TEXAS TRANSPORTATION INSTITUTE

TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

SOIL EROSION CONTROL ON NEW CONSTRUCTION PROJECTS

in cooperation with the
U. S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

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SOIL EROSION CONTROL ON NEW CONSTRUCTION PROJECTS

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Bibliography

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FOREWARD

This bibliography is limited in coverage to technical journals and reports and is not meant to be comprehensive but is selective. It is respectfully requested that any user keep in mind that it was designed specifically for the use of one group of researchers. The works of some major researchers may be omitted for the reason that the person who requested the bibliography was not only thoroughly familiar with these works, but had them in hand.

SOIL EROSION CONTROL ON NEW CONSTRUCTION PROJECTS

1. Duel, R. W. HIGHWAY VEGETATION: FOR UTILITY, SAFETY, ECONOMY, AND BEAUTY. Rutgers State University, New Jersey Agr Exp Sta, Agr & Environmental Science Coll, Bull 822, 30 pp. 69.

   "The Complete Highway" incorporates four basic elements into its design: Utility, Safety, Economy, and Beauty. Appropriate vegetation is a part of each of these requirements. Vegetation safeguards the utility of a highway because it generally offers the most practical protection against erosion and rutting of the roadsides. Vegetation, particularly grasses, forms a firm sod and can help the driver regain control of his car should it accidentally leave the road. There is some evidence to show that scenic highways, by reducing driver tension and fatigue, are significantly safer than nonscenic ones. Major emphasis centers around achieving the most serviceable and attractive vegetation with lower planting and maintenance costs. Minimum vegetative production once established, and maximum automation of operations are key objectives. An extensive bibliography is included in the report. /author/

2. Murdock, C. EROSION CONTROL ON HIGHWAY RIGHTS-OF-WAY IN ARKANSAS. Arkansas University, Arkansas State Highway Department, Bureau of Public Roads /US/ HRC-15.

   Materials and methods for establishment, maintenance and control of vegetation were investigated. Laboratory and field experiments indicate that a straw and/or wood cellulose fiber mulch is essential for establishment of vegetation. Prevention of erosion and maintenance of necessary moisture relationship are the principal factors. The need for adequate fertility following seeding and for maintaining nutrient levels were investigated. Original applications of 800 lbs./acre of 10-20-10 with 2 to 3 year repeat applications of 500-700 lbs./acre are recommended. Two to four tons of agricultural limestone or dicalcium silicate should be applied initially. Tall fescue, common Bermudagrass, weeping lovegrass and Bahiagrass are the most adaptable grass species for highway use in Arkansas. Tall fescue and weeping lovegrass have statewide adaptability. Bermudagrass can be grown throughout the state but is best adapted to the southern two-thirds. The use of Bahiagrass should be confined to the southern half of the state. It was demonstrated that effective vegetation control with 2,4D can eliminate weeks and reduce or eliminate expensive mowing operations on some areas. Greenhouse and field experiments with Maleic Hydrazide as a growth retardant proved effective. Johnsongrass can be effectively controlled with 2 to 3 applications of organic arsenical herbicided--DSMA (Disodium Methylarsonate) MSMA (Methanearsonic acid)--at 2 to 4 lbs./acre. A method was developed to determine the mode of action of organic arsenical herbicides on Johnsongrass. Simazine was found to be an effective soil steriland and caused the least damage from lateral movement. It was also the most economical of the soil sterilants tested. Experiments with 2,4-D, 2, 4, 5-T and Tordon, or mixtures, proved these herbicides to be effective control agents. However, extreme care in applications is essential so as not to damage susceptible agricultural crop plants. /author/

3. McCully, W. G., Bowmer, W. J. EROSION CONTROL ON ROADSIDES IN TEXAS. Texas Transportation Institute, Res Rept 67-8, 33 pp, 8 fig, 5 tab, 22 ref, Jul 69.

Research was conducted to review the established specifications for erosion control used by the Texas Highway Department and to determine better plant materials and operational practices for establishing a plant cover on roadsides. Field seedlings installed since 1960, and complemented by laboratory measurements, showed that grass stands adequate for erosion control can be established on roadsides in northwestern Texas without the expensive practice of topsoiling. A literature review was conducted on procedures and plants. Specifications recommended seeding mixture by soil type, date of planting, tillage and mulching. Specifications based on experimental seeding results have been proven on both contract and maintenance seedings. Cost of seeding in place using maintenance forces and following the recommended procedure was verified as $200.00 per acre or 4.1 cents per square yard.

