Mulching Practices and Materials

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•THIS REPORT is essentially an extension of Frank Brant's report made before this Committee at the 40th Annual Meeting of the Highway Research Board and published in the 1961 report of the Committee on Roadside Development. His definition of mulch

TABLE 1

EROSION-CONTROL MATERIALS 1962

State	Hay or Straw	Wood Cellulose	Soil-Set	Soil-Saver	Other[1]
Ala.	H	X	X	X	Excelsior
Alaska	-	-	-	X	Naturally-occurring materials.
Ariz.	S	-	-	-	Now testing various erosion control methods. No materials listed.
Ark.	S	X	-	-	
Calif.	S	-	-	X	
Colo.[2]	-				
Conn.	H	X	-	-	Wood cellulose in combination with bran and resins.
Del.	S, H	X	X	-	
Fla.	S, H	X	X	X	Knitnet; Troyturf; Fiberglass; Ultracheck; Bagasse.
Ga.	S	X	X	-	
Hawaii	-	-	-	-	Sawdust and wood chips on plant beds.
Idaho	S, H	-	-	-	
Ill.	S	X	-	X	Mulchnet; Erosionette.
Ind.[2]	-				
Iowa	S	X	X	-	
Kan.	S, H	-	-	-	Glass Fiber around trees and shrubs.
Ky.	S	X	-	X	Mulchnet; Erosionette; Knitnet.
La.	S	-	X	X	Knitnet
Me.	H	X	-	X	
Md.	S	X	X	X	
Mass.	H	-	-	-	Wood chips
Mich.	S, H	X	X	X	Troyturf
Minn.[2]	S, H				
Miss.	S	X	X	-	
Mo.	S	X	-	X	Ultracheck; Paper netting.
Mont.	S	-	-	-	
Neb.	S, H	X	-	X	
Nev.[3]	-				
N.H.	H				
N.J.	H	X	-	-	3½-in. layer Salt Hay on plant beds; also licorice stems.
N. Mex.[3]	-				
N.Y.	S, H	X	-	-	
N.C.	S	X	X	X	Troyturf; Glass Fiber; Asphalt; Pitch cobubles.
N.D.	S	-	-	-	
Ohio[2]	S				
Okla.	H	X	-	X	Asphalt emulsion over mulch sod; Ultracheck.
Ore.	H	X	-	X	Knitnet
Pa.	S, H	X	X	X	Ultracheck
R.I.	S, H	-	X	-	
S.C.	S	X	X	-	
S.D.	H	-	-	-	Mulchnet
Tenn.[2]	-				
Tex.	S	X	X	-	Asphalt
Utah	S	X	-	-	
Vt.	H	-	X	-	
Va.	S	X	X	-	
Wash.	H	X	-	X	
W. Va.	S	X	-	-	
Wis.	S, H	-	-	-	
Wyo.	S	-	-	-	
Total	43	27	16	17	

[1]See Appendix for individual State evaluations or comment on "other" and Soil-Saver materials.
[2]No report, 1962.
[3]No mulching.

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will be repeated: "Mulch, as dealt with in this paper, means a surface cover of either organic or inorganic material. Included is the practice of partial incorporation of mulch material into the soil as a means of holding it in place, but excluded is mulch material fully incorporated as a soil amendment. Also excluded is the tillage practice of soil mulch or dust mulch."

The purpose of this report is to follow up on trials of mulching materials and practices made by the States subsequently, and to record their evaluation of trials as an assistance and guide to others in the continuing search for improved methods and results in erosion-control practices. A composite picture of the major materials now in use or under trial, based on reports received from the States, is given in Table 1. Hay or straw is predominant among the materials being employed, and they are the standard control materials used in trials of new materials and methods.

