suggested the topic of the relationship of utility lines to the highway cross section design from the standpoint of legislation, zoning and the protection of roadside trees. Messrs. Wright, Deakin, and McManmon referred to policies in their respective states. Controlled access and the control of architecture on bordering property were emphasized by Messrs. Neale, Wright, Elwood and Deakin.

REPORT OF PROJECT COMMITTEE ON SHOULDERS

Harry H. Iurka, Chairman
Landscape Architect
New York State Department of Public Works

SYNOPSIS

This Committee offers its conception of the purpose of road shoulders and reviews briefly the literature on the effect of shoulders on traffic performance.

The Committee reports definite contributions made toward solution of one of the problems outlined in 1946 on the basis of which suggestions for the construction of stabile turf shoulders are made. Laboratory and field analyses of test projects are recommended to the end that reports on these may be integrated. Other problems to be studied by the Committee are defined.

Functions of Road Shoulder - Recognizing that the primary purpose of a road shoulder is to aid in the safe operation of traffic and the development of full traffic capacity of the road, this Committee believes that the functions of a shoulder should be:

1. To serve for occasional use only. Regular use would constitute a traffic hazard and would impose a maintenance burden.

2. To be stabile for all vehicles in all weather and at all times of year.

3. To carry water off from the pavement thereby preventing moisture from getting into the road subgrade. There should be no crack developing between the shoulder and the pavement.

4. To provide lateral support for flexible pavement.

5. To offer a good contrast in color and texture with the pavement to define the traffic lane.

6. To be pleasing in appearance not only in itself but as a part of the total highway seen by the traveler.

Relation of Pavement and Shoulder - Studies by others indicate that an adequate shoulder increases the effective width of pavement, that turf and gravel shoulders are comparable in this respect while macadam is more effective. (1,2,3)* Although no variation in the location of traffic on the pavement has been observed on roads having a shoulder of 10 foot width as compared with 4 feet, this should not be construed as meaning that 4 feet is ample as the effect on traffic using the road is but one of the factors to be considered (2,3). The shoulder should be wide enough to permit and encourage vehicles to leave the pavement when stopping or in an emergency (1,3).

Shoulder use by moving vehicles increases rapidly with a decrease in pavement width below 22 feet. With pavements of that width, few moving vehicles use the shoulders (2,3).

Good shoulders are preferred to curbs for rural and for high speed highways (1).

Recent records indicate a high percentage of accidents classified as rear end, sideswipe of vehicles moving in the same direction, and marginal. Many of these can be attributed to inadequate or unstabile shoulders.

Committee Work Completed - This Committee and others have presented reports (4) of stabilized**turf shoulder projects completed which have indicated that, within a wide range of climatic conditions and of soil materials, shoulders can be built which are stabile under load in excess of the maximum permitted on highways and that such shoulders can support and maintain a good growth of turf under occasional use.

It has been demonstrated that traffic using the same tracks on such a shoulder once a day regularly prevented the growth of turf.

It has been shown that turf should be considered as a surface material which has shear value just as is, for example, macadam, but should not be considered to have bearing value in design of the shoulder. Its possible bearing value is very slight considering the loads to be supported.

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

**The following definitions of terms are presented as representing the sense in which they are used:

Soil - Natural product of rock disintegration which may be clay, silt, sand, gravel, stone, caliche, or other similar materials or combinations of these and which might contain organic matter.

Turf - A vegetative growth which serves as a wearing course.

Stabilize - Treatment by selection of soil or selection and compaction of soil with or without moisture control to produce the required bearing capacity.

Recommendations - The Committee has the following recommendations to make for the construction of stabile turf shoulders, assuming that subgrade, base, and drainage are satisfactory (as they should be for other types of shoulders).

It is recommended that soil materials specified by American Association of State Highway Officials (5) for stabilized surface courses be used. With further study, the limits of these specifications may be extended as indicated by recent reports to the Highway Research Board. Organic material may be incorporated to the extent permitted by the requirements for stability. It is desirable but not essential for plant growth.

