REPORT OF SUBCOMMITTEE ON SLOPE EROSION

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The slope erosion project which has been sponsored by the Roadside Development Committee of the Highway Research Board is less than two years old. The results obtained are already making themselves felt in many sections of the nation. The scientific data accumulated are being used in several States, and the demonstrational value of these projects has been considerable. Erosion control is but one phase of highway maintenance, but the problems connected therewith are so ramifying and the effects of erosion along highways so far-reaching that it has become necessary to obtain accurate figures and facts for the solution of these problems. As pointed out in the 1937 Committee Report, slope erosion control goes far beyond the fence line of the right-of-way itself.

One hundred projects are under way in 31 States. This means that 200 miles of highways are either planned or under construction in accordance with the outline of this committee through cooperative arrangement of the U. S. Bureau of Public Roads and the Soil Conservation Service. This work is being executed in most all cases by CCC forces of the Soil Conservation Service which are operating in the vicinity of the project.

Wherever the solution of the problem was obvious and the answer definitely known, the project became an educational demonstration. Where the answer was sought and the solution of the problem was not conclusive, the techniques of research were applied.

Slope Design and Treatment

In the study of slope design some results must be immediate, although the cost may be relatively high. In such cases the best possible solution of the problem, as ascertained in the light of past experience, was the one which was chosen.

In general, low cost of control was one of the objectives sought, although the time required for such control to become effective was often two, three, or four years.

Often low cost controls with long-time objectives were failures because excessive erosion would destroy the initial highway construction work before the controls could become effective.

Ditch Design and Treatment

Certain field tests and experiments were initiated, these to be checked against information obtained in the hydraulic laboratory. Some of these were:

1. Determination of the maximum permissible velocity of flow of water over the different varieties of grasses and soil types without scouring, or the minimum without silting.

2. Proper width and depth of ditch in relation to the drainage area, soil type, and cover material used.

3. Effects of minimum ditch design required for safety and maintenance against the theoretical capacity design. (A manual is in the process of preparation).

FINDINGS AND RESULTS

The following results are based upon observations in the different States and on the different projects where this type of research is being conducted:

1. The proper design of cross section is the basic requirement of controlling most all types of erosion. The responsibility for this work can be met only by a man of wide experience and thorough knowledge of the problems that are involved and the dangers and damages which are likely to occur from improper cross section design. Sufficient data have been secured to show conclusively the inadequacy of poor design. There is crying need for more detailed examinations of projects and more careful training of division and district engineers who make field inspections to observe carefully the erosion factors involved and to study the likely damage which may occur. In many cases the average employee who is charged by the designing engineer with the responsibility of laying grades, balancing yardage, and designing slopes and ditches is inadequately trained to handle a job of such enormous responsibility.

2. With the use of Bermuda Grass, effective covers may be established in ditch cross sections where maximum velocities of 8 ft. per sec. may be expected.

3. Fertilizers are definitely more efficient in the establishment of Bermuda Grass than dense planting because dense planting means greater labor costs.

4. Strip sodding is effective in some areas when the strips are placed on very short spacings. However, the cost of sodding by this method is almost as much as solid or block sodding, and the results are not nearly so good. When the strips have been placed on slopes with intervals of 4 ft. on erodible soils, serious trouble has developed from benching and eroding between the strips. Even when nurse crops or mulches are used, the results have not proved to be an economical method of sodding.

5. Broadcast or streak sodding has proved very effective on high fertility soils. On some projects adequate permanent cover was obtained after the first growing season at a cost of less than two cents per square yard. This method offers possibilities and further developments will be observed during the coming year.

6. In the establishment of grasses by seeding, brush and straw mulch has proved very effective in some areas. Especially is this true if plantings are made during the seasons of heavy rainfall. There is a need for more information on low fertility grasses.

Mechanical covers such as cotton cloth, twisted paper, and burlap have proved successful in holding the soil until plantings develop. However, the costs are such that this use must be confined to critical areas and to seeding on raw soils.

7. Spot planting has proved ineffective in most instances. Experimentation has proved that the trench method used in Virginia is highly successful in the soils and climate of that region.

Benefits Accruing from Slope Erosion Control Outside of Highway Right-Of-Way

A successful program of slope erosion control will be beneficial to adjacent land and the landowner in the following ways:

1. To prevent gullies from extending into far lands and destroying farm structures (sloughing banks have passed right-of-way fence lines and in many instances destroyed farm boundaries).