4. Goss, R. L. THE ESTABLISHMENT OF VEGETATION ON HIGHWAY SLOPES WITHOUT THE USE OF TOPSOIL. Washington State University, Washington Department Highways, Bureau of Public Roads /US/ Y-1009.

Various factors of erosion control and vegetation establishment were studied over a four year period in Washington. They were: (1) Establishment of grass/legume cover without the use of topsoil, (2) Species of grasses and clover and proportion of each, (3) Mulching materials and (4) Fertilizations. It was found that erosion control vegetation can be established on subsoils without topsoil. No differences were found among general and species of seed tested. Subsoils, as exposed from construction, supported good stands of grass provided adequate fertilizers were supplied and they were given proper protection (mulching) from erosion. On erodible sites on 2:1 slopes or steeper, that excelsior matting or straw tacked with asphalt emulsion were superior to all other materials tested. Refertilization was important. /author/

5. ROCK AND WIRE BASKETS CAN FIGHT EROSION. Rural and Urban Roads, Vol 4, No. 1, pp 22-23 Jan 66.

Rock-filled wire baskets, called Gabions, can be put into place at any time of year. Since the rock used is ungraded, not entirely crushed, it can be purchased at reduced prices. The wire baskets are flexible. They can be adapted to odd corners or difficult areas where erosion is a problem. Inplace installation runs about $15.00 per cubic yard. Frequently, they are more permanent and cheaper than the conventional retaining walls or concrete crib walls. /Author/

6. Hodder, R. L. REVEGETATION METHODS AND CRITERIA FOR BARE AREAS FOLLOWING HIGHWAY CONSTRUCTION. Montana State University, Montana State Highway Commission, Federal Highway Administration /US/ R-4

Methods and criteria for revegetation and stabilization of roadsides in Montana involve problems of broad scope and complexity. Various facets of the roadside seeding problem were studied in sequence at several sites, each exploration indicating or substantiating the priority of study needs. A roadside vegetation survey and a contract seeding evaluation study provided a basis for a selection of initial studies concerning seeding and mulching. This work led directly to species selection tests, obvious fertilizer requirements, and effects of fertilizer slurries on seed germination characteristics. Unsatisfactory performance of mulches promoted trials with experimental mulch binders which provided some unexpected advantages. The sensitivity of time of seeding under semiarid growing conditions encouraged the testing of dryland planting innovations with both grasses and shrubs, which led to the development of dryland planting of tubelings and shrubs within condensation traps. These exploratory studies indicate areas of concern within which future maintenance economies may be realized with a minimum of investment in time and money. /Author/

7. Huntington, S. W. FINAL SUMMARY REPORT: GRASSES AND THEIR ESTABLISHMENT AS TURF ALONG NEWLY GRADED HIGHWAYS. Illinois University, Urbana, Illinois Division of Highways, Federal Highway Administration /US/ THR-67.

   Roadside turf establishment is investigated. Major portions include a literature review, study of species adapted to use on highway rights-of-way, study of time and fertilizer requirements, study of competitive effects between grasses and legumes, and study of time of seeding and seeding mixtures. Species now used for seeding mixtures in Illinois generally were found to be well adapted to condition within the state. A recommendation for application of agricultural limestone based on chemical tests of the soil has been adopted. It was found that temporary seedings are not needed at any time during the growing season except in late fall after it is too late to seed perennial species. /Author/

8. Swanson, N. P., Dedrick, A. R., and Dudeck, A. E. Highway Research Record No. 206, 1967, Authors respectively, Research Agricultural Engineer and Agricultural Engineer, USDA, and Assistant Professor of Horticulture and Forestry, University of Nebraska. PROTECTING STEEP CONSTRUCTION SLOPES AGAINST WATER EROSION.

