Technical Report Documentation Page

1. Report No. TX-95/1903-2F	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle AVOIDING DEGRADATION OF ROAD SHOULDER ASPHALT DUE TO TURFGRASS ENCROACHMENT		5. Report Date July 1995 6. Performing Organization Code
7. Author(s) M.C. Engelke, S.K. Riffell, and K.B. Marcum		8. Performing Organization Report No. Research Report 1903-2F
9. Performing Organization Name and Address Texas Transportation Institute and Texas A&M University Research Center The Texas A&M University System Dallas, Texas 75252		10. Work Unit No. (TRAIS) 11. Contract or Grant No. Study No. 7-1903
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Final: December 1992-December 1994 14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation.
Research Study Title: Avoiding Degradation of Road Shoulder Asphalt Due to Turfgrass Encroachment

16. Abstract

Bermudagrass is widely used to stabilize road shoulders. However, the invasive rhizomes of bermudagrass often penetrate the asphalt causing severe deterioration. To avoid expensive and time-consuming repairs, herbicides are used to retard the growth of bermudagrass, but frequent applications are expensive and are subject to ever increasing regulations. To identify suitable alternatives to bermudagrass, we planted four turfgrasses adjacent to an asphalt road. We evaluated competitive ability, overall turf performance and changes in asphalt integrity. Both St. Augustinegrass and bermudagrass caused substantial deterioration of the asphalt. Buffalograss caused little or no asphalt deterioration, and was a very strong competitor in the roadside environment. Use of buffalograss instead of bermudagrass would not only save valuable time and resources, but would also avoid controversial input of chemicals into the environment.

17. Key Words Buffalograss, Bermudagrass, Road Shoulder Maintenance, Herbicide, Turfgrass, Turf Quality, Turf Performance Index, Asphalt integrity, Ultrasonic Wave Methods, Rhizomes, Stolons, Analysis of Variance.	18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 30	22. Price

AVOIDING DEGRADATION OF ROAD SHOULDER ASPHALT DUE TO TURFGRASS ENCROACHMENT

by

Dr. M. C. Engelke
Associate Professor
Texas A&M Research Center at Dallas

S. K. Riffell
Research Associate
Texas A&M Research Center at Dallas

and

Dr. K. B. Marcum
Former Research Scientist
Texas A&M Research Center at Dallas

Research Report 1903-2F
Research Study Number 7-1903
Research Study Title: Avoiding Degradation of Road Shoulder Asphalt
Due to Turfgrass Encroachment

Sponsored by the

Texas Department of Transportation

July 1995

TEXAS TRANSPORTATION INSTITUTE
The Texas A & M University System
College Station, Texas 77843-3135

IMPLEMENTATION STATEMENT

Bermudagrass is widely used to stabilize road shoulders in central Texas because it is well-adapted to the drought-stress, low-maintenance conditions characteristic of road shoulder environments. However, bermudagrass has invasive rhizomes which often degrade the adjacent asphalt when growth of the turfgrass is left unchecked. Our research indicates that buffalograss is an acceptable alternative to bermudagrass. Buffalograss is competitive under low-maintenance conditions, but lacks invasive and damaging rhizomes. Using buffalograss along road shoulders would save not only time and money spent repairing road shoulders or applying herbicides, but would also avoid unnecessary input of potentially hazardous chemicals into the environment.

DISCLAIMER

ACKNOWLEDGMENT

This study was sponsored in part by the Texas Department of Transportation. Research was supported by the Texas Transportation Institute and the Texas Research Foundation. Site location and management were made possible by the Texas A&M Research and Extension Center in Dallas, Texas. Evaluation of asphalt integrity was graciously conducted by S. Nazarian.

TABLE OF CONTENTS

LIST OF TABLES

SUMMARY

Bermudagrass is well-adapted to low-maintenance conditions and is widely used to stabilize road shoulders. However, the invasive rhizomes of bermudagrass can and often do penetrate the asphalt. This results in road shoulder deterioration which is costly to repair. Thus, herbicides must be used to curb the growth of the bermudagrass so that asphalt degradation is delayed or avoided. Both the expense and environmental concerns associated with chemical applications make identifying suitable alternatives to bermudagrass a real need.