In addition to the exhaustive list of mulching materials and practices presented in the 1961 report, two new items have been reported—bagasse and excelsior. Bagasse would probably be considered a local material, whereas excelsior would have a wider

TABLE 2

WOOD CELLULOSE

State	Soil	Date	Slope	Exposure	Subsequent Weather	Check Plots	Remarks
Ala.	Sand, Clay	July 1961	3:1 or flatter	E & W	Rain, 19 days	Hay	Some rilling; no erosion or hay plots. Excellent grass stand all plots.
Ark.	-	April 1960	3:1 fill, 2:1 to 3:1 cut	-	Normal	Straw	
Conn.	Sand	Aug.-Dec. 1961	2:1 or steeper fill slopes	E & W	Drought, high evaporation	Hay	Severe test conditions. All treatments were equal to hay as mulch material; all provided adequate erosion control.
Del.			(No details. See Appendix.)				
Fla.	Sand	March 1961	2:1 fill	All	Normal Heavy rain May 26	Hay	Severe wind erosion one Turfiber test section. No significant difference in growth of grass.
Ga.	-	Fall 1961	1½:1 to 3:1 cut	All	Normal	Straw	Growth better than straw check plot.
Ill.			(No details.)				Used on critical areas with good results.
Iowa	-	Fall 1961	Various	-	Above normal rainfall	Straw	4 trials: satisfactory to unsatisfactory. Against erosion not as effective as straw.
Ky.	-	Fall 1962	-	-	-	-	Too early to evaluate results.
Me.	Heavy clay, silts, gravel	Aug. 1961	2:1 or steeper	N & S	-	-	Excellent catch of grass. Not a satisfactory test for erosion control due to lack of heavy rains.
Md.	-	Oct. 31, 1961	4:1 fill; 2:1 cut	N & S	-	Straw	By Feb. 1962 Turfiber had given practically no erosion control. Germination was superior on straw-mulched areas.
Mich.	Sand	May 1961	-	-	Extended dry period.	-	Experiment did not prove successful.
Miss.	-	-	3:1 cut	N & S	Excessive rainfall	Straw	Demonstration plots did not give adequate erosion control nor the residual results obtained from straw mulch.
Mo.				(No details.)			Recent experiment, comments reserved.
Neb.				(No details.)			Used in maintenance-repair work. Good results.
N.J.	-	Sept. 1962	-	-	-	-	Applied on plant beds at different thicknesses to control weeds. No conclusions.
N.Y.	-	Oct. 1962	-	-	-	-	40 Ac. application. No evaluation possible (Oct. 11, 1962).
N.C.	Clay	Aug. 1962	2:1 cut	E	-	Straw	
Okla.	Loam	April 1961	3:1 cut & fill	N & S	No rain 3 wk then 2¾ in. in 1-day period.	Hay	The 2¾-in. rain caused considerable damage to Turfiber plots, little or none to hay plots.
Ore.	Clay	May 1962	1½:1 cut	N	Normal	-	Applied 1,000, 1,500, and 2,000 lb per acre rates; 2,000 lb indicates best growth by Dec. Exposed to strong N.W. winds during summer. Approximately 15% mulch displacement by Dec.
Pa.	Shale	June-Nov. 1961	¾:1 to 1½:1 cuts	N & S	Normal	-	Growth and erosion-control results satisfactory.
S.C.	-	Fall 1962	-	-	-	-	Good stand of grass. Ideal to use near buildings, etc., easy to wash off, leaves no unsightly marks.
Tex.	Silty loam	April 1961	4:1 cut & fill	-	Normal	-	Erosion control and growth results unsatisfactory.
Utah	-	Fall 1962	-	-	-	-	5-acre project contracted. No report of results.
Va.	-	May 1961	-	-	-	Straw	Both methods very satisfactory. No significant differences apparent. Specifications require addition of 5 lb annual rye per acre when used by contractor.
Wash.	Gravelly	Spring 1961	2:1 cut	S & W	-	-	Results inconclusive due to soil conditions. Fall 1962 project in same area, similar conditions, produced good results.
W. Va.				(No details.)			Included in construction specifications as alternate for straw.