   Mulching practices on a roadside cut (3:1 slope) were evaluated with respect to controlling soil erosion and minimizing grass seed and fertilizer loss prior to grass establishment. A field plot rainfall simulator and a device to introduce additional surface flow over a simulator and a device to introduce additional surface flow over a test plot were used to evaluate the mulching practices. Measurements of soil erosion and grass seed and fertilizer losses were made from runoff samples taken through a series of simulated rainstorms. The effectiveness in protecting soil surfaces against water erosion was determined for 13 mulches. The best protection was provided by mulches of jute netting, wood excelsior mat, prairie hay (1 ton/acre) and fiberglass (1,000 lb/acre) anchored with asphalt emulsion (150 gal/acre). The least effective mulches were the latex (150 gal/acre) and a kraft paper netting. Anchoring a material with asphalt emulsion provided increased adherence to the soil surface and was generally beneficial.

9. Dudeck, A. E., Swanson, N. P., and Dedrick, A. R., Respectively, Asst. Professor Horticulture and Forestry, University of Nebraska; and Research Agricultural Engineer and Agricultural Engineer, USDA, Highway Research Record

No. 206, 1967, MULCHES FOR GRASS ESTABLISHMENT ON STEEP CONSTRUCTION SLOPES.

The Nebraska Department of Roads is constantly faced with the problem of establishment and maintaining vegetative cover along roadsides throughout the state. Prairie grass hay is most commonly used for mulching purposes. Anchorage is effectively and economically accomplished by means of a tractor-drawn mulch packer (4). Conventional tractor-drawn equipment, however, cannot be operated safely on slopes steeper than 4:1. For the purposes of this paper a steep slope is defined as one with a gradient of less than 4:1.

Slopes steeper than 4:1 pose special problems in the establishment of vegetation. Mulches, other than prairie hay and grain straw, and methods of application should be evaluated on steep slopes for ease of application, feasibility, erosion control, soil moisture retention, and for their effect on soil temperature during the critical periods of germination and establishment.

In 1965, a cooperative study was initiated between the Department of Agricultural Engineering and the Department of Horticulture and Forestry at the University of Nebraska. The purpose was to evaluate a number of mulching materials relative to their effects on erosion control and grass establishment on a variety of different soil types, slope gradients and cut and fill sections. Swanson et al (5)presents the results of the first study on a 3:1 roadside cut section relative to erosion control under simulated rainstorms. The objective of this paper is to evaluate the same selected mulches on the same regarded slope and soil type in terms of their effects on soil temperature, soil moisture and seedling grass cover during the critical period of germination and establishment.

10. McKee, Jr., W. H., Blaser, R. E., and Barkley, D. G., Respectively, Instructor and Professor, Agronomy Department, and Instructor of Horticulture, Virginia Polytechnic Institute, MULCHES FOR STEEP CUT SLOPES. Highway Research Record No. 53, 1963.

It is necessary to obtain a quick cover of grass or other vegetation for soil and water control along highways and approaches or interchanges to interstate highways. Steep 1:1 slopes are not generally recommended for grass stabilization, but such slopes in Virginia are often unavoidable because of the tremendous cost of earth removal due to topography or the lack of adequate right-of-way for establishing flatter slopes. This paper gives results of experiments on steep 1:1 sloping cuts that have been carried on since 1962 to study mulching materials including nets, straw mulch, asphalt, glass fiber, woodfiber cellulose, and combinations of these materials in view of establishing a sod quickly.

11. Coffman, Bonner C., Associate Professor Civil Engineering, and Sawhney, Jagdev S., Research Associate, Ohio State University. FERTILIZATION AND EROSION ON A NEW HIGHWAY. Highway Research Record No. 93, 1965.

In early 1961 a research project was established at the Engineering Experiment Station of the Ohio State University (1). The site of this project was a 33-mile section of Interstate 71 running north and slightly east of Columbus, Ohio. This roadway is a 4-lane divided highway constructed to standards of the Interstate System. Within the 33 miles there are some 890 acres of median, side slopes, drainage channels and back slopes. A typical section of the roadway would show a 300-ft right-of-way with two 39-ft wide pavements separated by a 74-ft median. Soils in the area traversed are glacial tills composed of unsorted and non-stratified mixtures of clay, silt, sand and coarser fragments. All of the alignment is over ground moraine except for a short stretch through the Powell end moraine where most of the cut sections in the project are located. The roadway traverses some of the poorer farm land in the state. Topography is generally level with some sections of rolling terrain.