To evaluate potential alternatives to bermudagrass, we planted four turfgrasses alongside a road shoulder-- bermudagrass, buffalograss, St. Augustinegrass, and zoysiagrass. We evaluated the persistence, competitive ability and overall turf quality of these grasses over a three year period. Growth of stolons over the asphalt and pegging of stolons into the asphalt surface were noted. We took baseline measurements of asphalt integrity using ultrasonic methods developed primarily for evaluating asphalt quality. We repeated these measurements at the close of the study. Differences between the two dates indicate the degree to which the asphalt deteriorated during the study period.

According to ultrasonic measurements, the most severe deterioration occurred in asphalt bordered by St. Augustinegrass and bermudagrass. Substantially less deterioration occurred in asphalt bordered by zoysiagrass. Ultrasonic measurements indicated little or no deterioration in asphalt bordered by control or buffalograss plots. Buffalograss was competitive with bermudagrass in terms of both persistence and overall turf quality.

Our data indicate that buffalograss is a competitive turfgrass suitable for use in roadside environments. The use of buffalograss for road shoulder stabilization would avoid the expensive repairs which accompany the use of bermudagrass. Additionally, no herbicide applications would be necessary to check the growth of buffalograss, saving dollars and avoiding controversial input of chemicals into the environment.

INTRODUCTION

Common bermudagrass (*Cyanodon dactylon*) adapts well to the varying environmental conditions characteristic of north Texas climate, thriving with little or no supplemental irrigation or fertilization. Because bermudagrass requires so little maintenance, it is often used to stabilize road shoulders, preventing undesirable and costly erosion along roadsides. As an erosion control tool, bermudagrass has been quite effective. However, the invasive rhizomes of bermudagrass can and do penetrate asphalt, resulting in substantial degradation of the road shoulder in just a few years. Repair and replacement of deteriorated road shoulders is costly.

The application of residual herbicides to prevent bermudagrass rhizomes from encroaching into the asphalt can reduce road shoulder degradation. Such remedies are still expensive, costing Texas millions of dollars annually. Additionally, recent shifts in both public opinion and government legislation will soon require reductions in the amount and frequency of chemical applications.

In light of the cost of repeated chemical applications and the uncertainty about the availability of herbicides, it is imperative that an effective alternative to bermudagrass be located and its use implemented. An ideal replacement would be similarly adapted to extreme seasonal fluctuations in climate, require little or no maintenance and be a strong competitor with vigorous growth habits. Additionally, an ideal replacement would lack the damaging rhizomes responsible for asphalt degradation. If a suitable turfgrass were identified, millions of dollars currently spent on road-shoulder repair and herbicide application could be redirected to other uses.

We believe that alternatives to bermudagrass do exist, and need only to be identified. One such possibility is buffalograss, which is native to the Texas and the Great Plains states. Like bermudagrass, buffalograss is competitive under low-maintenance, high-stress conditions, but buffalograss lacks invasive and damaging rhizomes, growing by stolons instead. We assessed the potential of buffalograss and other common turfgrass species to serve as effective alternatives to bermudagrass. We evaluated both turfgrass performance and asphalt degradation over a three-year period.

MATERIALS AND METHODS

TURFGRASS VARIETIES

We included four turfgrass varieties in the study: 'Prairie' buffalograss (*Buchloe dactyloides*); 'Meyer' zoysiagrass (*Zoysia japonica*); 'Nortam', an experimental variety of St. Augustinegrass, (*Stenotaphrum secundatum*); and 'Tifway' bermudagrass (*C. dactylon*).

TEST SITE

We located the study adjacent to an asphalt road within the confines of the Texas A&M Research and Extension Center in Dallas. The verge was initially planted with common bermudagrass. The road received a significant amount of traffic flow from a parking facility at the center.