2. To prevent silting of adjacent lands.

3. To prevent fast (flush) run-off from highway right-of-way which contributes materially to overflows and floods.

4. To prevent silting of streams.

5. To provide irrigation and eliminate surface erosion. In the semi-arid regions of the United States, water may be diverted (by the use of terraces and levees) to adjoining pasture lands and spread over wide areas for irrigation purposes. On some small watersheds it has been possible to treat the adjacent land by the use of contour furrows and level terraces so that little or no surface water reaches the highway, or runs in highway ditches or over slopes, thus automatically eliminating surface erosion.

Results of Experiments on Culvert Design

The ideal design of a culvert is one that will function properly in carrying the water under the road without erosion above or below the culvert. In must, above all, fulfill the requirements of modern highway design.

The problem with which the erosion engineer is confronted is the improvement of designs so that damaging features of the culvert may be eliminated and proper functioning permitted. Improvements have been made in drop inlet and head spillway structures for use at the inlet end of the culvert.

The design of the outlet end of the culvert has been sadly neglected. Research has been undertaken with the use of "de-energizer" and "flared ends" to prevent erosion at the outlet. Apparently the maximum increase in width of the lower end of the culvert should not be over a ratio of one ft. in ten. From results obtained in hydraulic laboratories, the water will not spread any faster than this ratio. The improvements sought are to decrease the velocity of flow and prevent the undermining of the culvert itself.

Ecology

The projects that have been undertaken have been developed along the lines of establishing native plant material on the affected areas in the most economical manner. During the first year most of the work consists of establishing grasses and vines. During the coming year the projects will be extended to the use of shrubs and low woody plants when such plant material can be adapted to the conditions. It must be realized that objectives of the cooperative work being carried on by the Soil Conservation Service and the various highway departments is primarily to control erosion. The correlation of the aesthetic improvements must necessarily be left entirely to the State department landscape engineer.

Water Conservation

Control of erosion and the conserving of moisture on highways and adjacent lands will be beneficial to the farmer by increasing the capaci-

ties of underground reservoirs, which will increase the amount of moisture for plant growth. Drainage areas contributory to the highway must be considered when improvements are made in the conditions on the right-of-way. The highway departments and agencies interested in conserving soil as well as moisture have a common problem that can be solved only by close cooperation of highway engineers and adjacent landowners. When the landowner understands the benefits that will be derived from concentrated efforts by all parties, little difficulty will be encountered in securing additional right-of-way at little or no cost for the solution of slope erosion problems.

Methods of Evaluating and Disseminating the Final Results and Recommendations

It is realized by the committee that the final answers to these problems will vary throughout the United States. In order that the results may be properly applied only within an area where successful results may be expected it has been necessary to divide the United States into "Problem Areas" according to:

1. Soil type
2. Climatological data
   (a) Rainfall, its amount and intensity
   (b) Temperature
3. Altitude
4. Plant adaptability

Within each problem area there must be established the most desirable season for construction and planting. Recommendations must also be made for plantings and protection of same when work is executed during other seasons.

The formation of these problem areas is being developed for immediate use in the choice of plants in the present program. The areas will be revised at the end of each year if it is deemed advisable after evaluation of the current season's results and observations.

Slope Erosion Control on County Trunk and Farm-to-Market Roads

One of the means of measuring the effectiveness of demonstration and research work is the acceptance of the methods employed by other agencies which have similar problems. In some sections of the country the results of research projects have been so outstanding that requests have come from farmers, landowners, and county highway agencies for help in the solution of their problems. There are also instances where farmers have requested that their local highway officials cooperate with the Federal agencies in the elimination of paralleling ditches and duplicating structures. This is a very significant indication of the the practical value of the demonstrations and research projects. Due

to these requests and demands, the Soil Conservation Service, through the co-ordinator, has initiated and planned erosion control projects with 175 county highway departments in the United States. Programs are being developed to prevent erosion on the county roads in critical areas where agricultural land is being seriously damaged. This program is correlated with the demonstrational work that the Soil Conservation Service is doing on agricultural land. This work consists to a large extent of resectioning county roads along modern lines and stabilizing the highway ditches and slopes so that the highway drainageway may be utilized to carry off concentrated flow from water disposal systems on agricultural lands.

The practice of discharging water into unstabilized highway ditches is being discouraged in order to eliminate damage to public property or to abutting private lands.

For economical reasons, one drainageway should be used to serve both purposes, namely, the run-off of the highway right-of-way itself as well as the adjacent farm land. The solution of this problem can be obtained only by full realization of the various aspects of the problem by both cooperating parties. The correction of a damaging condition that is destroying public property and decreasing land values of private property holders can be made most economically where the officials charged with soil erosion control work have the willing and hearty cooperation of the county highway officials whose roadways traverse the area involved.