This soil material should be placed, mixed as necessary to make it homogenous, and shaped to meet the pavement surface (1) and to give an adequate slope for drainage.

The soil should be compacted to obtain the required bearing capacity.

A turf surface should be established which will protect the stabilized course. Very high rates of fertilizing should be used and lime applied as indicated by analysis. Seeding may be done in late spring and summer with satisfactory results if a mulch is used. Seeding by economical methods has proven satisfactory, for example, raking and rolling of seed is not necessary under a mulch or, if no mulch is used, seeding may be done just before rolling for compaction.

For the cool humid regions of the United States, the Fescues, Kentucky Blue, and Canada Blue are recommended permanent grasses. For areas of ample rainfall of the south and southwest of the country, Bermuda, Centipede, and Bahia are recommended.

Established turf should be adequately maintained, especially for the first 2 years, and of greatest importance is that mowing should be no lower than 3 inches and should be frequent enough to obviate removal of the cuttings and that the turf should be adequately fertilized.

For the reconstruction of shoulders which have built up, it is recommended that blading off of soil should be done deep enough to provide an adequate slope for drainage. The soil remaining after blading should be analyzed to assure its satisfying the above specifications (5). Saving of the roots of plants that may be existing is relatively unimportant. Too shallow a cut would only mean that the operation would have to be repeated sooner than if it was adequately done in the first place.

For shoulder areas used by traffic more than occasionally, as at mail box turnouts, it is suggested that, by using concrete blocks or other similar available material set in the soil and seeding the joints, the continuity of appearance of the turf shoulder might be maintained.

Correlation of Investigations - With the advice of the Department of Soils Investigations of the Highway Research Board, this Committee has adapted the analyses suggested in "A Study of Turf Shoulders" prepared in 1946 and published by the Highway Research Board and recommends their use in reporting all future investigations of stabilized turf projects so that these reports may be integrated. (See Table I.)

Problems to be Studied - In addition to further studies of the construction of stabile turf shoulders and the integration of the reports made available there are four related problems to be studied by the Committee.

1. What cross section design of shoulder should be recommended to retain safety of traffic under all conditions and yet obtain the best drainage possible and the reduction of the frequency of blading necessitated by build up?

2. What are the reasons for and treatment to eliminate or minimize build up? It should be noted here that it has not been proven that build up is due to growth of turf. Some authorities consider that this is characteristic of some soil materials.

3. Where should stabilized turf shoulders be used? This question will have to be answered in cooperation with other Departments of the Highway Research Board. An evaluation of the performance of various types of shoulders in relation to the pavement as well as to traffic is indicated.

4. What are the comparative costs of construction and of maintenance of stabilized turf as compared with other types of shoulders?

Shoulder design and construction is currently an important phase of highway engineering. The reduction of accident rates, the development of full capacity of the pavement, and the greatest economy of construction and of maintenance are purposes this Committee hopes to serve.

Stabilized turf shoulders, with the specific exceptions noted, can fulfill the functions of a road shoulder as outlined by this Committee. If it is agreed that a shoulder must be made stabile and that turf is merely a surface course, stabilized turf shoulders can probably be most economically constructed. This Committee hopes to present later information which will indicate the relative economic value of various materials in respect to both construction and maintenance.

NOTE: An illustrated talk was given by Dr. G. O. Mott, of Purdue University, describing with slides his "Study of the Establishment of Turf on Various Stabilized Aggregates and Its Effect on Stability."

REFERENCES

1. "A Policy on Highway Types (Geometric)", American Association of State Highway Officials, 1940.

2. "Effect of Roadway Width on Vehicle Operation", A. Taragin, Public Roads, Vol. 24, No. 6.

3. Notes made in conference September 1, 1948 with O. K. Normann, Chairman of Highway Capacity Committee of Traffic and Operations Department of Highway Research Board.

