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RI COOPERATIVE HIGHWAY RESEARCH PROGRAM

REPORT 81-3

INVESTIGATION OF EROSION CONTROL MATERIALS FOR DITCHES IN HIGHWAY CORRIDORS IN MISSOURI

FINAL REPORT

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"INVESTIGATION OF EROSION CONTROL MATERIALS FOR DITCHES IN HIGHWAY CORRIDORS IN MISSOURI"

STUDY NUMBER 81-3

Prepared By

Missouri Highway and Transportation Department

Division of Materials and Research

FINAL REPORT

June, 1983

In Cooperation With

U.S. Department of Transportation

Federal Highway Administration

The opinions, findings, and conclusions expressed in this publication are not necessarily those of the Department of Transportation, Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ABSTRACT

Plastic mat (Enkamat), Mulch Blanket (Hold Gro), Excelsior Blanket (Curlex Blanket), and Lightweight Mulch Blanket (Roll Lite) were installed and evaluated as alternates to concrete ditch liner, sod, and plastic netting over straw used for erosion control in ditches. The materials included in this study were only the materials promoted to the Missouri Highway and Transportation Department and are not claimed to be representative of all materials available.

Field study results indicated that Plastic Mat could be satisfactorily used in velocity ranges less than 11 fps and when used in lieu of concrete ditch liners it works well at approximately half the cost. The remaining erosion materials, although accomplishing the intended purpose, were not considered outstanding and did not offer any significant cost savings over sod or plastic netting over straw.

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INTRODUCTION

Current methods of erosion control in ditches of Missouri Highway projects include: (1) plastic netting over straw mulch used in locations with velocities up to 4 feet per second; (2) sod where velocities are a maximum of 6 feet per second; (3) straw embedded in ditches by a disk type roller, where velocities do not exceed 5 feet per second, and (4) concrete liner with no maximum design velocity. Lower design velocities are used with highly erodible soils.

New materials were presented to the Missouri Highway and Transportation Department which reportedly would be competitive and would give greater flexibility of design, particularly in the 6 to 11 feet per second velocity range. A study was thus proposed to evaluate the new materials for their applicability and cost effectiveness.

CONCLUSIONS AND RECOMMENDATIONS

The four materials investigated could be generally considered successes as used. Plastic Mat performed very well as a ditch liner in areas with generally less than 11 fps design water velocity. Considerable cost savings is indicated when used in lieu of concrete ditch liners. The remaining materials, Mulch Blanket, Lightweight Mulch Blanket, and Excelsior Blanket were adequate as used but do not indicate any advantage over the current sod or plastic netting with straw liners either in application or economically. These three blankets could be considered as equal alternates to the current methods.

IMPLEMENTATION

Results from this study will be considered in the development of design and specification changes.

SCOPE

The proposed method of study was to include the available materials in ten projects each, to be let to contract with statewide distribution to be achieved as near as possible. Predominant soils were to be sampled for pH and grain size classification, installation of materials was to be observed, daily high and low temperatures recorded, and rainfall monitored until vegetative growth was achieved or failure was identified. Each materials' success or failure was to be evaluated in relation to the degree and length of slope, weather, erodibility of the soil, and application problems. Environmental effects and the economic feasibility of the products versus current standards were to be determined. The proposed materials for evaluation were Enkamat (plastic mat), Hold-Gro (mulch blanket), Roll Lite (lightweight mulch blanket), Excelsior Blanket, and Land Glas.

Specifications for the various materials were prepared using manufacturer's recommendations and used as job special provisions in selected contracts in lieu of standard erosion control specifications. These materials replaced such items as straw held by plastic netting, sod, and concrete liners.

Field personnel in each of the ten Districts comprising the MHTD monitored the projects, and obtained desired data as the experimental materials were placed. Reports on the data obtained were then sent to the Materials and Research Division. In addition, Division personnel made occasional field checks on various installations.

The data collected generally included soil samples at the time of application for pH and grain size classification and samples two weeks after application for pH. Application procedures were checked when possible for problem areas. After installation, daily high and low temperatures and rainfall amounts were generally obtained with a max-min thermometer and a rainfall gauge. Projects were monitored for 30 days for growth and erosion and any unusual occurrences such as intensive rainfall or high winds. At the end of 30 days, growth was evaluated and a report with the applicable data and comments was submitted. When possible, photographs were taken. Generally, data collection ceased after 30 days although a number of projects were checked thereafter.

The data and applicable field notes are tabulated in Tables I-IV.

