curves were superelevated for a speed of 70 mph with compatible horizontal and vertical sight distances. The Parkway has a speed limit of 50 mph and is restricted to passenger vehicles.

The design of the profile grade line for the pavement and, incidentally, the stabilized shoulders demanded careful consideration for practicable and economical

Figure 3. Stabilized shoulder on 2A11 portion (Alabama) after final compaction and one full growing season. Photograph taken during winter. Tire track from car is only faintly visible on supersaturated stabilized shoulder.

Figure 4. Stabilized shoulder on 2A11 portion (Alabama) after final compaction and one full growing season. Photograph taken during dormant winter months. The "ghost finger" inexplicably points to the tire mark, which is only a slight indentation on the supersaturated stabilized shoulder. This is one of a few places where the grass developed poorly; numerous quail flocked to this area and may have eaten all the seed.

reasons on Project 1H6-1J9-2A11 and Project 3W5-3W6. The gravel bases of these projects had been constructed many years prior to the inception of the work on the pavement and stabilized shoulders for turf. Some of the shoulders had a fair to excellent stand of Bermuda grass and some gravel whipped from the base course. This existing gravelly crust with an interstitial root system of Bermuda stolons had a noticeable stability which was incorporated into the design for the stabilized shoulders insofar as possible.

On all three projects the shoulders were designed for a pitch of 1 in. per ft and a minimum 3-in. thickness of stabilized material after final heavy compaction.

SPECIFICATIONS

Although the specifications for each of the three projects were basically the same, some modifications were required to adapt them to local conditions and available materials. To permit the exploitation of native aggregates, it was believed that the maxima and minima on gradations of aggregate should be as liberal as is commensurate with the desired results. However, gravel particles that are too large in proportion to the 3-in. thickness of stabilized shoulders diminish the interstices needed for the growth of turf, are easily dislodged, and will damage mower blades.

The grading for the composite mixture given in Table 1 has permitted the use of a wide range of gradations with excellent results. In all cases the material used was an uncrushed gravel.

TABLE 1

REQUIREMENTS FOR GRADING

Sieve Designation	Percentage Weight Passing (AASHO T-27)
$1\frac{1}{2}$ in.	100
1 in.	80 - 100
3/4 in.	70 - 100
3/8 in.	60 - 100
No. 4	50 - 75
No. 10	30 - 60
No. 40	20 - 40
No. 200	10 - 20

It was specified that the stabilizer material should be either a natural material or a blend of two or more materials. Some blending is usually required because of the incorporation of loamy topsoil, if for no other reason. The fraction passing the No. 200 sieve was less than two-thirds of the fraction passing the No. 40 sieve. The portion of the material passing the No. 40 sieve had a liquid limit of not more than 35 and a plasticity index of between 4 and 9.

Figure 5. On Project 1H6-1J9-2A11 following final compaction and one full growing season. Note supersaturated stabilized shoulder after several passes with empty maintenance truck. Grass is in winter dormancy.

Figure 6. On Project 1H6-1J9-2A11. Close view of turf on stabilized shoulder during winter months following final compaction and one full growing season. Shoulder is thoroughly saturated, but only a slight tire track is evident immediately behind the car.

The specifications for the seeding of the stabilized shoulders called for ground limestone at the rate of 70 lb per 1,000 sq ft of surface area, 10-6-4 fertilizer or the equivalent for nitrogen content at the rate of 25 lb per 1,000 sq ft,

Figure 7. This and Figures 8 and 9 show the varied results on the 6-mile length of the 2A11 portion after three full growing seasons. Photo shows the vestige of the "phantom strip" next to the pavement. The 2A11 portion has a gravel base for the full width of the roadbed.

Bermuda grass roots at the rate of at least 6 linear ft of roots per sq ft of surface, Bermuda grass seed and Lespedeza seed each in the amount of 3/4 lb per 1,000 sq ft of surface, and straw mulch at 80 lb dry weight per 1,000 sq ft. For fall seeding, Italian ryegrass seed was also added at the rate of $\frac{1}{2}$ lb per 1,000 sq ft.