4. a. Reports of Committee on Roadside Development, Highway Research Board Proceedings, Vols. 25, 26, 27.

b. "Reference Material on Stabilized Turf Shoulders" Highway Research Board Committee on Roadside Development, 1947.

c. "Report on Stabilized Soil and Turfing" United States Army Airfields in Jacksonville, Florida District, United States Engineer Office, Jacksonville, Florida, 1944.

d. "Turf Base Shoulder Investigation, Maxwell Field, Montgomery, Alabama" War Department, Corps of Engineers, Office of the District Engineer, Mobile, Alabama, 1947.

e. "Data Report Turf-Base Investigation" MacDill Field, Florida, Department of the Army, Corps of Engineers, South Atlantic Division, Office of the District Engineer, Savannah, Georgia, 1948.

5. "Highway Materials" Part I Specifications Adopted by The American Association of Highway Officials, 1942. (See Appendix.)

TABLE I

RECOMMENDED ANALYSES OF STABILIZED TURF SHOULDERS

1. General data.

   a. Description of site and road.
   b. Traffic volume and character.
   c. Meteorological records.

2. Laboratory data.

   a. Density, lb/cu. ft.
   b. Moisture content.
   (These should be obtained at most moist and most dry conditions naturally existing).
   c. Porosity
   d. Liquid limit.
   e. Plastic limit.
   f. Plasticity index.
   g. Sieve analysis (American Association of State Highway Officials specifications). Should include percent clay and percent silt.
   h. pH value.
   i. Organic content.

   Samples should be taken after removal of the top growth of the vegetation and taken in three or four inch increments to a depth to include at least one increment from the sub-base.

3. Data on turf.

a. Kind of plants. (Grasses, legumes, or other plants.)

b. Condition of vegetation (percent cover, percent growth, percent weeds, condition of desired plants).

Quality of turf growth should be appraised relatively as Excellent, Good, Fair, Poor, and None, using numerical method in which 1 = E, 3 = G, 5 = F, 7 = P, and 9 = None or Bare. Photographic records should be made at the same time. Date of inspections should be noted.

c. Turf history, such as date and method of establishment of turf and resume of maintenance operations.

4. Data for Build Up Study.

Accurate measurements to determine changes of elevation of pavement, shoulder, ditch, and backslope, together with density determinations in spring and fall.

5. Traffic Test Data.

a. Measurements of depressions caused by test vehicles at worst time of year having an axle load of 18,000 pounds after one pass and after repeated passes to cause maximum depression or failure. The rear axle should have dual wheels and standard tires. Run should be made in low gear.

b. Moisture content of soil at time of test.

c. Data on test vehicle. Total weight, axle weight, number of wheels, tire size, and inflation pressure.

d. California Bearing Ratio.

COMMENTS

Comment:

Report holds that all weather shoulders should be provided on roads carrying as little as 100 vehicles per hour. This limitation was later removed. Should not shoulder stabilization be limited to highways carrying relatively heavy traffic?

Answer: Committee on Shoulders suggests that good firm shoulder in all weathers be provided for all surfaced highways.

Comment:

Another committee is working on shoulder design. We should be concerned only with shoulders having a turf cover.

Comment:

It was believed that all road shoulders do not require "stabilization" especially on roads with light traffic. Many road shoulders in Ohio, for example, are not stabilized.

Comment:

If a turf cover is to be provided, soil underneath should always be stabilized, that is, mechanically stable.

Another Commentator did not believe that stabilization should be limited by traffic density figures.

Question:

Why omit figures for soil density attained under experimental turf shoulders?

Answer: Soil density varies with soil mixtures used. Shoulder soils rolled to a certain density before turf is established on them tend to return to original natural or potential density after a period of rainfall, freezing and thawing, or other action by the elements under field conditions.

Comment:

It was believed that species of grasses for use on shoulders should not be named in the committee's reports. We should refer to "the bluegrasses, the fescues, etc.," not individual species. We do not know what species to recommend in light of present knowledge.

Question:

Why are not specific rates of seeding given in Project Committee on Shoulders report?

Answer: We should not recommend specific rates of seeding. We do not know how much seed to specify even under known field conditions. Rates of seeding are the responsibility of Dr. Monteith's Project Committee on Turf Culture.