TABLE 3

SOIL-SET

State	Soil	Date	Slope	Exposure	Subsequent Weather	Check Plots	Remarks
Ala.	Sand, clay	July 1961	3:1 or flatter	E & W	Rain, 19 days	Hay	Some rilling; no erosion on hay plots. Excellent stand of grass all plots.
Del.	"	Aug.-Sept. 1962	(No details.)				Stands of grass "remarkable" on 5-ft shoulders of dirt roads. Use eliminates difficulty of movement of straw by traffic next to pavement edge. See appendix.
Fla.	Sand	March 1961	Roadway ditch	"	"	Soil-saver	Material found very susceptible to damage. Not recommended.
	Sand	March 1961	Fill slopes	N, S, E & W	"	"	Test discontinued in Oct.; no evaluation made due to development of volunteer grass.
Ga.	"	Fall 1961	(No details.)				Good results with Bermuda grass on loose and prepared soils, 3:1 slopes.
Iowa	"	Fall 1962	(No details.)				One-half-acre test plot. Too early to determine results.
La.	Loessial terrace	April 1961	3:1 backslopes, shoulders & foreslopes	N & S	4.8 in. rain in 30 days	Hay	Application approximately twice normal rate. By 14 June best grass on south slope, equal to hay check plot. Excellent grass on mulch-sodded shoulders.
	Loessial terrace	April 1961	Shoulders, 4:1 foreslopes	N & S	4.8 in. rain in 30 days	"	Little results from seeding except in ditch. Backslopes had some ripplet-washing with little or no grass sprouting. Recommend further trials.
Md.	2-in. topsoil on A-2 base	May-June 1960	2:1 cut	S	Excellent growing weather	Straw	Practically no germination of seeded species. Weed growth flourished presumably from the ammonia in Vulcanol. Other tests also indicate that Vulcanol has practically no mulching qualities, is only fair as a soil stiller and when applied directly on the seed has an inhibiting effect on the seed. (Report date Nov. 11, 1961).
Mich.	"		(No details. See Appendix.)				
Miss.	"	1960-61	3:1 cut	N & S	Excessive rainfall	Straw	Demonstration plots did not give adequate erosion control nor the residual results obtained from straw mulch.
N.C.	Clay	Aug. 1962	2:1 cut	E		Straw	Report not yet available.
Pa.	Silt loam	May-Nov. 1961	1½:1 cut	N & S	Normal	Hay	Exhibited good erosion control; hay gave better growth results.
R.I.	"	Sept.-Nov. 1961	2:1 cut & fill	E & W	Normal	Hay	Prevented erosion as well as hay or straw mulch but latter promoted germination and growth better.
S.C.	A-7-6(6)	June 1961	2:1 cut	E	Rainfall 50% above normal	Straw	Test section resisted erosion better than check plots; germination slower but caught up with check plot by Oct.
Tex.	Sandy loam	Nov. 1961	4:1 cut 8:1 fill	N, S, E & W	Normal	No treatment	Material gave little or no protection. Erosion was just as bad as on check areas with no treatment.
Vt.	"	Sept. 1961	2:1 fill	N	Normal	Hay	Retarded germination, erosion control not as good as check plot.
Va.	Sandy loam & clay	Spring 1960 to Fall 1961	1½:1 fill 2:1 & 1½:1 cut	All	Normal	Hay	Grase growth unsatisfactory, erosion control satisfactory.

application. The results of both trials compared favorably with hay or straw controls, and each has the advantage of being free of weed seeds. An interesting adaptation and combination of two old materials, asphalt and mulch sodding, is reported by Oklahoma. No State reported on "Glassroot" trials.

With respect to mulches used on plant beds, two States are experimenting with wood cellulose to control weeds. Kansas reports the use of glass fibers for the same purpose. The results of these trials are not yet available.

Reports from several States disclose an increase in the use or trial of three materials in the last two years. Reports on wood cellulose (primarily Turfiber) increased from 11 to 26, on "Soil-Set" from 11 to 16, and "Soil-Saver" from 12 to 17. These totals are smaller than those published by manufacturers of the products. State evaluations of wood cellulose and Soil-Set are summarized in Tables 2 and 3. The results reported vary widely.

The use of Soil-Saver is reported most generally for drainage channel stabilization. There may be some significance in that several States used Soil-Saver as the control or check for comparison with performance of other materials. State evaluations of Soil-Saver are included in the Appendix and contain valuable information to those planning trials of this material.

CONCLUSIONS

As stated in the previous report, "There is no trend apparent toward major changes in mulching practices or materials." A review of the material presented in the 1961 report and in this follow-up report show that many factors enter into the choice and

success of erosion-control materials and practices. The availability, cost of materials, cost of application, and the variables of soil, slope, weather, to mention but a few, point to the conclusion that there is no single all-inclusive best material. The increased number of trials of new materials show that the problem is being approached with an open mind.