PLANTING AND MANAGEMENT

The turfgrasses were planted 27 March 1992. We initially prepared the test site for planting by removing three feet of the sod immediately adjacent to the asphalt. We removed the sod to a depth of 5.1 cm. The grasses were planted in 0.9 m x 2.4 m plots. Plots were rolled, fertilized and irrigated regularly until established. Once established, the study was maintained as part of the roadside verge -- mowed regularly with little or no irrigation or fertilizer.

EVALUATIONS

Overall turf performance and persistence

We evaluated the overall turf quality of each turfgrass on a scale of 1 to 9, where 9 was the best and 5 was the minimum acceptable level of turf quality (*sensu* Hickey and Engelke 1984). Seven aspects of turf performance contributed to this rating: turf cover, color, canopy density, uniformity, smoothness, spread and texture. We estimated turfgrass persistence as the percentage of the plot that was covered with turf, which is an indicator of the relative competitive ability of the turfgrass.

Stolon overgrowth and pegging

We determined the distance of stolon overgrowth by pulling the turfgrass back to the edge of the asphalt and measuring the distance to the furthest stolon. This was done at three sampling points within each plot. Sampling points were located 0.61 m, 1.21 m and 1.83 m from the northern most edge of the plot. We also marked the furthest point where stolons had pegged (or penetrated) the asphalt surface at each sampling point.

Asphalt integrity

We determined the degree of asphalt degradation using wave-propagation techniques developed by Nazarian (1990; see also Yibin and Nazarian 1992). We compared initial measurements of asphalt integrity taken June 1992 to measurements taken after the completion of the study (January 1995).

In wave propagation techniques, the goal is to determine the travel time (or wave velocity) of compression waves in the asphalt. Wave velocity is a direct indication of the stiffness, or integrity, of the asphalt. Higher wave velocity is associated with greater stiffness (Yibin and Nazarian 1992). The ultrasonic body wave method (UBW) measures the velocities of both shear and compression waves. From these measurements, we can calculate Young's modulus and Poisson's ratio of the surface layer. Young's modulus, G, is equal to:

$$G = \rho V^2$$

where V is shear wave velocity and ρ is mass density. Poisson's ratio (υ) is related to Young's modulus by

$$E = 2G(1+\upsilon).$$

Thus, lower values for Young's modulus and higher values of Poisson's ratios would indicate less stiffness and greater deterioration of the asphalt (S. Nazarian, *personal communication*).

Because properties of asphalt can vary with depth, wave velocities can also vary with depth. Thus, it is necessary to employ the ultrasonic surface wave method (USW), where cross power spectrums are used to determine Young's modulus and Poisson's ratio at various depths. The quality of the data can be significantly enhanced by averaging spectral functions several times.

STATISTICAL ANALYSES

We planted the study in a randomized complete-block design with four replications and used analysis of variance to test for difference among means (Zar 1984). When the ANOVA *F*-test was significant, we used the Waller-Duncan *k*-ratio *t*-test (Ott 1988) to separate the means. All percentage data were arcsin transformed prior to performing statistical tests (Zar 1984). If the assumptions of analysis of variance were not clearly satisfied, the results of the nonparametric Kruskal-Wallis tests were consistent with the results of the parametric tests. *A priori* $\alpha = 0.10$ for all analyses. All tests were conducted using SAS statistical software (SAS Institute, Inc. 1985).

For each turfgrass in the trial, we calculated a turf performance index or TPI (Engelke, et al. 1994). A TPI is the number of times a particular turfgrass was rated in the best statistical category. The TPI is a dimensionless, nonparametric statistic and yields valuable information about the performance consistency of a turfgrass relative to the other grasses in the trial.

RESULTS AND DISCUSSION

STOLON OVERGROWTH AND PEGGING

The amount of stolon overgrowth did not differ significantly among grasses early in the study (Table 1). However, we did observe significant differences at the end of 1994. Bermudagrass had overgrown the asphalt edge by an average of 24.6 cm, significantly more than any other grass. Buffalograss had overgrown the asphalt edge by 13.5 cm, St. Augustinegrass by 11.3 cm, and Meyer zoysiagrass by 3.3 cm.