Question:

Report recommends blading off of shoulders once they have built up "to depth great enough to obtain free run-off of surface water." Should "deep blading" be done at all?

Answer: Mr. Finney suggests blading down of shoulder by stages—one inch at a time.

Question:

Should we make any recommendations in correction of build-up of shoulders until we know what causes build-up? Why not say in the report "rolling has controlled shoulder build-up on a number of highways."

Answer: All methods of control of shoulder build-up should be noted in report of the Project Committee on Shoulders.

Comment:

We should clearly separate problems of correcting shoulder build-up (1) on unstabilized earth shoulders; (2) on stabilized earth shoulders.

Question:

Many existing road shoulders have had 4 to 6 inches of crushed stone added in the course of maintenance. Are not these to be classed as stabilized shoulders?

Comment:

We should make studies of existing earth shoulders having a turf cover by removing and studying 3-inch increments of soil on such shoulders.

Question:

Would it not be desirable to add conclusions in the report as to relative safety or value of shoulders with $\frac{1}{2}$-inch pitch as compared with 3/4-inch pitch of shoulder per foot?

Answer: Experiments mentioned in report do not demonstrate any difference in the two shoulder pitches mentioned.

Question:

Should not further tests be made with turf covered stabilized earth shoulders with pitch of one inch, $1\frac{1}{2}$ inches or 2 inches per foot?

Answer: Such tests will be made in the future.

Question:

Were all drivers of vehicles used in motion picture expert drivers?

Answer: No, and it is recognized that the driver is the weakest point in the shoulder tests photographed. No two drivers will drive off a paved surface onto a shoulder in exactly the same way. Two successive tests by same driver in same vehicle will not be exactly the same. Probably professional drivers such as those at General Motors proving grounds near Detroit should be used in future tests of shoulders.

Comment:

In using road shoulder, drivers often drive only one wheel on shoulder. A raised slab edge is extremely dangerous. Stabilization of shoulders will avoid this raised edge.

Comment:

Mr. Iurka's experiments deal with a shoulder kept true with surface of traffic lane.

DISCUSSION - Continued

Q. Rolling of turf shoulders when moist has been successful in some areas as a treatment for build up of the shoulder. Why does the Committee not recommend the practice?

A. Although it is recognized that this method of control or reduction of build up has been practiced for some years in Ohio and was used to restore the grades of the New Jersey experimental stabilized turf shoulders following the heaving of last winter, this Committee has not sufficient information at this time to recommend this method for general practice under all conditions.

Q. It has been found that, by constructing a turf shoulder about an inch lower than the elevation of the pavement adjoining, it is possible to allow for the effect of build up. Why does the Committee not recommend this practice?

A. The Committee believes such construction to be a potential traffic hazard. If turf does not develop in the area adjoining the pavement immediately after construction (and this area is the most difficult for turf establishment) there might be a lowering of the elevation of the shoulder due to loss of soil by erosion or traffic wear. A hazardous condition could quickly develop unless there were careful maintenance.

Q. Michigan reports the correction of shoulder build up by successive bladings of one inch layers during each growing season to preserve the turf roots. Does the Committee recommend this practice?

A. It should be noted that the report referred to states that this blading is continued until the proper grade is obtained. If that is done and if the soil material remaining is satisfactory, this practice is satisfactory and will eliminate the necessity of seeding most of the areas bladed.

Q. Has the Committee any data on costs of construction of stabilized turf shoulders?

A. Costs are the subject of one of the recommended further studies. Some data is included in papers presented to the Highway Research Board this year by Committee members.

Q. Does the Committee recommend the use of a transition strip such as bituminous material adjoining the pavement?

A. Reference is made to that part of the Committee report pertinent to this question under "Functions of Road Shoulder", "Relation of Pavement and Shoulder", and "Problems to be Studied".

Q. Is the California Bearing Ratio an acceptable measure of stability of shoulders?

A. As a laboratory method, it is an indicator. Although there has been a lack of correlation of the CBR values with actual performance under traffic in reports referenced (4), it is the best laboratory method we know of at present.