Practical evaluations of the results of tests on new mulching materials by experienced personnel are invaluable, but there is a demonstrated need for testing erosion-control materials and practices on a more thorough and scientific research basis to reach reliable, fair conclusions.

Appendix

SUPPLEMENTAL INFORMATION

Alabama

Mulch tests were planned and carried out in cooperation with Auburn University Agricultural Experiment Station, Dr. Dana Sturkie, Agronomist, and manufacturers of the following products: Turfiber, Soil-Set, Soil-Saver and excelsior. An abstract of the report follows: Mulches of hay, excelsior, Turfiber, Soil-Set and Soil-Saver were tested on back slopes seeded July 6, 1961. All mulches were beneficial in preventing erosion. Hay, excelsior and Soil-Saver were somewhat superior to Turfiber and Soil-Set for preventing erosion at the rates tested. Thorough preparation of the land and mixing of lime and fertilizer with the soil was essential in maintaining a stand of plants. Mulching on unprepared land would not maintain a stand of plants.

Excelsior broadcast by hand, rate 4,000 lb per acre, should be cut short and wide (18 in. fine cut difficult to apply uniformly; 6 in. wide cut easily applied). Excelsior has no weeds. Hay and excelsior were evident on Sept. 13; Turfiber and Soil-Set were not.

Alaska

Present plans provide for slope treatment with naturally occurring material, jute mesh and seeding. This work, although confined to the more pronounced areas of silt composed terrain, will eventually include other material also affected by erosion.

California

Two small experimental installations were made of jute-mesh material. Installation in San Jose, made in February, is now badly decomposed. Ivy was planted through the mesh, and good growth was obtained. The rapid decompositon of the mesh was probably due to the constant watering required to keep the ivy growing. Even though the mesh is decomposed, the slope suffered no damage during heavy rain on October 12 and 13. The remains of the mesh plus the partial cover provided by the ivy plus the surface compaction obtained by constant sprinkling probably all contributed to the result. This particular installation showed a saving over the previously used straw and wire mesh. However, it requires a smoother, more evenly graded surface than the straw and wire mesh treatment. The staples must be long enough to go through the cultivated soil and anchor firmly into the uncultivated soil beneath. It appears to be satisfactory where mechanical protection is not required for more than 8 to 10 months. For overall protection straw and seed rolled into the soil, or straw and wire mesh on the surface followed by planting is the most satisfactory.

Connecticut

See detailed report in 1962 Committee on Roadside Development, Highway Research Board.

Delaware

Specification calls for mulching to be as follows: Hay, straw, or other approved

materials. This covers a broad category of material but it was intentionally done. Most mulching in recent years has been straw. For three reasons this has gotten to be impractical: (a) straw is becoming hard to obtain; (b) after a heavy rain straw clogs up catch basins, pipe, etc.; and (c) the wind will often blow the mulch from the backslopes so that seed will not catch.

In the past two or three months, excellent results were obtained with a material called Soil-Set. Turfiber has also been used.

Either of these is much better than straw mulch. Soil-Set has been used on approximately 40 miles of bituminous surface (dirt shoulders) road for seeding and mulching. Stands of grass have been remarkable, particularly on backslopes and shoulders and close to the edges of the pavement where traffic would normally blow straw over into the ditch line; the Soil-Set seems to have held these 5-ft shoulders from washing until growth of grass or settlement has taken place. This is believed to be an excellent material to use for this type of work but it must be applied at the proper rate.

Florida

Bagasse is the fibrous residue of sugar cane after the juice has been extracted. It is being used as a mulch in horticultural nurseries and as litter in the poultry industry. Test used bagasse at rates of 1, 2 and 3 tons per acre with hay at 3 tons per acre as control check. Due to short fibers, the bagasse was raked into the top 3 to 4 in. of soil, the hay cut into the top 4 in. with shovels. From the results of this project it appears that bagasse will perform as well as the standard State Road Deparment mulch. The fact that bagasse has short 2 to 3 in. long fibers and might not provide a good mechanical anchorage does not seem to be a problem. Bagasse reputedly does not decompose as fast as hay mulch.