A major concern for highway systems is the establishment of an adequate turf on the roadside. This need includes the prevention of erosion as well as an obviously improved appearance. Unfortunately, a pleasing roadside cannot be understood in terms of dollars; erosion, however, results in increased maintenance costs which are clear when gullies must be filled and drainage systems unclogged. Before this, however, wheel alignments may be distorted and axles, mower-blades, etc., broken in traversing hidden erosion channels. Mowing and other maintenance patterns may be changed to less efficient ones and the abscure costs from operator fatigue and of shortened equipment life can accumulate unnoticed. A major objective of this research was to determine the effects of post-construction fertilization on the turf in this 30-mile section of Interstate highway.

12. Shepard, C. H., Mason, N. E., and Ray, Dorothy J., Ohio Department of Highways. A PROBLEM IN HIGHWAY SLOPE STABILITY. Highway Research Board Bulletin 309, 1961.

This paper describes the application of soils engineering to the correction of an unstable highway slope.

During construction of a highway cut through clays, silts, and sands of glacial outwash origin, the cut slope became very unstable. Extensive sloughing and erosion, with some slope movement, developed as excavation of the cut proceeded. A heavy flow of ground-water seepage developed in the cut slope. Drainage methods used to control this seepage are described.

After excavation of the cut area was complete, further slow movement of the slope face was observed. Successive cross-sections showing rate and nature of movement are presented. Additional field explorations employing continuous sampling techniques were made to determine cause of movement. Methods of sampling and testing are described. Investigation revealed slickensides, resulting in low-strength zones, in a soil mass that had general high-shear strength. Also, a zone of soft low-strength elastic clay was disclosed at a critical location below subgrade.

Observations indicated movement on a failure plane approaching the shape of a circular arc. Analyses by the Swedish circular arc method and the critical height of slope method are discussed. Results of further study to determine the slope section required to attain stability are presented. Corrective treatment used is described, and principles and techniques used in this solution that are considered to have general application to similar problems are summarized.

Pictures illustrate conditions from the beginning of construction to final completion of corrective work in September 1960.

13. Diseker, E. G., McGinnis, J. T. EVALUATION OF CLIMATIC, SLOPE, AND SITE FACTORS ON EROSION FROM UNPROTECTED ROADBANKS. Am Soc Agric Engrs--Trans v 10 n 1 1967 p 9-11, 14. Studies of detailed analysis of rainfall, runoff, and sediment records that were collected during 5-yr field study on six bare experimental road plots to obtain inter-relationship that influences sediment production and yield; objectives were to evaluate factors affecting rates of runoff, erosion, and sediment production from highway cuts, and to determine effective types of plant cover; research sites were located in upper reach of Coosa Watershed in northwest Georgia.

14. Jackobs, J. A., Professor of Crop Production; and Andrews, Jr., O. N., Murdoch, C. L. and Foote, L. E., Assistants in Crop Production, University of Illinois, Highway Research Record No. 161, 1967.

The development of turf on newly graded roadside slopes is the most economical method of controlling erosion and providing pleasant scenery. The establishment of turf, especially the grass component, is often difficult. The object of this review is to summarize pertinent information on turf establishment under conditions found along newly graded highways for use in planning future research. It is also intended that this review may serve as a reference for those working on roadside development.

Roadside development, particularly turf establishment, involves a combination of problems which are encountered only along roadsides. Steep slopes and infertile, compacted subsoils make turf establishment difficult. The characteristics required in grass and legume species for roadside turf are (a) rapid establishment to prevent undue erosion, (b) the ability to maintain themselves, (c) low growth habits and other characteristics which permit ease in mowing, and (d) absence of weed-like characteristics.

The problem of establishing vegetative cover on high-cut slopes which often have exposed C and D soil horizons is similar to that on badly eroded soils where B horizons with unfavorable physical and chemical characteristics are exposed.

In respect to their physical structure, compact subsoil layers influence the soil water movement and are responsible for conditions of excessive moisture during periods of rainfall and dry conditions at the soil surface during periods of scanty rainfall. These alternating conditions of soil moisture affect soil aeration and are associated with extremes in soil temperature which in turn affect plant growth. The compact layers with high clay content, when wet, are plastic, sticky and relatively impermeable to water and air. Impermeable substrata increase water runoff and soil erosion. Plant growth on sand and gravel strata is limited by low moisture, inadequate nutrients, and high soil temperatures. In coarse materials soil aeration is good unless the water table is too high; however, the water holding capacity is low. The rate of run-off from a high-cut slope is excessive because of the acceleration of the water due to its steepness. As a consequence, soil erosion is frequently severe before a vegetative cover can be established. Contains bibliography of 152 items.