As a means of evaluating the projects, the vegetative growth at 30 days was ranked in varying degrees as none, minor, satisfactory, or good, on the basis of photographs and field reports. This information is also shown as data.

Each of the projects was ranked in terms of the success of that particular overall installation at 30 days without regard to extenuating circumstances:

A failure (-) indicated the material did not provide erosion control.

Success (+) indicated the material worked well, erosion was very minor, a stand of vegetation was present at 30 days and the area could be considered stable.

Zero (0) indicated the installation could not be classified as a failure or a success at 30 days. Lack of any growth but no erosion was typical of a zero rating. Also minor erosion with some growth was possible.

These ratings were determined individually on each location by three individuals familiar with the materials and with field experience, using the field reports and any personal knowledge of the location. The rankings were fairly consistant between the individuals so the average was used as a means of eliminating possible field bias that might be present and thus placing the results in some quantifiable form.

The reduction of projects for this study due to critical Department funding during the study period and the many variables included in the original proposal precluded any statistical study of the data.

DISCUSSION

Analysis of the various materials was rather difficult due in part to the small number of projects available and partly to the small number of failures incurred. The latter indicating that either not very severe conditions were incurred or the materials were not pushed to their limit. Another complicating factor was that each material was specified for a different range of velocities so that there is little comparison between materials. Soil tests did not indicate any applicable data but are tabulated in Table V.

Of the four materials examined Plastic Mat (Enkamat) appears to be the most desirable. It is not any more difficult to place than the other materials and does not ravel when cut. It has an open weave allowing seeds to fall through and growth to protrude through the openings. It is not biodegradable and remains in place for the life of the plastic. Vegetation within the plastic mat grew more rapidly and thicker than the surrounding area. The plastic mat provided satisfactory erosion protection in design velocity areas of 11 fps although most projects averaged 6-8 fps where plastic mat was used.

The Mulch Blanket and Lightweight Mulch Blanket are similar consisting of a knitted construction of white polypropylene yarn interwoven with strips of biodegradable paper, designed to degrade in one growing season. The Mulch Blanket has polypropylene yarn on 1/2" squares and the Lightweight Blanket has yarn on 1" squares. The biodegradable characteristic was by no means

considered to be a detriment. However, both of these materials tended to ravel somewhat when cut, or under heavy water flow.

They seemed to be more prone to encourage the flow of water underneath the blanket as compared to the plastic mat. Although not tightly knitted, the blanket construction was such as to discourage seeds from going through to the soil and to form a tent over vegetation growth until the fabric had begun to disintegrate.

Both mulch blankets tended to be at least adequate if not completely successful under the conditions for this study. The Mulch Blanket was used in areas averaging 3-5 fps design velocities. The Lightweight Mulch Blanket was used in lower velocity areas in the 1-2 fps range.

Only two Excelsior Blanket jobs were done under this study. It tends to blend characteristics of both of the above materials. It is a machine produced mat of wood excelsior with a netting on top to help hold the fibers in place. The excelsior is tight enough to sometimes encourage water to run under the mat but the mat itself seems to be conducive to vegetative growth. The two installations were fairly successful.

Lack of time and the reduction of projects during the investigation period prevented any Land Glas installations.

Admittedly there are many factors which contribute to potential erosion of a ditch. While they can be engineered on an individual

basis, using select materials with a lot of preliminary testing and investigation is not warranted in most cases. The intent of this study was to generalize the erosion preventing materials and determine what would work and show potential savings under most conditions statewide.

The problem for all materials was getting them into intimate contact with the ground. Ideally, this means a clodless, smooth condition with the mat or blanket tightly staked. Practically it meant something less. The ditches may contain water at installation time and completely smooth is impractical. The plastic mat was checked slotted 12" deep every 25 feet, the mulch blankets 4" deep every 50', and the excelsior blanket was not. This may have made the plastic mat less susceptible to under erosion.

Two materials had failures. A Plastic Mat and a Lightweight Mulch Blanket installation on the same project at the same time both failed under a 3.1" rainfall two weeks after installation. This was in conjunction with other smaller rains during the same period of time and was considered to be a fairly rare occurrence and not particularly reflective of the material performance.

Economically the Plastic Mat is the most promising. Savings of $8-9/square yard are indicated over concrete ditch liners (as shown in Table VI) when it can be used in the proper velocity ranges. The remaining experimental materials indicate very little, if any, cost savings over conventional materials and in fact are considerably more costly than plastic netting over straw.

Although the blankets were not failures, they were not outstanding and offer little to no cost incentive.