We observed an identical pattern in the maximum distance of stolon pegging (Table 2). Bermudagrass pegged the asphalt at a mean maximum distance of 17.7 cm, significantly farther from the edge than any of the other grasses. Buffalograss pegged the asphalt surface 11.2 cm from the edge; St. Augustinegrass at 5.7 cm; and zoysiagrass at 3.0 cm.

COMPETITIVE AND OVERALL TURFGRASS PERFORMANCE

Bermudagrass and buffalograss still covered > 80% of the plot by the end of 1994 (Table 3), significantly more than the other two grasses. Neither St. Augustinegrass nor zoysiagrass covered more than 60% of the plot.

Similarly, bermudagrass and buffalograss exhibited excellent overall turf quality (Table 4). We rated these grasses at a mean of 7.5 and 7.1, respectively, significantly higher than either St. Augustinegrass or zoysiagrass.

ASPHALT INTEGRITY

Lower values of Young's modulus and higher values of Poisson's ratio result from lower wave velocities, indicating lower asphalt stiffness (or greater degradation due to turfgrass penetration). In contrast to this expected trend, however, the moduli were typically higher and the Poisson's ratios were lower in 1995 than they were in 1992. Two factors account for these trends in the data:

(1) We carried out measurements in 1992 at an ambient temperature of approximately 29°C, whereas measurements in 1995 were carried out at a temperature of 21°C. Although we corrected readings empirically, the correction is not perfect (S. Nazarian, *personal communication*).

(2) Aging of asphalt typically results in higher modulus and lower Poisson's ratio (S. Nazarian, *personal communication*).

Table 1. Distance (cm) of stolon growth over the asphalt edge.

Grass	1 Dec 1992	1 Dec 1994
Tifway Bermudagrass	8.2	24.6a
Control	5.3	13.8b
Prairie Buffalograss	9.0	13.5b
Nortam St. Augustinegrass	4.3	11.3bc
Meyer Zoysiagrass	4.6	3.3c
MSD[1]	ns	8.6

[1] MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test. Means with the same letter are not significantly different. 'NS' indicates means were not significantly different based on an ANOVA *F*-test.

Table 2. Maximum distance (cm) of stolon pegging into asphalt surface.

Grass	1 Dec 1994
Tifway Bermudagrass	17.7a
Prairie Buffalograss	11.2b
Control	9.8b
Nortam St. Augustinegrass	5.7bc
Meyer Zoysiagrass	3.0c
MSD[1]	6.1

[1] MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test. Means with the same letter are not significantly different.

Table 3. Percent of plot covered with turf.

Grass	1 Dec 1994
Control	96.3a
Tifway Bermudagrass	86.3a
Prairie Buffalograss	82.5a
Nortam St. Augustinegrass	55.0b
Meyer Zoysiagrass	50.0b
MSD[1]	21.9

[1] MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test. Statistical tests were carried out on transformed values, but means of untransformed values are listed. Means with the same letter are not significantly different.

Table 4. Mean turf quality ratings[1] of grasses planted along road shoulder.

Grass	1 Dec 1994
Tifway Bermudagrass	7.5a
Prairie Buffalograss	7.1a
Control	7.0a
Nortam St. Augustinegrass	5.1b
Meyer Zoysiagrass	4.9b
MSD[2]	2.1

[1] Turf quality ratings 1 to 9, where 9 is the best and 5 is the minimum acceptable level of turf quality.

[2] MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test. Means with the same letter are not significantly different.

Nonetheless, the data still contain useful information about the integrity of the asphalt. Analysis of the 1995 measurements does indicate the relative stiffness or integrity of the asphalt, albeit it does not account for differences in the asphalt at the inception of the study. Low moduli and high Poisson's ratios would indicate the asphalt was less stiff, likely due to penetration by turfgrass rhizomes.

We can also examine the change over time in modulus and Poisson's ratio. Because the modulus increases with age and decreases with turfgrass damage, we would expect the effects of turfgrass penetration to offset the time- and weather-related changes in these two parameters. Thus, we would expect decreases or only small increases in the modulus for plots where asphalt degradation had occurred. When little or no degradation occurred, we would expect to observe large increases in the modulus. We expect to observe the opposite pattern in Poisson's ratio: small decreases or increases indicating asphalt degradation and large decreases indicating no degradation due to turfgrasses.