Other Activities

There is another approach to slope erosion control quite within the scope of scientific research, namely, a survey and analysis of methods now being used or inaugurated in the various State departments. This past year the subcommittee headed by John L. Wright, Director of Roadside Improvement for the Connecticut State Highway Department, and Frank H. Brant, State Landscape Engineer for the Highway Department of North Carolina, by a well-planned questionnaire have inquired into such topics as the highway cross section most desirable as a foundation for erosion control work; slope drainage; drainage structures; topsoiling, fertilizing, seeding, sodding, mulching; and the planting of trees, shrubs, and vines for erosion control. Survey lists were sent to a mailing list of 24 in 22 States. Eight of these were consistent contributors. These and intermittent replies from 14 accounted for a response of slightly more than 50 per cent.

The explicit replies received in this survey have enabled this sub-committee to gather, and subsequently disseminate, much interesting and valuable information. The replies have also indicated the wide recognition of the economical importance of sound highway slope erosion control.

Analysis of the various replies indicates the following general rating of soil erosion control methods:

1. desirable cross section
2. topsoiling
3. berm ditches
4. seeding
5. mulching
6. sodding
7. paved ditches
8. fertilizing
9. planting
10. drop inlets
11. ditch checks
12. underground drainage
13. wing and outlet ditches

A blue print tabulation has been inserted in this report, containing an analysis of the survey circular letters, containing information on topsoiling, seeding, fertilizing, ditch checks and paved ditches.

Proposed Extension of Slope Erosion Control Projects

A geographical survey of the distribution of the various research and demonstration projects indicates that most of these are located in the southern half of the United States. The reasons appear to be:

(1) Greater need for the work in this area; (2) readiness on the part of the highway departments in requesting this service for their States; (3) availability of men who have had experience in highway construction work as well as erosion control projects; and (4) the economical and practical value of concentrating the projects in order to minimize the expense and the amount of time involved in travel from project to project.

The subcommittee recommends that additional help be made available through the Soil Conservation Service to reach those areas in the northern States that also have serious erosion control problems. They further urge upon the various highway officials throughout the northern States that they make a closer study of the research projects, become familiar with their values, and request this service for their highway departments.

CONCLUSIONS

The effectiveness of the research work has been clearly demonstrated. It has been an important factor in aiding highway departments (1) to promote the streamlining of their highways; (2) to solve

their highway slope erosion control problems; (3) to promote friendly relations between county and federal agencies and landowners working in the same area and having common problems; (4) to establish definite techniques for the collection of data and standardizing of results; and (5) to establish problem areas, which is another step in the regional approach to sympathetic and harmonious study of slope erosion on highways.