TABLES

TABLE I
Excelsior Blanket Field Data

Project	State Dist.	Installed	30 Day Avg. Temp.			30 Day Rain		Des. Vel. (fps)		Growth At 30 Days	Area (Sq.Yd.)	Success
			Hi	Lo	Avg.	Hi	Avg.	Avg.	Range			
AA	3	9/21/82	74	48	61	1.5	.097	2.69	2.4-2.9	Satis.	2231	0
Easy to place. Some erosion under blanket. 1.5" rain was intense.												
KK	6	10/15/82	62	43	53	.6	.073	3.0	1-3.4	Minor	13952	+

TABLE II
Lightweight Mulch Blanket Field Data

Project	State Dist.	Installed	30 Day Avg. Temp. Hi	30 Day Avg. Temp. Lo	30 Day Avg. Temp. Avg.	30 Day Rain Hi	30 Day Rain Avg.	Des. Vel. (fps) Avg.	Des. Vel. (fps) Range	Growth At 30 Days	Area (Sq.Yd.)	Success
CC	1	10/23/81	61	35	48	2.25	.095	*		None	400	+
Minor erosion.												
DD	1	7/7/81	86	70	78	3.1	.345	*		Minor	6.158	-
Eroded under blanket. Heavy rain 2 weeks after installation.												
DD	1	8/12/81	84	67	76	.97	.100	*		Minor	6159	+
No washing apparent.												
EE	5	12/14/81	32	9	21	.58	.095	*		None	11,112	0
Failed on steep ditches.												
FF	6	7/15/81	86	71	78	2.4	.291	1.82	.6-3.4	Minor	8253	0
Didn't work on steeper slopes.												
LL	7	9/30/82	75	45	60	.95	.092	2.56	1.2-3.9	Satis.	6292	+
Difficult application due to rocky soil. Prevented erosion compared to unlined areas.												

*Replaced plastic netting in areas of 1% or greater slope. Generally less than 3 fps velocity.

TABLE III
Mulch Blanket

Project	State Dist.	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Des. Vel. (fps) Avg.	Range	Growth At 30 Days	Area (Sq.Yd.)	Success
BB	6	6/8/81	83	64	74	2.6	.197	1.82	1.2-2.8	Satis.	709	0
Undercut in a few places. Lining held.												
CC	1	10/23/81	61	35	48	2.25	.095	3.0	3.0	Minor	470	0
After 6 months, very little growth and some erosion, especially on steeper areas.												
DD	1	7/10/81	86	70	78	3.1	.345	3.0	3.0	Satis.	14,459	0
Some erosion under blanket. Some areas rolled up and failed.												
II	6	11/10/80	48	34	41	.8	.168	4.57	2.4-8.0	None	4401	0
MM	8	9/23/82	72	52	62	.92	.052	5.0	5.0	Satis.	900	+
Some growth under blanket.												

TABLE IV
Plastic Mat Field Data

Project	State Dist.	Installed	30 Day Avg. Temp. Hi	Lo	Avg.	30 Day Rain Hi	Avg.	Des. Vel. (fps) Avg.	Range	Growth At 30 Days	Area (Sq.Yd.)	Success
AA	3	9/21/82	74	48	61	1.5	.097	6.83	4.8-11.6	Satis.	2713	+
Difficulty placing stakes in rocky soil. 1.5" rain was intense.												
DD	1	7/7/81	86	70	78	3.1	.345	5.1	5.1	Minor	169	-
Washed out in heavy rain 2 weeks after installation.												
GG	4	3/20/81	68	45	57	1.1	.097	--	--	Satis.	4598	+
Worked well.												
HH	6	5/11/82	80	62	71	2.5	.295	7.14	4.5-10.1	Minor	9908	+
Held soil from slopes.												
JJ	6	4/22/81	72	49	61	1.8	.215	7.92	1.7-12.2	Satis.	2526	0
Failed in one area due to obstruction in ditch. Concrete interception ditches caused some problems.												
MM	8	9/22/82	72	52	62	..92	.052	8.0	8.0	Good	223	+
Worked very well.												
NN	8	9/9/82	78	57	68	1.52	.116	--	--	Satis.	1966	+
Minor erosion.												