Evaluation of ditch erosion control materials:

1. Ultracheck.—Will perform satisfactorily in preventing erosion, but due to the thickness of the material it is difficult for grass to penetrate through. Grass will not grow until the material erodes away.
2. Soil-Saver.—Has shown the most promising performance in this test both with respect to erosion control and germination of the seed.
3. Troyturf.—Results of test are inconclusive due to the severe washing conditions it was exposed to in the Kings Road installation. In the West 8th Street installation it was buried under a layer of soil and could not be evaluated.
4. Soil-Set.—Very susceptible to damage and any break in the membrane may result in the complete failure of the installation.
5. Fiberglass.—Evaluation not complete—Fiberglass preventing erosion but preventing germination to date.
6. Knitnet.—Performance was equal to Soil-Saver.

Illinois

Turfiber, Erosionette over straw, and Soil-Saver have been used over critical areas with good results.

Kansas

At present high density fiberglass mat is used around trees and shrubs instead of hay mulch. Tree planting specifications call for placing 2 in. of hay mulch over an 8-ft diameter area around each tree and also over each shrub bed. Cultivation of the areas is required prior to placing mulch. The idea is that glass fiber mat will reduce or eliminate the need for hand cultivation of plants and shrub beds to remove the weeds. Use of glass fiber mat is limited until the results of field application experience are obtained. It is also planned to experiment with jute blankets or other materials that may become available for this type of weed and moisture control.

Kentucky

Excellent results using jute matting were obtained. In side ditches, one width is

used but in medians 2 widths are usually used. Soil preparation is the usual discing and harrowing, followed by raking to remove large stones, clods, etc., that would prevent close contact of the jute mesh with the ground. Cost of the material varied, from about $0.35 to $0.52 per sq yd in place.

Louisiana

At Leesville, jute mesh was applied with hand labor in 3 percent grade ditch. The soil was sandy loam. In spring 1960, the soil was prepared for ordinary seeding methods. Jute mesh showed very good possibilities of checking erosion. Material needs good smooth grade and careful fastening to ground. Price about $0.37 per sq yd in place.

At Hammond, jute mesh was applied with hand labor to 3:1 slopes on overpass. Soil varied from sandy loam to clay loam. Fall 1961, overpass slopes were eroded badly and were repaired by maintenance forces. Slopes were seeded with normal methods and jute mesh applied. Checked erosion satisfactorily; good seed germination. Also, jute mesh needs to be rolled after installation.

At Hineston, spring 1962, a 2 percent ditch grade was seeded normally with several grasses. Knitnet was rolled out by hand labor and secured with pins. It was cheaper than jute mesh. Fair erosion-control material, light in weight. Some shrinkage after material is wet. More testing is needed.

Maine

Jute matting in drainageways continues to be satisfactory. A paper fiber mesh tried as a substitute for jute seemed stiff and had a tendency to bridge.

Maryland

Jute is the standard method for establishing vegetation in drainage channels.

Massachusetts

Very good success with the use of wood chip mulch for erosion control on slopes, inducement of natural growth on slopes, protection of plant material, including individual trees, abutment plantings, beds of shrubs, groups of trees and as a mulch on slopes prior to the planting of seedling pines and other evergreens, natural growth sods, low bush Blueberry sods, Bearberry sods, Sweetfern sods, Bittersweet, Woodbine, Multiflora and Creeping Roses as well as two-year lining out stock.

Wood chip mulch is far superior to hay for use around plant material. On slopes where wood chip mulch is used no loam is required, helping to offset the cost. Massachusetts is trying to take large areas out of grass mowing by mulching and planting. The initial cost is not the most important point involved in roadside development. The steadily increasing cost of maintenance and the many acres of grass to be maintained annually are the important factors. These must be taken out of mowing by planting.

Michigan

Turfiber, Troyturf, Soil-Set, and jute mesh material all have their good points, but with the exception of the jute mesh material they are rather expensive when compared with grass sod. Large quantities of heavy jute net material are being used as a substitute for sod. It is very highly thought of for use on rather steep slopes in combination with seeding. One advantage over sodding is that it can be applied to an area immediately after fine grading operations, whereas, if sod is used, the time of year must be considered. The cost of heavy jute mesh material applied is approximately $0.35 per sq yd which, with the addition of seeding costs, makes it somewhat comparable to sodding, except for the previously noted advantage. Satisfactory sod sources are becoming more and more difficult to find.