JOINT COMMITTEE ON ROADSIDE DEVELOPMENT
SUB-COMMITTEE ON SLOPE EROSION
INFORMAL SURVEY OF EROSION CONTROL METHODS
1938

STATE	TOP-SOIL	FERTILIZING AND SEEDING							SODDING				DITCH CHECKS					PAVED DITCHES				
		KIND OF FERTILIZER	RATE OF APPLICATION	SEED MIXTURES	RATE OF SEEDING	SEEDING METHODS	MULCH USED	NURSE OR COVER CROP	SOLID SODDING	STRIP SODDING	SOD DITCH CHECKS	SOD MULCH	CONCRETE	RUBBLE MASONRY	BRUSH DAMS	EARTH DYKES	WIRE	CONCRETE	LOOSE RIP RAP	CEMENT MASONRY	ASPHALT OR OTHER BIT.	SOD
ARIZONA													Too expensive	Satisfactory	Satisfactory	Fine	Extensively	Occasional	Not Satisfactory	Successful Expensive	Yes	
CONNECTICUT	4"-6"	Seeding: 5-8-7 Top Dressing 8-6-6	Seeding 2"per 100 sq.ft. Top dressing 1½" per 100 sq.ft	20% Kentucky Bluegrass 15% Canada Bluegrass 20% Red Top 5% Alsike Clover 20% Chewings Red Fescue 20% Domestic Ryegrass	3" per 1000 sq. ft.	Sown by hand and Cyclone Seeders Hand raked or brush dragged Hand rolled	Not extensively used Has great possibilities		On special jobs and at drainage structures. Too expensive for general use.	Extensively on high cuts and fills			No	No	No	No	No	Not recommended	Very satisfactory	Not recommended	Very satisfactory	Yes
FLORIDA							Special Cases		Steep slopes only												Very good	
IOWA	Seldom used	None		#1 20% Domestic Rye 25% Kentucky Blue 15% Red Top 25% Timothy 15% Alsike Clover #2 20% Domestic Rye 20% Kentucky Blue 20% Timothy 20% Alsike Clover 20% Brome	25# per acre	Sown by Cyclone seeder Harrowed or hand raked Cultipacker used occasionally for rolling	Occasional	Oats & Rye	Berm ditches & special locations	Occasionally on backslopes	Extensively where needed	Occasional						Used only in extreme conditions			
MAINE	4"-6"	8-16-16	50#-75# per 1000 sq. ft	Best mixtures undetermined	3#-3½# per 1000 sq. ft	Broadcast by hand	No	Oats & Domestic Rye	Very little Some ditches & slope drains	Used almost entirely on slopes	No	No								Not very Satisfactory		Occasional
MASSACHUSETTS	6"	10-6-4 60% organic nitrogen	20# per 100 sq. Yds	For grass plots: 40% Red Fescue 20% Red Top 20% Kentucky Bluegrass For Slopes: 30% Sheeps Fescue 20% Canada Bluegrass 20% Rye grass 15% Red Top 15% White Clover or Alsike	4# per 1000 Sq. ft	Sown by hand or mechanical Seeder Hand raked Hand rolled			Extensively on slopes										Paving Blocks Sand Filler		Satisfactory		Occasional
MICHIGAN													Seldom	Yes	Occasional	Seldom	No	Not Satisfactory	Seldom where flow excessive	Not Satisfactory		Most widely used
NEW YORK	2"-4"	4-16-8 and Raw Bone Meal	4-16-4 2# per 100 sq. ft. Bone meal 1# per 100 sq. ft	Clay soils: 10% Kentucky Bluegrass 25% Red Top 30% Domestic Rye 5% Alsike Clover Sandy soils: 40% Chewings Fescue 30% Red Top 25% Domestic Rye 5% Alsike Clover	3" per 100 sq. ft	Sown by hand or mechanical seeder Hand raked Hand rolled	No		Extensively on slopes	Experimenting on slopes												Good up to 5% grade
NORTH CAROLINA	1½"-2½"	4-8-4	7#-10# per 100 Sq. yds	No. determined mixtures. Grasses most commonly used are: Common or Kurzis Bermuda, Red Top, Rye grass, Orchard grass, Carpet grass, Alsike Clover, White Dutch Clover.	1¼#-2½# per 100 sq. yds	Sown by mechanical seeder Harrowed or brush dragged Animal drawn roller	Yes	Sudan Ryegrass Carpass Rye	Special locations	No	Yes	No	No	Ineffective	No	No	No	No	No	Occasional Expensive		Yes
OHIO	2"-4"	8-5-3 and Bone Meal	8-5-3 & 4-12-4 200# per 1000 sq. ft Bone meal 10# per 1000 Sq. ft	Shoulders & ditches: 60% Kentucky Bluegrass 25% Red Top (Chewings Fescue in Sand) 15% Domestic Rye Fill slope cover: Yellow & White sweet Clover Cut slope cover: 30% Red Clover 30% Timothy (also vetch)	4# per 1000 Sq. ft	Hand Sown Hand raked Hand rolled	Yes	Domestic or perenial Ryegrass	Special locations	On extensive slopes	Not proven very good	No	Occasional	Occasional	Too Unsightly	Excellent	Effective	Yes	Yes	Yes		Increasing use
OKLAHOMA													Yes	Practical								
TEXAS		4-8-4 For Sodding	16# per Sq. Yd.	Bermuda grass or Carpet grass Vegetatively propogated			Yes	Italian Rye Sweet clover	Occasionally on steep slopes	Yes (also spot sodding)	Yes	Yes	Seldom	Seldom	Abandoned	Yes & Sod	Abandoned			Seldom		
VIRGINIA	2½"-3"	4-12-8 With 40% organic Well rotted stable manure preferred	200#-600# per acre	Tide water Section: 25% Bermuda 20% White Clover 30% Domestic Rye 20% Orchard grass 30% Red Top Piedmont Section: 25% Red Top 35% Domestic Rye 25% Orchard grass 15% White Clover Blue Grass Section: 20% Kentucky Blue grass 20% Red Top 15% Domestic Rye 20% Orchard 15% White & Clover	35#-70# per acre	Broadcast by hand after light harrowing Dragged with special type chain drag	Yes	Domestic Ryegrass Carpass Soy beans Cereal Crops	Special locations	Yes											Yes
WISCONSIN	2"-4"				2" per 100 sq. yds			Winter Rye	On steep slopes	Less effective than solid sodding	Yes										Just as good as Sod	Yes
S.C.S. ENG'R. (N.C.)	½"-1"	4-16-4 4-12-4	50# 13# per 100 Sq.ft		1#-1½# per 100 Sq.ft		Yes						Yes	Yes	Temporary		Temporary		Yes	Yes		