TABLE V

Soil Test
Field Data

Project	Installed	Material	Soil pH	Soil Classification	
				ASTM	AASHTO
AA	9/21/82	EB	7.4	CL	A-4
			7.8	SM	A-4
			6.7	CL-ML	A-4
AA	9/21/82	PM	7.3	CL	A-6
			7.7	CL	A-6
			7.2	CL	A-6
			7.3	ML	A-4
BB	6/8/81	MB	---	--	---
CC	10/23/81	MB	7.1	CL	A-6
CC	10/23/81	LWMB	6.8	CL	A-7-6
DD	7/7/81	LWMB	6.8	CL	A-6
DD	7/7/81	PM	6.6	CL	A-6
DD	7/10/81	MB	6.4	CL	A-6
DD	8/12/81	LWMB	6.4	CL	A-7-6
EE	12/14/81	LWMB	7.0	SC	A-6
FF	7/15/81	LWMB	---	--	---
GG	3/20/81	PM	---	--	---
HH	5/11/82	PM	7.1	--	---
II	11/10/82	MB	---	--	---
JJ	4/22/81	PM	---	--	---
KK	10/15/82	EB	---	--	---
LL	9/30/82	LWMB	5.2	MH	A-7-5
			7.0	CH	A-7-6
			6.4	GL	A-6
			6.5	CL	A-7-6
MM	9/22/82	PM	7.0	CL	A-6
MM	9/23/82	MB	7.5	CL	A-7-6
NN	9/9/82	PM	6.9	--	---

TABLE VI

In Place Equivalent Costs

	Paved Concrete Ditch	Concrete Ditch Liner	Plastic Mat (1)	Sod (3)	Type III Netting (2)	Mulch Blanket (1)	Lt. Wt. Mulch Blanket (1)	Excelsior Blanket (1)
1980								
$/Sq.Yd.	18.35	14.30	9.47	2.49	0.56	1.36	1.10	--
Sq. Yds.	12,146	13,319	5,632	157,087	81,919	20,039	32,092	--
1981								
$/Sq.Yd.	17.66	17.56	9.78	1.66	0.62	--	1.30	1.40
Sq. Yds.	40,876	19,580	14,587	242,124	140,250	--	6,292	16,183
1982								
$/Sq.Yd.	19.48	15.29	12.71	1.71	--	1.85	--	--
Sq. Yds.	8,246	21,246	9,462	179,454	--	900	--	--
1983								
$/Sq.Yd.	17.08	17.59	8.04	1.53	--	1.76	--	--
Sq. Yds.	7,877	29,473	25,932	153,247	--	3,792	--	--

(1) Including seeding, lime, and fertilizer.
(2) Including seeding, lime, fertilizer, and straw.
(3) Including lime and fertilizer estimated at $.05/sq. yd.