In summary, sod has the advantage of giving immediate slope protection but has a drawback in the time element. Mulch net material is highly satisfactory, particularly on steeper slopes and as a substitute for sod. Straw or hay mulch will always remain

an important device for stabilizing soils disturbed by highway construction projects.

Minnesota

Some of the newer materials were placed in test plots this fall, but it is still too early to determine the results of these experimental plots. Due to the low cost of area sodding in Minnesota, an average cost of $0.3865 per sq yd, which includes six weeks maintenance period with watering, is cheaper than using the new mulching materials now on the market. (From 1961 Report.)

Missouri

During the past two years (1961-62), more than 1,000,000 sq yd of (Type I) jute netting have been used, primarily in accord with the standard design for new construction. This material has been and is being used on all types of soils encountered in the State including loess, sand and clay. The jute should provide protection for a period of 12 to 24 months, which is sufficient time to establish a good grass turf. Its use has been limited to the more critical areas on slopes and ditches where difficulty was experienced in establishing turf with old procedures. For design purposes, in loess soil a Manning's 'n' of 0.020 and a maximum velocity (ft/sec) of 4 were selected for this material. In clay soils a Manning's n of 0.020 and a maximum velocity of 5 are used. In the construction procedure for the above soils, check slots are required within 100 ft on slopes of 4 percent or less. On slopes of 4 percent or more check slots must be spaced within each 50 ft. The material must be applied in the direction of the flow of water and lap joints lapped not less than 4 in. The netting is to be placed immediately after the seeding operation and firmly embedded in the soil by rolling which usually requires watering. The netting is held in place with 6-in. No. 11 U-shaped staples. There has been less experience in sand; however, on one project 24-in. staples and check slots on slopes 4 percent or less each 20 ft and on slopes of 4 percent or more each 10 ft were required. The costs for this material in place has ranged $0.25 to $0.45 per sq yd. In general, the results have been highly satisfactory with proper application, particularly in median ditches where much difficulty with straw mulch was experienced in the past. Jute netting work has compared favorably with sodding.

Limited quantities of paper netting were used under similar construction procedures as jute netting. The selected Manning's n for this material is 0.026 and the maximum velocity is 4 (ft/sec). Discretion must be used in applying this material with respect to location, soil type, abrasive action, growing season, etc. Generally, results with this material have ranged from highly satisfactory to unsatisfactory. Effectiveness is more erratic than jute netting but superior to straw mulch. It has not held up in V-shaped ditches but has looked good in flat-bottom ditches and medians. The major factor has been the cost in place which ranges from $0.30 to $0.35 per sq yd.

Glass fiber blanket as a ditch liner is rather new. Several experiments have been conducted using it in different ways. This work is inconclusive, but it has brought to light some interesting points.

1. The 1-in.-thick blanket with nominal weight of 28 g per sq ft used as a ditch liner with seed has not been too successful. Stiff stem grasses will penetrate the mat satisfactorily, but the liner does not sufficiently offset the eroding action of running water prior to turf establishment to justify cost. The material with necessary pins cost $0.57 per sq yd. This material is classified as less effective than netting material.
2. There have been both apparent successes and failures with the ½-in.-thick glass blanket impregnated with 2 gal asphalt per sq yd. (The Manning's 'n' for the material is estimated at 0.016 and the maximum velocity (ft/sec) at 8 in. in loess soil.) Most failures tend to occur where abrasive action takes place in association with increasing velocities. At a recent installation in a sand area it has prompted some of the following comments: (a) The material has proven so far to be adequate for protection of berms and ditches on relatively flat areas; (b) On medians where grade exceeds 4.5 percent the material is beginning to fracture around pins at bottom of grade; (c) For ditch-erosion control a small amount of scouring by gravel will quickly damage the material to the extent that it comes apart and actually floats off; and (d) During hot weather, equipment cannot pass over this material without fracturing it.

The contract cost of glass fiber blanket in place is approximately $2.50 to $3.00 per sq yd. The extended use of this material seems questionable due to both results and cost.