15. Highway Research Board Special Report 23, PLANNING AND MANAGEMENT OF ROADSIDE VEGETATION. 1956. Nat'l Academy of Sciences--Nat'l Research Council.

This report is designed as a guide for planning and managing vegetation along the sides of highways. It comprises essentially a list of principles regarding the relationships of plant growth to highways and to traffic on highways from a landscape-engineering point of view. These principles have been assembled from many sources and are set forth as a series of consideration. The greatest number of them will probably apply to a highway of a major type on new location. The fewest will probably apply to highways on narrow rights-of-way in heavily built-up areas. Where a highway exists and no new construction is planned, some of the considerations may aid in maintenance procedures.

This report thus becomes a check list for reference use when planning or managing vegetation along all kinds of highways, including parkways and arterial routes, both old and new, and in all kinds of situations. It is intended to serve in the creation of the most ideal and complete developments; applicable portions, each aiming toward the ideal, may serve where only a limited amount of work is possible.

Those who are given the responsibility of designing and managing vegetation are assumed to have had basic training and experience in the field of landscape architecture. This report may serve them as a reminder of desirable features to be included or as a caution in avoiding certain recognized undesirable features. It is hoped that it may also aid in the administration of roadside-development work wherever plants existing or are being introduced onto highway property.

16. Woodruff, John M. and Blaser, Roy E., Virginia Polytechnic Institute and State University, Blacksburg, Highway Research Record No. 335, 1970. ESTABLISHING CROWN VETCH ON STEEP ACID SLOPES IN VIRGINIA.

There is a critical need for persistent vegetation with low maintenance costs for steep roadside slopes. Crown vetch (Coronilla varia) is one such leguminous plant that is adapted to many environments. Experiments in Appalachian, Blue Ridge, and Piedmont regions of Virginia were conducted to investigate effects of lime, nitrogen and phosphorus ferilizers, companion grasses, establishment methods, and slope exposure on growth, establishment, and persistence of crown vetch. Crown vetch seedlings developed slowly the first year and generally required 2 to 3 years to provide a complete ground cover. Agricultural limestone at 2,000 to 4,000 lb/acre or hydrated lime at 1,000 to 2,000 lb/acre substantially improved survival and seedling growth of crown vetch at all locations; 100 to 200 lb/acre of P_2O_5 gave additional responses but high rates (150 lb/acre) of soluble N generally overstimulated growth of Kentucky 31 tall fescue and other companion grasses that retarded crown vetch seedlings and subsequent stands. Applying 50 to 75 percent nitrogen per acre as slow-release nitrogen (ureaformaldehyde) provided stable and less aggressive companion grass growth and permitted satisfactory crown vetch establishment. Best crown vetch seedling stands and first winter survival were obtained with early spring seedlings. More uniform and faster ground cover was obtained on the cooler semishaded slopes than on sunny slopes. Satisfactory stands were obtained with root cuttings, but this establishment method was more costly than that of seeding. Stands of crown vetch on slopes, limed and fertilized liberally at establishment, have persisted without additional lime and fertilizer for 12 years.

17. Richardson, E. C., Diseker, Ellis G., and Sheridan, Joseph M., U. S. Department of Agriculture. Highway Research Record No. 335, 1970. PRACTICES FOR EROSION CONTROL ON ROADSIDE AREAS IN GEORGIA.

Several studies of erosion and establishment of vegetative cover on roadside areas in Georgia indicate that 5-year average sediment yields from bare roadside areas ranged from 78 to 234 tons/acre/year. Yearly sediment yields ranged from 25 to 455 tons/acre. After the establishment of a full vegetative cover and lining of ditches, these high sediment yields ranged from 0.12 to 11.5 tons/acre. Protection afforded by 2 tons/acre of straw as adequate for soil stabilization until plants could develop into a permanent cover. Forty-one plant species were tested at Cartersville and in the expanded program for adaptability in supplying protective cover on roadside areas. Eight of these species proved successful in the northern half of Georgia, and 8 species were also successful in the coastal plains. The best stands of Bahia grass were obtained when seeded alone and when seeded in March and June rather than in September. Stands were more difficult to obtain on sandy soils than on clay soils. Seeding rates above 40 lb/acre did not improve stands unless competition was removed. Maintenance fertilizer treatments at Cartersville showed that periodic applications adjusted to the plant needs were economical. Excessive rates of nitrogen and annual treatments increased material and labor costs and caused excessive plant residue on some areas. These residues tended to smother and thin the desirable plants.