FIGURES

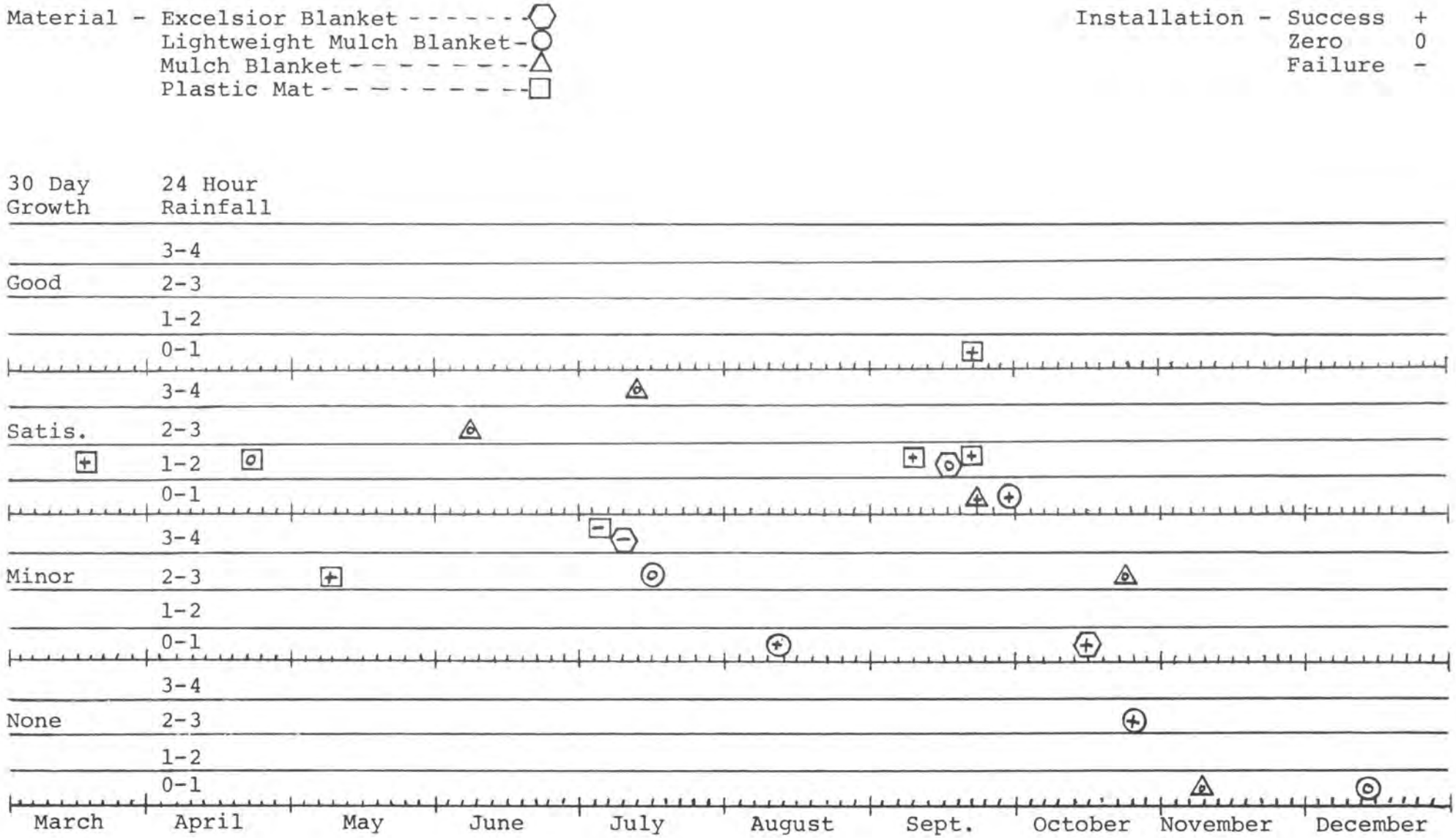
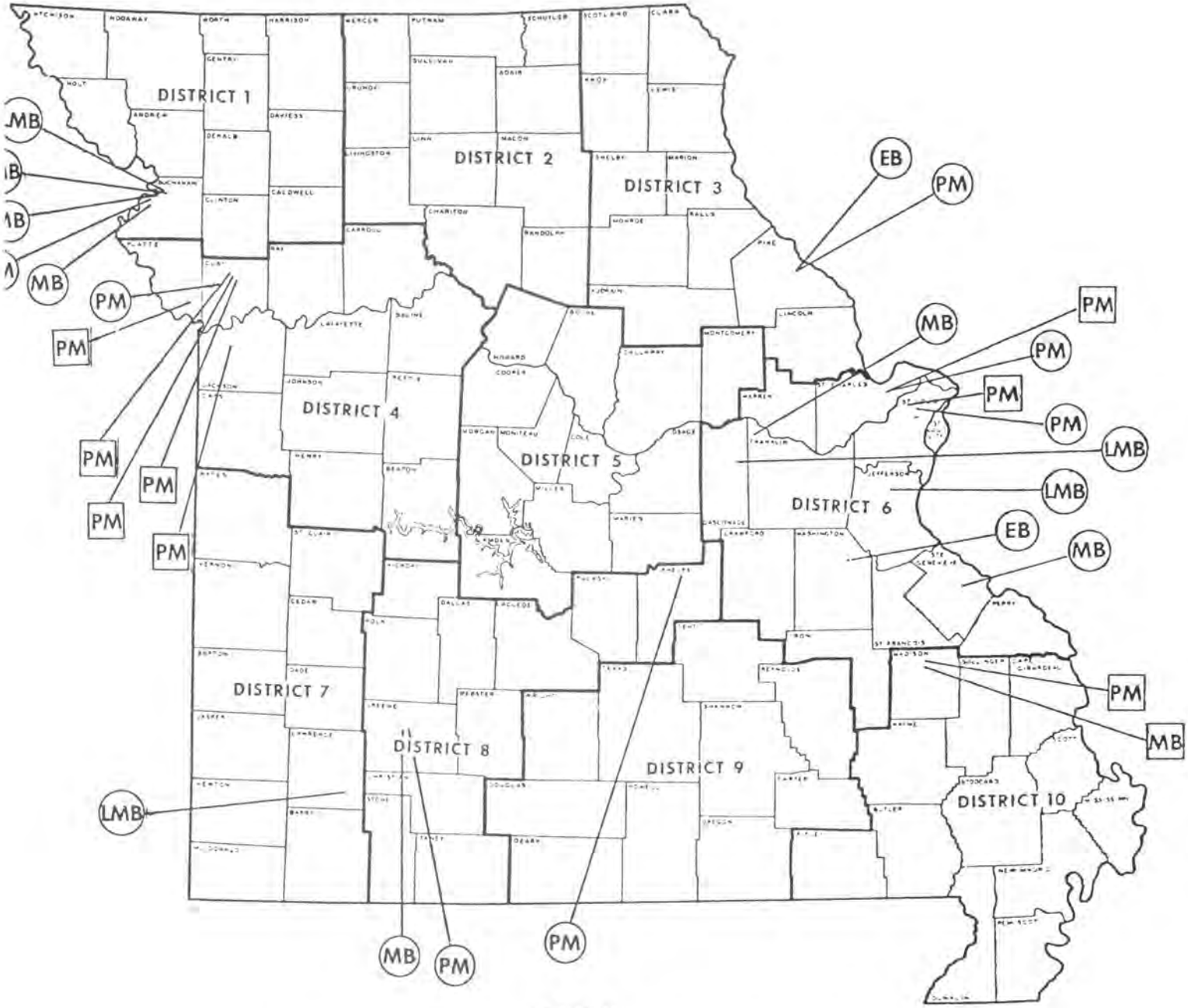