3. The ½-inch-thick glass blanket heavy-duty weight (57 g per sq ft) impregnated with 2 gal of asphalt and covered with chips, estimated at 20 lb per sq yd has not been used in construction as yet. Approximately one year ago, a maintenance installation was made. The liner was placed in a 5 ft flat-bottom ditch 340 ft in length on a 7 percent grade. The soil type was Memphis silt loam in the C horizon with a texture of clay loam. This installation was completed at an estimated cost of $1.50 per sq yd. The material has been subjected to the passage of routine maintenance equipment with no apparent damage. The experiment to date has been very successful in all respects, but what will happen in the future is only a guess. It is estimated that it will withstand maximum velocities of 12 ft/sec. This material has merits within limitations for substitution with concrete; however, further experimentation is needed.

Nebraska

Either native hay or straw is presently used as mulch on new right-of-way seeding. Both seem quite adequate in most areas. Present specifications call for jute mesh as waterway or slope protection. Jute mesh and Turfiber have been used experimentally in maintenance repair work. Results with Turfiber were very good, but the jute mesh rotted out quickly and there was considerable erosion under the mesh. Straw mulch has been used with fair results. The best results have been obtained by filling the deep washes with clay soil and top dressing it with barnyard manure from local commercial cattle feedlots. In small washes, the manure is used for the entire fill. Some erosion was controlled with check dams of this material built at 25- to 50-ft intervals. Manure that has been piled up for several years and is well rotted worked best.

New Jersey

Salt hay mulch has been used for planting areas at a cost of approximately $0.07 to $0.08 per sq yd when applied in a 3½-in. layer. This method has not been too satisfactory for controlling weeds. Wood chips are now being placed 4 in. thick on new plantings at a cost of $0.34 to $0.40 per sq yd. Wood chips have been doing a good job in controlling weed growth. For new plantings, a mulch of licorice stems has been used in a 4 in. layer, and the results have been excellent. Licorice mulch is not flammable; it contains 93 percent organic matter, and costs $6.00 to $9.00 per ton delievered to the project.

An experimental mulching of plant material with wood cellulose (Turfiber), was recently conducted, and it was applied at different thicknesses to determine whether it controls weeds. It has been in place only one month; therefore, results are inconclusive.

North Carolina

Use of asphalt alone has been dropped from the recent schedule as being unsatisfactory, at least in clay soils. In sandier soils, it probably will be tried again. Troyturf also has been dropped, principally because of cost. It gave good erosion control and quick germination but requires a very careful maintenance program to accomplish thorough establishment. It would be considered only for very special situations. In addition, plots have recently been installed including Turfiber, Soil-Saver, Knitnet No. 346, two materials from the Pextile Corporation of America, and sodium silicate. Glassroot is also scheduled for trial, but no report on this extensive list of trials is available. Final evaluation of fish solubles is also unavailable.

Oklahoma

Asphalt emulsion over mulch sodding was used on 3:1 fill slopes, facing both north and south. The length of slopes (toe to top) was variable, ranging from about 15 ft to more than 100 ft. The western project was composed of fine sand, on which no topsoil had been applied. The soil series was not determined. Soils on the other two projects

were composed of 4 to 5 in. of fine sandy loam topsoil, which had been replaced on sandy fill material obtained from Stephenville series.

The Bermuda mulch sod consisted of a mixture of surface soil and Bermuda roots, which had been excavated together. The material was spread about 4 in. deep over the slopes, then compacted. The asphalt mulch was a high-viscosity medium-set emulsified asphalt. One part of the emulsion was mixed with three parts water before application. Slopes were reshaped where necessary. Weeds were destroyed by disking if present.

The slopes were watered by sprinkling. The mulch sodding was applied and compacted, then watered thoroughly. Fertilizer was applied before placing the sod, then again on top of the sod. The fertilizer was incorporated by sprinkling. The water-asphalt mixture was then applied over the sodding, at the rate of 1.2 gal per sq yd. This amounted to 0.3 gal of residual asphalt per sq yd.

In general, results were good. However, several factors tended to keep results from being better:

1. The weather during the work period was very hot, dry and often windy, not suitable for sodding work.
2. Such weather made it very difficult, if not impossible, to properly water the slopes before and after application of sod.
3. Lack of coordination resulted in considerable delay between application of sod and application of asphalt. As a result, the sod was often much too dry when the asphalt was applied.
4. The sodding was done late in the summer, which left a very short growing season for the grass.