18. Blaser, R. E. and Woodruff, J. M., Virginia Polytechnic Institute. Highway Research Record No. 246, 1968. THE NEED FOR SPECIFYING TWO- OR THREE-STEP SEEDING AND FERTILIZATION PRACTICES FOR ESTABLISHING SOD ON HIGHWAYS.

There is a critical need for establishing plant cover quickly along newly constructed highways. Such a sod cover should be well established so as to require a minimum of maintenance after the road construction has been completed. Many miles of new seedings along highways turned over to the Virginia Department of Highways for maintenance have not developed a well-established turf ready to be turned over to the maintenance crews.

The one-shot fertilization and seeding practices now specified often result in failures because one or more of the factors necessary for germination, emergence, and seedling growth is adverse. Also, many newly established seedlings soon begin to degenerate because of low soil phosphorous and available nitrogen. It is strongly recommended that specifications be amended to include several-step seeding-fertilizer procedures to assure better stands and sod establishment and lower maintenance costs. Several-step seeding procedures, based on grass-legume sod establishment along highways and observations of present practices are recommended. Slowly available sources of nitrogen such as ureaformaldehyde should be included in initial seedings to provide available nitrogen to prolong plant growth, especially in one-step seedlings. Research findings for obtaining effective grass stands along highways are summarized.

19. Pruett, Lester J. and McCully, Wayne G. PRESURFACE APPLICATIONS OF HERBICIDES FOR HIGHWAYS. Down to Earth, Dow Chemical Co. (Midland, Mich.), Vol. 17, No. 3, pp. 10-11, Winter 1961.

Modern highway construction and maintenance often involves paving the shoulder immediately adjacent to the trafficway. This paved shoulder varies in width from approximately 1 ft to as much as 10 ft.

Engineers estimate these asphalt pavements have a life expectancy of 20 yr, but invasion by unwanted vegetation causes them to deteriorate much sooner. Invasion of pavements by grasses and weeds assumes financial significance when viewed from the standpoint of the investment in pavement.

Engineers and scientists are considering the application of herbicides to the flexible base (gravel) before it is "shot" with the asphalt (presurface treatment) or to vegetation growing in a pavement (post-surface treatment).

The Texas Highway Department initiated a screening program to compare various herbicides for presurface treatment in 1959. In 1960, a cooperative research project was initiated with the Texas Agricultural Experiment Station and the Texas Transportation Institute of the Texas A and M College System to develop management practices for controlling vegetation on highway rights-of-way.

Herbicides were applied to shoulders using a modified water truck after the flexible base was "set up" and just prior to "shooting" the asphalt. A standard highway watering truck was fitted with a loading pump to circulate spray material and in some cases to maintain a static head pressure on the spray bar. During the 1959 applications the spray material was dispensed using a 1/2 in. opening and a splatter plate. The 1960 applications were made using standard asphalt nozzles which produced a fan pattern.

All treatments applied in 1959 were successful in preventing emergence of vegetation through the asphalt pavement. The results from the 1960 treatments confirmed those obtained in 1959.

In summary, it appears that herbicides may be useful in reducing the cost of maintaining asphalt pavements. From the results of these tests, presurface application can be expected to give adequate vegetation control at least during the season of treatment. Post-surface applications will be required later to prevent enroachment by Bermudagrass from the adjacent unpaved area. Since all of the materials tested prevented emergence of vegetation through the pavement at the rates used, the selection of an herbicide for presurface application would seem to be governed by the relative cost of material together with the absence of any detrimental effect on desirable vegetation growing in the area adjacent to the pavement.

20. MANMADE RAINSTORMS: A NEW TOOL FOR EROSION RESEARCH. Georgia Agricultural Research, University of Georgia, Agricultural Experiment Sta. (Athens, Ga.), Vol. 2, No. 4, p. 14, Spring 1961.