FIGURE 1
Ditch Erosion Control Materials



LEGEND

○	PROJECTS LET TO CONTRACT AND COMPLETED DURING THIS STUDY
□	PROJECTS LET TO CONTRACT BUT NOT COMPLETED DURING THIS STUDY
PM	PLASTIC MAT
MB	MULCH BLANKET
LMB	LIGHTWEIGHT MULCH BLANKET
EB	EXCELSIOR BLANKET

Figure 2 - Location of Ditch Erosion Control Projects

APPENDIX A

EROSION CONTROL - PLASTIC MAT

1.0 Description. This work shall consist of furnishing and placing a plastic erosion control mat as a ditch liner, in accordance with these specifications.

2.0 Materials.

2.1 Plastic Mat. Plastic mat shall consist of three-dimensional structure of entangled nylon monofilaments, melt-bonded at their intersections, forming a stable mat of suitable weight and configuration. The mat shall be crush-resistant, pliable, resilient, water permeable and highly resistant to chemicals and environmental degradation. The mat shall comply with the following physical properties:

Material Type - Nylon 6 plus a minimum content of 0.5% by weight of carbon black

Filament Diameter, inch, min.	0.0157
Weight, pound per square yard	0.747 ± 0.075
Thickness, inch, min.	0.70
Nominal width of roll, inches	38
Nominal length of roll, yards	109
Color	Black
Tensile Properties (1)	
Strength, pounds per inch, min.	
Length Direction	7.5
Width Direction	4.4
Elongation, percent, min.	
Length Direction	50
Width Direction	50

(1) ASTM D 1682 Strip test procedure modified to obtain filament bond strength to indicate tensile properties.

Resiliency (2)

30 Minute Recovery, percent, min. (3 cycles)	80

(2) Compression load cycling of 100 psi on 2" x 2" sample size, crosshead speed of 2 inches per minute.

2.2 Pins. Pins shall be 1" x 2" x 12" wedge shaped wood stakes or 12" x 12" x 6 gauge, one piece or two piece, ungalvanized steel T pins.

2.3 Acceptance of Materials. The contractor shall furnish to the engineer a manufacturer's certification in triplicate stating the number of rolls furnished and that the material complies with the requirements of these specifications. The engineer reserves the right to sample and test the materials. Acceptance will be based upon certification and test results of any tests performed by the engineer.

3.0 Construction Requirements.

3.1 All surfaces to be protected shall be graded and finished so as to be stable and firm in the absence of erosive forces. Prepared surfaces that become crusted shall be reworked to an acceptable condition before placing the plastic mat.

3.2 Ditch Lining Application. Plastic mat used as a ditch lining shall be applied with the length of roll laid parallel to the flow of water. Start the installation with the initial strip placed in the center of the ditch to avoid an overlap in the center of the ditch. Where more than one width is required, a longitudinal lap joint of not less than 3 inches shall be used, with the upslope width on top. All lap joints and upslope edges shall be pinned or staked at intervals of 3 feet or less.

All wood stakes shall be driven to within 2 inches of the ground surface. All steel pins shall be driven flush to the ground surface.

An anchor slot shall be placed at the upslope and downslope ends of the plastic mat placement. At least 12 inches of the end of the mat shall be buried vertically in a slot dug in the soil. The mat shall be secured in the anchor slot by pins or stakes at intervals of 3 feet or less prior to burying. The soil shall be firmly tamped against the plastic mat in the slot.