Ultrasonic Body Wave (UBW) Method

Poisson's ratio did not differ significantly among turfgrasses in either 1992 or 1995 ($F = 0.48 - 0.79$; $df_1 = 4$; $df_2 = 18 - 19$; $P = 0.55 - 0.75$). The change in Poisson's ratios was also not significant among turfgrasses ($F = 0.04$; $df_1 = 4$; $df_2 = 18$; $P = 0.99$).

The control plots had the highest values for Young's modulus in 1995 (Table 5). Buffalograss and zoysiagrass were also in the top statistical category. Moduli were low for both St. Augustinegrass and bermudagrass.

For bermudagrass, the moduli actually decreased between 1992 and 1995. Because moduli were increasing naturally due to aging (see above), this would seem a strong indication that the asphalt adjacent to the bermudagrass plots was substantially degraded by the turfgrass. We observed the biggest increase in moduli (i.e. least damage) for the control plots, followed by buffalograss and zoysiagrass.

Ultrasonic Surface Wave (USW) Method

At all five depths, we observed the greatest increases in modulus values (least damage) in asphalt adjacent to buffalograss (Table 6). Increases in moduli for buffalograss, zoysiagrass and control plots were consistently in the top statistical group. St. Augustinegrass and bermudagrass consistently had the smallest increases in modulus values.

ACCUMULATIVE TURF PERFORMANCE

We collected a total of nineteen separate evaluations on the turfgrasses in this experiment. Out of those evaluations, control sites and buffalograss were in the top statistical category nearly 90% of the time (Table 7). Zoysiagrass was also in the top group over 80% of the time.

Table 5. Young's modulus (YM) calculated from the ultrasonic body wave (UBW) method

	YM 1992	YM 1995	ΔYM	TPI[1]
Controls	968	1695a	727a	2
Prairie Buffalograss	1197	1615ab	383ab	2
Meyer zoysiagrass	1069	1443ab	374ab	2
Nortam St. Augustinegrass	961	1170b	210ab	1
Tifway Bermudagrass	1244	1193b	-51.3b	0
MSD[2]	ns	445.6	611.1	

[1] TPI is the turf performance index which is the number of times an entry performed in the best statistical group.

[2] MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test. Means with the same letter are not significantly different. 'NS' indicates the means were not significantly different.

Table 6. Young's modulus at different depths calculated using the ultrasonic surface wave (USW) method.

	YM92	YM95	ΔYM
	Depth = 4"		
Prairie Buffalograss	1173	2155a	982a
Controls	1171	2025ab	854ab
Meyer Zoysia	1336	1870abc	534ab
Nortam St. Augustinegrass	1163	1603c	440ab
Tifway Bermudagrass	1457	1720bc	264b
MSD [1]		351	NS
	Depth = 6"		
Prairie Buffalograss	1081	1953	871
Controls	1118	1903	785
Meyer Zoysia	1241	1810	569
Nortam St. Augustinegrass	1167	1515	348
Tifway Bermudagrass	1362	1600	238
MSD		NS	NS
	Depth = 7"		
Prairie Buffalograss	1062	1928a	865
Controls	1179	1783ab	603
Meyer Zoysia	1324	1773ab	449
Nortam St. Augustinegrass	1149	1480b	331
Tifway Bermudagrass	1269	1530b	234
MSD		351	NS
	Depth = 9"		
Prairie Buffalograss	890	1885a	995a
Controls	1147	1740ab	593ab
Meyer Zoysia	1280	1605ab	326ab
Nortam St. Augustinegrass	1071	1250b	179b
Tifway Bermudagrass	1279	1373ab	93b
MSD			

Table 6. Continued.