A new erosion research tool is now in use at the Southern Piedmont Soil Conservation Field Station, Watkinsville, Georgia. It is called a "Rainulator," short for Rainfall Simulator. This machine will be used to determine the relative erodibility of different soils and the erosion control effectiveness of various soils, slope, crop, and management practices.

The basis design of the Rainulator was developed by an Agricultural Engineer-Agronomist team of the Agricultural Research Service at Purdue University.

It distributed water uniformly onto plots through a system of reciprocating overhead nozzles at rainfall intensities of 5 and 2-1/2 in. per hour.

The Rainulator can operate simultaneously on three plots 12 to 14 ft wide and 75 ft long, or four plots if the length of at least two are reduced to 35 ft. Any combination of rainfall intensities of 1-1/4, 2-1/2, or 5 in. per hour can be applied to the individual plot.

The water needed is pumped from nearby ponds or streams. The entire system is portable. It can be moved to the location of any soil, slope, crop, and management complex needing study. Runoff and soil loss rates can be determined as well as total rainfall, runoff, and soil loss.

Current efforts are directed toward the development of a "standard storm" through the correlation of rainfall simulator erosion data with erosion data from natural rainfall. This "standard storm," when developed, will be used to study the relative erodibility of soils and the erosion control effectiveness of cropping system and managements practices in different combinations on various soils and slopes throughout the Southeast.

21. SEE NEW SEEDING PROCESS FOR HIGHWAY EMBANKMENTS. Michigan Contractor and Builder (Contractor Publishing Co., 642 Beaubien St., Detroit 26, Mich.), Vol. 54, No. 10, p. 52, June 1960.

Michigan State Highway Department engineers witnessed a demonstration of a newly-developed process for seeding highway embankments and interchange areas.

The demonstration was held at the intersection of Interstate 94 (US-12) freeway and M-78 just south of Battle Creek.

The new process, developed by a paper company, calls for a specially-prepared solution of woodpulp, fertilizer, grass seed and other additives to be air sprayed over the ground.

The mixture forms a coating like a blotter paper over the ground when it dries and is designed to protect the new seed beds against erosion until grass starts growing.

Highway Department officials said that if the new process is acceptable, it would be included in future contracts and the work would be done by contractors.

One of the big advantages of the new method is that the seeding, fertilizer and protective coating is done in one operation.

At the present time, embankments and interchange areas on Michigan's new highways are seeded and then fertilizer and a coating of a straw mulch is spread over the seeded area in separate operations.

22. Fox, Lester. JUTE MATTING SAVES SLOPES. Abstracted by William T. Parrott. Highway Magazine (Armco Drainage & Metal Products, Inc., Middletown, Ohio), pp. 15-17, January 1960.

In an effort to combat excessive bank and slope erosion, the Maryland state highway engineers in cooperation with the Soil Conservation Service, developed a scheme of using jute matting. A standard weave matting is used and stapled with No. 8 wire staples--6 or 8 in. long and about 6 ft apart. The matting should be overlapped to prevent water from spilling over the sides. It should also be tucked in at the top for 6 in. with the soil tamped firmly in place. Prepare the soil as usual but overseed at half the normal rate. Do not cover or mulch the jute.

In addition to promoting effective grass cover, the jute slows weed growth. The jute rots adding organic matter to the soil. Preliminary reports indicate that this method is most effective.

23. Palmertree, H. D. and Ward, C. Y., Mississippi Agricultural Experiment Station, and Kimbrough, E. L., VPI. FERTILIZATION OF ESTABLISHED ROADSIDE TURF WITH VARIOUS RATES AND SOURCES OF NITROGEN FERTILIZERS.

A field evaluation of ammonium nitrate, urea, coated urea, ureaform and a natural organic at 25, 50, 100 and 150 lb of nitrogen per acre for fertilization of bermudagrass (Cynodon dactylon) sod on highway roadsides showed that the first two sources produced the most desirable sod density during the initial first growing season after application. During the second growing season, sod fertilized with ureaform was equal in density to that produced by ammonium nitrate, urea, and coated urea. In the spring and early summer months after application, mixtures containing proportionally more ammonium nitrate than ureaform produced a more dense sod than the reciprocal mixtures. However, by the end of the growing season, mixtures containing equal and greater amounts of ureaform to ammonium nitrate were producing sod of equal density to mixtures containing higher amounts of ammonium nitrate. All studies conducted indicated that at least 100 lb of nitrogen are needed to develop a dense erosion-resistant turf, and that slow-release sources in combination with readily soluble sources might greatly reduce fertilizer application frequencies and mowing costs.