Successive lengths of plastic mat shall be overlapped at least 3 feet, with the upstream length on top. Pin or stake the overlap by placing 3 pins or stakes evenly spaced across the end of each of the overlapping lengths and by placing 3 pins or stakes across the width of the center of overlap area.

Check slots shall be constructed by placing a tight fold at least 8 inches vertically into the soil. Check slots shall be spaced so that a check slot occurs within each 25 feet. Pin or stake the plastic mat in the check slot at each edge overlap and in the center of mat.

Upslope edges of plastic mat used as ditch lining shall terminate on 6-inch wide horizontal shelves running parallel to the axis of the ditch for the full length of the ditch. Pin or stake the edges of the mat at 3 foot intervals then backfill with soil, tamped to original slope.

After the plastic mat has been placed, the area shall be evenly seeded as specified, allowing the seeds to drop to the grade through the openings in the mat.

4.0 Method of Measurement. Plastic mat shall be measured in place to the nearest 0.1 square yard of actual surface area protected.

5.0 Basis of Payment. This work will be paid for at the contract unit price per square yard for plastic mat, pay item number 609-99.99.

A. EROSION CONTROL MULCH BLANKET

1.0 Description. This work shall consist of furnishing and placing an erosion control mulching blanket as a ditch liner at the locations shown on the plans.

2.0 Materials.

2.1 Mulch Blanket. The erosion control mulch blanket shall consist of a knitted construction of white polypropylene yarn with approximately 1/2 x 1/2 inch uniform openings interwoven with strips of biodegradable paper. The biodegradable paper shall be brown and the entire fabric shall be designed to degrade in one growing season. The mulch blanket shall weigh approximately 0.2 pounds per square yard and shall be furnished in rolls no less than 4.5 feet wide by 360 feet long. The rolls shall be packaged for outdoor storage in a manner which protects the mulch blanket from degradation prior to use.

2.2 Staples. Staples shall be 11 gauge or larger ungalvanized wire. They shall be "U" shaped, have a four inch crown, and have one leg at least 6 inches long and the other leg at least 3 inches long.

2.3 Acceptance of Materials. The contractor shall furnish to the engineer a manufacturer's certification in triplicate stating the size and number of rolls furnished and that the material complies with the requirements of these specifications. The engineer reserves the right to sample and test the materials. Acceptance will be based on the certification and test results of any tests performed by the engineer.

3.0 Construction Requirements.

3.1 All surfaces to be protected shall be seeded and fertilized in accordance with the contract, prior to placing the mulch blanket. Mulching materials, such as straw, shall not be used under the mulch fabric.

3.2 Ditch Lining Application. The mulch blanket shall be applied with the length of the roll laid parallel to the flow of water. The first strip of blanket shall be placed in the center of the ditch to minimize overlaps in the flow line. The blanket shall be draped loosely, without folds or stretching so that continuous ground contact is maintained. Stapling shall be done in such a manner that lap joints are properly stapled first to avoid any tendency to stretch the material. Work shall proceed from the downstream end toward the upstream end of the ditch.

If more than one width of material is required, a longitudinal lap joint of not less than 4 inches shall be used, with the upslope width on top. All longitudinal lap joints shall be stapled along each edge of the overlap at 18 inch centers. The double row of staples shall be on staggered centers by beginning one row 9 inches from the end of the fabric and beginning the other row of staples 18 inches from the end.

An anchor slot shall be placed at the upstream and downstream ends of the installation. The blanket shall be placed across the bottom and up one side of a 4 x 4 inch trench, stapled on 9 inch centers in the bottom of the trench, and backfilled and tamped.

Check slots shall be constructed by placing the blanket in a 4 by 4 inch trench perpendicular to the flow line, stapling on 9 inch centers in the bottom of the trench, and backfilling and tamping. Check slots shall be spaced so that a check slot occurs within each 50 feet.

Outside longitudinal edges of the mulch blanket shall be stapled on 12 inch centers.

The mulch blanket shall be stapled on a maximum of 3 foot centers.

4.0 Method of Measurement. Erosion control mulch blanket shall be measured in place in square yards of actual surface area protected.

5.0 Basis of Payment. This work will be paid for at the contract unit price per square yard for erosion control mulch blanket, pay item 802-99.98.

JOB SPECIAL PROVISION

A. LIGHTWEIGHT EROSION CONTROL MULCH BLANKET

1.0 Description. This work shall consist of furnishing and placing a lightweight erosion control mulching blanket as a ditch liner at the locations shown on the plans.