	YM92	YM95	ΔYM	TPI
	Depth = 11"			
				TPI [2]
Prairie Buffalograss	803	1775	972a	10
Controls	1076	1368	292ab	10
Meyer Zoysia	1126	1548	421ab	10
Nortam St. Augustinegrass	983	1088	105b	5
Tifway Bermudagrass	1175	1398	222b	5
MSD		NS	683	

[1] MSD is the minimum significant difference between means based on the Waller-Duncan *k*-ratio *t*-test. Means with the same letter are not significantly different. 'NS' indicates means were not significantly different based on an ANOVA *F*-test.

[2] TPI is the turf performance index which is the number of times an entry performed in the best statistical group.

Table 7. Accumulative turf performance indices (maximum possible = 19).

	TPI	% of Maximum
Controls	17	89.5
Prairie Buffalograss	17	89.5
Meyer Zoysiagrass	16	84.2
Tifway Bermudagrass	11	57.9
Nortam St. Augustinegrass	10	52.6

CONCLUSIONS AND RECOMMENDATIONS

We observed very consistent trends in the modulus and Poisson's ratio measurements which indicate that buffalograss and zoysiagrass cause significantly less asphalt degradation than do either St. Augustinegrass or bermudagrasses. In fact, readings for buffalograss were quite similar to measurements for control plots where we had positioned a plastic barrier to prevent *any* turfgrass penetration. Substantial distance of both stolon overgrowth and stolon pegging are characteristic of stoloniferous grasses like buffalograss, but this growth characteristic apparently did not result in asphalt degradation.

In contrast, bermudagrass, which is strongly rhizomatous, consistently produced the greatest degree of asphalt deterioration. Meyer zoysiagrass is also rhizomatous, but asphalt next to Meyer zoysiagrass plots was not severely degraded. Meyer zoysiagrass did not compete well with respect to either turf coverage or overall turf performance. Two of the four Meyer plots had been completely overrun by adjacent grasses. Thus, the lack of asphalt degradation adjacent to Meyer zoysiagrass plots was likely due to the poor persistence and spread of the species in this study. Had conditions been more favorable for the growth of Meyer zoysiagrass, or if a hardier variety of zoysiagrass had been used, the results may have been quite different. There is considerable diversity among zoysiagrasses, and other commercial and experimental varieties perform well under low-maintenance conditions (M. C. Engelke, *unpublished data*). The efficacy of zoysiagrasses as road shoulder borders warrants further research.

Within this study, buffalograss was competitive with bermudagrass with regard to both turf coverage and overall turf cover. Buffalograss borders along road shoulders would require infrequent mowing and little maintenance. Our data also indicate that buffalograss does not cause deterioration of the asphalt. Using buffalograss to border road shoulders instead of bermudagrass would avoid both the expensive repairs and frequent chemical applications. Based on the data, buffalograss is recommended as an alternative to bermudagrass for road shoulder borders. Using buffalograss to border road shoulders instead of bermudagrass would save not only considerable time, resources and money, but would also avoid controversial and potentially harmful inputs of chemicals into the environment.

LITERATURE CITED

Engelke, M. C., V. G. Lehman, C. Mays, P. F. Colbaugh, J. A. Reinert, and W. E. Knoop. 1994. 'CATO' Creeping Bentgrass - adaptation and potentials. pp. 31-35. *In* Texas Turfgrass Research. Texas Agric. Exp. Sta. PR-5113.

Hickey, V.G. and M.C. Engelke. 1984. Evaluation of quality in tall fescue turf trials. pp. 56-62. *In* Texas Turfgrass Research. Texas Agric. Exp. Sta. PR-4276.

Nazarian, S. 1990. Detection of deterioration within and beneath concrete pavements with sonic and ultrasonic surface waves. In Proceedings of Nondestructive Evaluation of Civil Structures and Materials, Boulder, Colorado.

Ott, R. L. 1988. Introduction to statistical analysis. PWS-Kent Publishing Company, Boston.

SAS Institute, Inc. 1985. SAS user's guide: statistics, version 5 edition. Cary, North Carolina.

Yibin, L. and S. Nazarian. 1992. Evaluation of asphalt-concrete layer adjacent to grass beds. Unpublished report.

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.