The rate of application of mulch was actually 40 to 80 lb per 1,000 sq ft. The heavier application was given on the low side of the superelevated sections. The possibility of heavy rains during or soon after the seeding of the stabilized shoulders also influenced the rate of application of mulch.

The specifications provided for the undercutting of the existing shoulders to remove excess or unsatisfactory material. Very little work of this nature was necessary. The grading and gravel bases on some stretches of the projects were constructed in the late 1930's when the requirements on compaction were not as specific as in later years. Records of the older construction are incomplete but, from observation during the construction of the stabilized shoulders, it is believed the density on the existing roadbed material would equal present-day requirements, or 95 percent for embankment and 100 percent for gravel base.

CONSTRUCTION METHODS

The specifications for construction by contract were as broad as possible to permit general experimentation and were prepared on the premise of additional work on booster applications of seed and fertilizer, and final heavy compaction by post construction. The construction of the stabilized shoulders followed soon after the completion of the roadway pavement.

The narrow working limits of each shoulder indicated the use of spreaderboxes for the placing of the stabilizer material. However, satisfactory results were obtained with motor graders, and disking and harrowing machines. Traveling mixers were used and produced excellent results.

Figure 8. See general comments for Figure 7. A lush growth of turf in stabilized shoulders.

The stabilized shoulders were designed for a compacted thickness of 3 in. To permit an initial growth of the seed and grass roots in the interstices of the stabilizer material before reducing the porosity with the final compaction it was specified that the stabilizer material be left by the contractor in a loosened or semi-loosened condition as obtained for normal seeding operations with a Culti-packer. For a compacted thickness of 3 in. a loose thickness of about 4 in. was required. With light compaction by a Culti-packer following the seeding operations the shoul-

Figure 9. See general comments for Figure 7. View of stabilized shoulder used for pull-out parking to read an information sign.

Figure 10. Typical for the 12-mile 1H6 portion (Tennessee) after three full growing seasons. Lush growth might subside upon discontinuation of yearly booster application of fertilizer.

ders were even with the pavement. Upon final compaction by a medium heavy roller several months later during post-construction operations the finished surface of the stabilized shoulder depressed in general to about 1 in. below the pavement surface.

Prior to placing the stabilizer material, the subgrade of the shoulders was depressed from approximately 2 to 4 in. below the grade of the pavement edge and

Figure 11. Good cover of turf on stabilized shoulders of the 1J2 portion after three full growing seasons.

with the same pitch of the finished shoulder. The actual depth of the subgrade depended on the extent to which the "in place" material was suitable for pulverizing and blending with imported material.

If the stabilizer material was furnished in the separate components, that is, in components of gravel metal, coarse sand, fine sand, and loam, they were placed by layers of the constituent parts to the predetermined thickness and then blended.

The ground limestone, fertilizer, and seed were applied by conventional methods. The Bermuda grass roots were cast and disked into the stabilizer material. Mulch was cast by hand or by mechanical blower.

POST CONSTRUCTION

Upon completion of the contract phase of construction the stabilizer material with all the components of the seeding operation was left in a loosened or semi-loosened condition. In this condition the shoulders were soft and had no stability.

The contract work on all three projects was completed during November or December. Except for the southernmost project this left little or no growing time for the seed and grass roots before cold weather closed in.

By arrangements with the National Park Service their maintenance force performed the post-construction work. On each project the post-construction work was started during the early spring season following completion of the contract work. The shoulders were mowed and the cuttings left in place as mulch. If the surface of the shoulders was encrusted, the crust was broken by a light harrowing or scarifying but not to an extent that would tend to turn the stabilizer material over or unduly disturb it. Bermuda grass seed was applied at the rate of 20 to 30 lb per mile of each shoulder. Commercial 5-10-5 or 6-8-8 fertilizer was applied at the rate of 300 to 400 lb per mile of each shoulder.

With an allowance of at least a 30-day growing period following these booster applications of fertilizer and seed, the shoulders were given a final hard compaction immediately after a saturating rain. A rubberized roller approximately 6 ft wide and weighing about 4 tons was used. Two to four passes were made with the roller on each shoulder. There were no noticeable differences between the results of two and four passes.