Q. Can data of value to the Committee be supplied by others who may not have constructed stabilized turf shoulders?

A. Definitely yes. Analyses of turf shoulders whether these be stabile or unstabile will add to the information needed to establish the limits of specifications for stabilized turf shoulder soil material. It is recognized that the present recommendation of the use of the specifications of A.A.S.H.O. for stabilized surface courses can probably be extended but much more information is needed to determine those limits. To be of value for integration with other reports, analyses should be those recommended in Table 1 of the Committee report.

Q. Some of us may not have access to the referenced A.A.S.H.O. specification. Could it be given as a part of the Committee report?

A. It will be included in the Committee report as an appendix.

APPENDIX
to
REPORT OF COMMITTEE ON SHOULDERS

Standard Specifications for MATERIALS FOR STABILIZED SURFACE COURSE (A.A.S.H.O. Designation: M 61-42)

Scope

1. These specifications cover the quality and size of sand-clay mixtures, gravel, stone or slag screenings or sand, and crusher run coarse aggregate consisting of gravel, crushed stone or slag combined with soil mortar or any combination of these materials for use in the construction of a stabilized surface course. The requirements are intended to cover only materials having normal or average specific gravity, absorption and gradation characteristics. Where materials such as caliche, gypsum, limerock and water soluble salts are to be used, appropriate limits suitable to their use must be specified.

Types

2. The following types of surface course stabilized mixtures are specified. The Engineer shall designate the type or types desired:

Type A - Sand-clay mortar
Type B - Coarse-graded aggregate.
Type C - Gravel, stone or slag screenings or sand.

General Requirements

3. The type or types designated shall conform to the following requirements:

4. Type A - The materials for this type shall be composed of natural or artificial mixtures of clay or soil binder and gravel, sand or other aggregate proportioned to meet the requirements hereinafter specified. The aggregate retained on the No. 4 sieve shall be composed of hard, durable particles and shall be free from injurious or deleterious substances.

5. (a) Type B - The material for this type shall consist of natural or artificial mixtures of gravel, stone or slag and soil mortar so proportioned as to meet all the requirements hereinafter specified.

(b) The coarse aggregate shall consist of clean, hard, durable particles of crushed or uncrushed gravel, stone or slag free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be hard and durable enough to resist weathering, traffic abrasion and crushing. Shales and similar materials that break up and weather rapidly when alternately frozen and thawed or wetted and dried, shall not be used.

(c) The soil mortar shall be that portion passing the No. 10 sieve and shall be composed of soil binder and granular material such as stone or slag screenings or sand.

6. (a) Type C - The materials for this type shall be composed of gravel, stone or slag screenings or sand or mixtures thereof proportioned to meet the requirements hereinafter specified.

(b) The material shall be composed of hard, durable particles, free from injurious or deleterious substances, uniformly graded from coarse to fine.

Detail Requirements

7. The type or types designated shall conform to the following requirements:

Type A Passing	Percent by wt.
1-in. sieve	100
No. 10 sieve	65-100

The material passing the No. 10 sieve shall meet the following requirements:

Passing	Percent by wt.
No. 10 sieve	100
No. 20 sieve	55-90
No. 40 sieve	35-70
No. 200 sieve	8-25

The fraction passing the No. 200 sieve shall not be greater than two-thirds the fraction passing the No. 40 sieve. The fraction passing the No. 40 sieve shall have a liquid limit not greater than 35 and a plasticity index not less than 4 nor more than 9.

Type B Passing	Percent by wt.
1-in. sieve	100
3/4-in. sieve	85-100
3/8-in. sieve	65-100
No. 4 sieve	55-85
No. 10 sieve	40-70
No. 40 sieve	25-45
No. 200 sieve	10-25

The fraction passing the No. 200 mesh sieve shall not be greater than two-thirds of the fraction passing the No. 40 sieve. The fraction passing the No. 40 sieve shall have a liquid limit not greater than 35 and a plasticity index not less than 4 nor more than 9.