In spite of the adverse factors, results were much better than on similar areas where sodding was applied without an asphalt mulch cover. The grass started to grow sooner, grew faster, retained a dark green color, and continued to grow long after the unmulched grass had ceased to grow and had gone dormant.

The western project received some very hard rains a short time after the asphalt mulch was applied. These rains may have dumped 6 to 8 in. of water on the area in less than 12 hr. The mulched areas eroded rather badly in some instances. The erosion, however, was much less than on similar but unmulched areas. It is believed that asphalt mulch will be very effective in promoting the growth of Bermuda sod in areas normally deficient in moisture during much of the growing season. Results indicate that success with this method will require thorough watering (soaking) of the soils before application of sod, thorough watering of the sod immediately following application, and application of asphalt over the sod immediately following the watering.

Ultracheck was used in a road ditch on Interstate 35, a few miles north of Oklahoma City. Before the test, the ditch had tended to erode and was requiring frequent maintenance. (The material tested was 1 in. thick.)

The road ditch was reshaped, a good seedbed was prepared, fertilizer was worked into the soil, then both warm and cool season grass seeds were broadcast over the area. Strips of blanket, secured with wire pins, were then laid across the ditch, overlapping so that water could not run under the strips. The installation was about 100 ft long. The work was performed during late summer.

The seeded area was longer than the area treated with Ultracheck. No seedlings emerged through the glass blanket, but a good stand emerged on the uncovered area. When evaluated this summer, no erosion had occurred. The glass blanket however had become ragged in appearance, the pins were working out, the wind had turned up the seams, and a vehicle had left the road and run over part of the blanket causing considerable damage. In general, the area was not eroding, but the material did not have a good appearance and did not seem to have characteristics that would result in long time protection of a road ditch.

Soil-Saver was used as part of an erosion-control project on Interstate 40, about 27 mi southeast of Oklahoma City. The area treated consisted of 2:1 cut slopes, some facing west and some facing south. The slopes ranged from about 30 to 60 ft in length (toe to top). The contract price was $0.35 per sq yd, in place. Area covered was about 11,000 sq yd.

The soils were composed of parent material and substrata, probably of the Dougherty series. Texture ranged from sandy loam to sandy clay. The soils were extremely erosive. Fertility was extremely low.

The soils were reshaped and covered with 4 in. of good soil which contained Bermuda roots (Bermuda mulch sod). Fertilizer of 12-12-12 grade was applied at the rate of 100 lb per 1,000 sq yd. Jute mesh was then applied over the mulch sod, in vertical strips which overlapped four inches. The jute mesh was secured in place with U-shaped No. 8 wire pins. The sod was watered for a 30-day period, as needed.

Growth was satisfactory; unfortunately check plots were not constructed. It is thought that it would have been impossible to hold mulch sod on these slopes without the jute mesh cover. During the process of reshaping, some of the areas became steeper than 2:1, probably approaching 1:1 or 1½:1. Later during the summer, these slopes collected enough moisture to cause sloughing. The jute mesh did not pull loose from the top but broke at the top of each slide. With this exception, there were no major failures.

Based entirely on this one project, the material is expected to be very useful when used as a cover over mulch sod on highly-erosive soils, 2:1 or flatter. This project was carried out during the spring of 1961.

Oregon

Jute was used as ditch lining in sand material in late Sept. and early Oct. of 1962. RC-250 asphalt binder coarse was used on the roadway and was sprayed over jute at approximately 0.25 gal per sq yd. No erosion or failure, germination showed by December 14. This material is standard for drainage channel erosion.

One contractor is placing wood cellulose on the plant bed to control weeds and erosion. State forces have also used this material in a dry state and wet down in the second operation. It is too early to evaluate this method of application.

Knitnet, regular and heavy, has been used successfully to hold down straw under extreme wind conditions on the southern Oregon coast.

South Dakota

Mulchnet was applied over native hay with satisfactory results.

Texas

An extensive experimental project on establishment of turf will be conducted through the Texas Transportation Institute regarding methods and procedures.

Wyoming

It was found that SC-2 asphalt, 0.2 gallon per sq yd, on sand, was subject to wind erosion. It was observed that straw mulching has produced the best stand of grass, however, the asphalt cover has resulted in grass growth in areas where it would not grow otherwise and the asphalt cover has reduced the erosion in these areas, resulting in a saving to maintenance.