The final rolling generally left the shoulders depressed about 1 in. below the surface of the edge of the pavement. This is considered a desirable feature to provide for the future build-up of the stabilized shoulders.

In addition to the first spring booster application of fertilizer, on the initial or northernmost project, booster applications of from 200 to 300 lb per mile of each shoulder were given during the two succeeding spring seasons. It is not intended to extend these applications of fertilizer beyond the third spring season following the initial construction. During the succeeding spring seasons the shoulders were spot-seeded where needed. Because of the more favorable growing conditions on the two southernmost projects, less spot seeding and fewer applications of fertilizer were required beyond the first spring following construction.

CONTRACT ITEMS OF WORK AND COSTS

The provisions for the contract construction work included the following pay items: (a) unclassified excavation for the removal of surplus material from the existing shoulders; (b) gravel material for stabilized shoulders; (c) stabilizing shoulders (disking, blading, shaping, etc.); (d) seeding stabilized shoulders; and (e) water for wetting stabilizer material and seeded areas.

The number of pay items could be reduced by combining several of the above items. The multiple-item basis was preferred because it relieved the contractors of some of the elements of chance in their bidding due to the variable conditions usually encountered on a project. Also, in the event that the stabilized shoulders are completed too late in the winter months to permit seeding operations, the multiple-item basis would permit omitting this work from the contract without upsetting the unit bid prices.

The cost per mile of roadway of the contract work on the stabilization of shoulders for the three projects ranged from $1,150 to $1,965, the seeding $445 to $560, and the post-construction work $140 to $185. The figures for post-construction work are based on estimates rather than actual costs. Including the pavement and all other work, each of the three contracts was in the category of $375,000 to $500,000. Bidding was very competitive.

OBSERVATIONS

1. The three projects in the states of Tennessee, Alabama, and Mississippi covered by this report are spread over a north-south range of about 275 miles. One has been completed for one year, another for two years, and the third for three years. It will probably be several more years before definite conclusions can be determined on the permanency of the results on either the stabilization or seeding. The results to date have proved to be very satisfactory.

2. An intermediate degree for both stability of shoulders and turfed covering was the goal. On the inception of the design and the preparation of the specifications, it was the assumption that overemphasis of the importance of one of these features would be to the detriment of the other. Designing for the needs of only passenger vehicles permitted some latitude in this assumption. A heavy cover of turf, for example, with cuttings from frequent mowings, combined with the expanding root system would probably contribute to the building up of the shoulders and would require more frequent scalping of raised shoulders with the loss of valuable stabilizer material in the process.

3. To provide some leeway for the future build-up of the stabilized shoulders it is believed that the stabilized shoulders should be depressed by about 1 in. upon completion of the final heavy compaction. Driving tests in a light passenger car have shown that this slight depression does not endanger the vehicle when running off the pavement at speeds up to 55 mph. This depression of 1 in. is provided by the 4 in. of loose stabilizer material being even with the pavement on the initial operation and compressing to about 3 in. on the final compaction.

4. The stabilized shoulders have equaled or exceeded expectations. All three projects have been inspected several times following the final compaction and during or immediately following heavy saturating rains. At speeds up to 60 mph in a light passenger car the outside wheels have repeatedly been driven off the pavement and onto the wet stabilized shoulders. At 50 mph there was no danger or discomfort, at 55 mph it was safe with a slight uneasiness, and at 60 mph there was a tenseness of the operator because of the vibration of the car from the roughness of the shoulder. The only evidence of wheel marks left on the wet stabilized shoulders was more from the crushed turf than from tire indentations. On an adjoining section of parkway road with ordinary dirt shoulders with turf the same tests were made under similar conditions except that the speed of the vehicle was reduced to about 15 mph. The car renegotiated the pavement only by virtue of the vehicle's momentum and a spinning driving wheel, leaving ruts in the wet shoulder at least 6 in. in depth.

5. A slope of shoulder of 1 in. per ft is believed to be ideal. This is steep

enough for fast surface drainage yet flat enough for a good surface continuity as observed from the driving tests.