Type C Passing	Percent by wt.
3/4-in. sieve	100
No. 4 sieve	70-100
No. 10 sieve	35-80
No. 40 sieve	25-50
No. 200 sieve	8-25

The fraction passing the No. 200 sieve shall not be greater than two-thirds of the fraction passing the No. 40 sieve. The fraction passing the No. 40 sieve shall have a liquid limit not greater than 35 and a plasticity index not less than 4 nor more than 9.

Moisture Content

8. The materials A, B and C herein specified shall contain sufficient moisture to insure maximum compaction.

Admixtures

9. Chemicals or other admixtures shall meet all the requirements of the current A.A.S.H.O. specifications. When the chemical to be used is not covered by an A.A.S.H.O. specification, a good commercial grade meeting the approval of the Engineer shall be used.

Methods of Testing

10. Sampling and testing shall be in accordance with the following standard methods of the American Association of State Highway Officials:

Sampling	T 2-42
Sieve analysis	T 27-42
Liquid limit	T 89-42
Plasticity index	T 91-42

ABSTRACT*

THE ESTABLISHMENT AND COMPARATIVE WEAR RESISTANCE OF VARIOUS GRASSES AND GRASS-LEGUME MIXTURES TO VEHICULAR TRAFFIC

R. H. Moorish and C. M. Harrison[1]

In an attempt to measure the comparative wear resistance of grasses and grass-legume mixtures, traffic was applied to a series of plots which had been established in 1943 and 1944. The grasses and legumes planted were selected on the basis of their potential value in producing wear resistant sods on airfields and highway rights-of-way. Seedings were made in April, June, August and October of each year in order to determine the optimum time of planting.

The grasses used were Kentucky and Canada bluegrass, bromegrass, timothy, redtop, orchard grass, ryegrass and Chewings, sheep and tall fescue. Red clover and alfalfa were planted in mixtures with some of the grasses on a few plots. The plots were located on a fertile well-drained silt loam soil.

*Abstract - from Journal of American Society of Agronomy, Vol. 40, No. 2, February, 1948.

[1]Chief, Grounds Section, Headquarters, U. S. Air Force and Professor in Farm Crops, Michigan State College, respectively.

Seedings made in April, August, and October were superior to the June seedings and produced an average of about 18 percent more ground cover than did the latter. The October seedings performed as dormant seedings and produced cover the following spring. Seeding in excess of forty (40) pounds per acre did not appear to be justified as measured by the quantity and quality of the sod produced.

Before the application of wheeled traffic each plot was evaluated on the basis of percentage of existing cover and its composition. All plots were subjected to traffic with a passenger car weighing 3,300 pounds. A truck weighing 40,000 pounds was used on the April and June seedings of the 1943 series. Tests with the car were discontinued on the 1944 seedings and on the August and October seedings of the 1943 series after 200 trips. Four hundred (400) trips were made with the car and 210 with the truck on the April and June seedings of the 1943 series.

The quality of the remaining cover was evaluated after each 100 trips with the car and after 75, 150 and 210 trips with the heavy truck. The major portion of the traffic was applied in October 1946 when the moisture content of the surface soil was approximately 7 percent. Rutting and deformation resulting from the loads applied was negligible.

Kentucky and Canada bluegrass and Chewings, sheep and tall fescue produced the most wear resistant turfs. Where adapted, these grasses should be given first consideration for use in the construction of airfields and highway rights-of-way. Redtop was intermediate in its resistance to wear, and timothy, bromegrass, and orchard grass were the least resistant. Alfalfa and red clover wore off at the surface of the ground long before the grasses showed any serious effect from traffic. Domestic ryegrass had disappeared from the plots at the time of testing. The inclusion of domestic ryegrass in the mixtures appeared to be detrimental in the establishment of wear resistant turfs.

The bluegrasses recovered from intensive wear more rapidly than did the fescues. Orchard grass, timothy, and bromegrass were the slowest to re-establish a satisfactory cover.