2.0 Materials.

2.1 Mulch Blanket. The lightweight erosion control mulch blanket shall consist of a knitted construction of white polypropylene yarn with approximately one inch square uniform openings interwoven with strips of biodegradable paper. The biodegradable paper shall be brown and the entire fabric shall be designed to degrade in one growing season. The mulch blanket shall weigh approximately 0.08 pounds per square yard and shall be furnished in rolls no less than 4.5 feet wide by 360 feet long. The rolls shall be packaged for outdoor storage in a manner which protects the mulch blanket from degradation prior to use.

2.2 Staples. Staples shall be 11 gauge or larger ungalvanized wire. They shall be "U" shaped, have a four inch crown, and have one leg at least 6 inches long and the other leg at least 3 inches long.

2.3 Acceptance of Materials. The contractor shall furnish to the engineer a manufacturer's certification in triplicate stating the size and number of rolls furnished and that the material complies with the requirements of these specifications. The engineer reserves the right to sample and test the materials. Acceptance will be based on the certification and test results of any tests performed by the engineer.

3.0 Construction Requirements.

3.1 All surfaces to be protected shall be seeded and fertilized in accordance with the contract, prior to placing the mulch blanket. Mulching materials, such as straw, shall not be used under the mulch fabric.

3.2 Ditch Lining Application. The mulch blanket shall be applied with the length of the roll laid parallel to the flow of water. The first strip of blanket shall be placed in the center of the ditch to minimize overlaps in the flow line. The blanket shall be draped loosely, without folds or stretching so that continuous ground contact is maintained. Stapling shall be done in such a manner that lap joints are properly stapled first to avoid any tendency to stretch the material. Work shall proceed from the downstream end toward the upstream end of the ditch.

If more than one width of material is required, a longitudinal lap joint of not less than 4 inches shall be used, with the upslope width on top. All longitudinal lap joints shall be stapled along each edge of the overlap at 18 inch centers. The double row of staples shall be on staggered centers by beginning one row 9 inches from the end of the fabric and beginning the other row of staples 18 inches from the end.

An anchor slot shall be placed at the upstream and downstream ends of the installation. The blanket shall be placed across the bottom and up one side of a 4 x 4 inch trench, stapled on 9 inch centers in the bottom of the trench, and backfilled and tamped.

Check slots shall be constructed by placing the blanket in a 4 by 4 inch trench perpendicular to the flow line, stapling on 9 inch centers in the bottom of the trench, and backfilling the tamping. Check slots shall be spaced so that a check slot occurs within each 50 feet.

Outside longitudinal edges of the mulch blanket shall be stapled on 12 inch centers.

The mulch blanket shall be stapled on a maximum of 3 foot centers.

4.0 Method of Measurement. Lightweight erosion control mulch blanket shall be measured in place in square yards of actual surface area protected.

5.0 Basis of Payment. This work will be paid for at the contract unit price per square yard for lightweight erosion control mulch blanket, pay item 802-99.97.

A. EXCELSIOR BLANKET

1.0 Description. This work shall consist of furnishing and placing excelsior blanket as a ditch liner.

2.0 Materials.

2.0 Excelsior Blanket. The excelsior blanket shall meet the requirements of the Standard Specifications, 1977 Edition and its supplements.

2.2 Staples. Staples shall be "U" shaped, 11 gauge or larger ungalvanized steel wire with approximately a one inch crown and legs at least 6 inches long.

3.0 Construction Requirements. The area to be covered shall be seeded and fertilized in accordance with the requirements of the contract before the excelsior blanket is installed.

The blanket shall be unrolled in the direction of water flow, with the netting on top and the fibers in contact with the soil. A longitudinal joint of adjoining blankets shall not be placed on the centerline of the ditch. The blanket shall not be stretched or pulled tight. Successive rolls shall be snugly butted at ends and edges.

The blanket shall be stapled along each edge and along the center of each blanket with staples at 6 foot centers and it shall be stapled across each end of each roll with

four staples. The center row of staples shall be staggered 3 feet from the edge staple spacing.

A row of staples across the blanket, spaced at 6 inch centers and at right angles to the ditch line shall be placed within each 50 feet on ditch grades of 4 percent or less and within each 25 feet on ditch grades greater than 4 percent.

4.0 Method of Measurement. Measurement of excelsior blanket will be made to the nearest square yard of surface area covered by the completed blanket.

5.0 Basis of Payment. The accepted quantity of excelsior blanket will be paid for at the contract unit price.

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