6. There is a definite saving in maintenance cost by not having to patch ruts in shoulders.

7. There is some economic value in having stabilized shoulders that can be mowed immediately following a heavy saturating rain. On the sections of the parkway having dirt turfed shoulders the mowing operations have to be suspended for several days following each heavy rain; otherwise ruts are left by the mowing machines.

8. On the two southernmost projects all seeding and grass roots grow satisfactorily. On the northernmost project the Lespedeza and Italian ryegrass seed produced good results, with little or no noticeable results from the Bermuda grass seed and roots on the initial planting. This is common to the locality for this type of planting, especially when it is planted during the fall season.

9. This report would not be complete without some comment on the so-called "phantom strip." On all three projects, after the seeding had obtained the initial growth, it was noticed on occasional long stretches of shoulder that there were regular strips about 1 ft wide and adjacent to the pavement that had no growth of grass. Through successive periods of refertilization and reseeding these bare strips acquired some growth or have narrowed down to only a few in. The reason for this phenomenon is unknown. It was not caused by car wheels over-riding the pavements. Neither is it believed to have been caused by the wash of surface water from the pavement floating the seed and fertilizer off to other places. It occurs on both the high and low side of superelevated curves. The bare strip could not be due to the bituminous material in the adjacent pavement. On older projects without stabilized shoulders Bermuda grass actually grows in the edges of similar pavement. On the previous construction of 65 miles of bituminous pavement with ordinary shoulders of topsoil and seeding the "phantom strip" did not appear. It was thought that the seed in flotation in the surface waters might be carried to sufficient depths in the interstices of the loose stabilizer material to prevent growing. However, subsequent seeding after the heavier compactions of the shoulder material does not give noticeably improved results.

DISCUSSION

IURKA: The Committee on Roadside Development welcomes this addition to the information on stabilized turf shoulders which it has been gathering since 1945.

I am sure that Mr. Buchanan does not intend that his report should convey the impression that a 3-in. top course, without definition of base or subgrade and particularly with no compaction for stability (and no specification of compaction) should be considered acceptable for stability even for passenger cars. Additional information, such as soils data of base and subgrade, soil density, and traffic tests comparable to others reported would make the report more valuable.

The concluding report of the Subcommittee on Stabilized Turf Shoulders, published as Special Report 19 by the Highway Research Board, recommended particularly that terms such as "loam" and "topsoil" should not be used as a panacea for turf growth. It has been shown that an excellent turf could be grown on materials satisfying the AASHO specifications for "Materials for Soil Aggregate Surface Courses" compacted to 95 percent of maximum density.

It is not necessary to get turf growth started before compaction for stability, and this practice is certainly undesirable from the standpoints of safety and economy. At Maxwell Field, Montgomery, Ala., for example, the Corps of Engineers, in 1945 found no correlation between compaction and turf development.

SLACK: The work described by Mr. Buchanan and done near Natchez, Miss., is of twofold interest to me. First, it was done in the loess-soil area, and second, it being near the Mississippi-Louisiana line, I had the opportunity to visit and inspect the project on December 19, 1957, a few weeks before coming to the Annual Meeting. Louisiana itself has certain areas of loess soil with which I am familiar, and it must be handled carefully to prevent erosion.

On December 19, 1957, one or two days after a rain, I inspected this project of 12 miles and made notes. Purposely I drove onto the shoulders at a speed of 30 to 40 mph. It was my observation that the shoulders were stabilized sufficiently that no rutting whatever occurred. It was my opinion that Mr. Buchanan's work accomplished the purpose of providing turf stabilized shoulders, safe for light traffic emergencies, on this parkway, the Natchez Trace. Further, the objective of the turf being less dense on the shoulders in comparison to the other parts of the rights-of-way was definitely accomplished and still holds, thus tending to cut down the maintenance cost of mowing. As a whole, this new section of the Natchez Trace is a well-designed parkway and a beautiful job. As no trucks are allowed on this parkway, it is my opinion that the stabilized shoulders serve the purpose for which they are intended.