24. Swanson, N. P. and Dedrick, A. R., U.S. Department of Agriculture; and Dudeck, A. E., University of Nebraska. PROTECTING STEEP CONSTRUCTION SLOPES AGAINST WATER EROSION.

Mulching practices on a roadside cut (3:1 slope) were evaluated with respect to controlling soil erosion and minimizing grass seed and fertilizer loss prior to grass establishment. A field plot rainfall simulator and a device to introduce additional surface flow over a test plot were used to evaluate the mulching practices.

Measurements of soil erosion and grass seed and fertilizer loss were made from runoff samples taken through a series of simulated rainstorms. The effectiveness in protecting soil surfaces against water erosion was determined for (a) wood cellulose, (b) fiberglass, (c) latex material, (d) asphalt emulsion, (e) nettings, and (f) a combination of asphalt emulsion used as an anchorage for woodchips, corncobs, wood cellulose, fiberglass, and prairie hay.

The best protection was provided by materials such as jute netting, wood excelsior and prairie hay (1 ton/acre) anchored with asphalt emulsion (150 gal/acre). The least effective mulches were the latex (150 gal/acre) and a kraft paper netting. Anchoring a material with asphalt emulsion provided increased adherence to the soil surface and was generally beneficial.

25. Dudeck, A. E., University of Nebraska, and Swanson, N. P. and Dedrick, A. R., U.S. Department of Agriculture. MULCHES FOR GRASS ESTABLISHMENT ON STEEP CONSTRUCTION SLOPES.

Thirteen mulch treatments were evaluated on plots seeded to Lincoln bromegrass on a 3:1 roadside backslope in September 1965. Plots protected with excelsior mat, prairie hay anchored with a loose paper netting, or a combination of emulsifiable asphalt as an anchorage for woodchips, chopped corncobs, prairie hay, or wood cellulose had significantly more grass cover than did the no-mulch treatment. Although differences in soil moisture percentages and soil temperatures between mulch treatments were statistically significant, these factors apparently had no great practical effects on seedling grass stands with one exception. The poor stand of grass on the plot mulched with emulsifiable asphalt may have been due to high soil temperatures and the wide range between soil temperature extremes. The rate of 1200 gallons per acre also may have been excessive for good germination. Differences between mulches probably would have been greater under conditions of normal, or preferably below normal, precipitation.

26. Coffman, Bonner C. and Sawhney, Jagdev S., Ohio State University. FERTILIZATION AND EROSION ON A NEW HIGHWAY.

The effects of nitrogen and phosphorus fertilization of a turf mixture consisting of tall fescue Kentucky bluegrass, redtop and alsike clover on erosion of the level, cut and fill slopes of a new highway were studied. The effect of fertilization on cover varied with location and initial fertility levels. Erosion developed first on the east side of the cut slope on plots receiving only nitrogen or phosphorus or nothing. No erosion developed in 4 yr in plots fertilized after construction with both nitrogen and phosphorus, although bare area is developing. Cover in the form of strong vigorous grasses was necessary for the prevention of erosion. Percent grass cover alone could not be correlated with its erosion-preventing capacity, as evidenced by the appearance of completely bare area or of small gullies.

27. Bailey, Richar E. Oklahoma State University (Stillwater, Okla.), Thesis, Master of Science in Agronomy, May 1966. 45 pp. EVALUATION OF GRASS SPECIES AND MULCHES FOR EROSION CONTROL ON OKLAHOMA HIGHWAYS.

Erosion control along Oklahoma highways necessitates costly annual maintenance practices. The objective of this study is the evaluation of grass species and mulches relative to their combined effectiveness in stabilizing highway slope areas. The influence of slope exposure on grass germination and growth, and mulch effectiveness, was determined. Seven experiments were conducted to evaluate grass species and mulches on erosive highway slope areas. A split plot and a split-plot-in-strips experimental design were used with three replications. All data were analyzed statistically.

28. Drablos, Carroll J. W. and Jones, Jr., Benjamin A., HIGHWAY AND AGRICULTURAL DRAINAGE PRACTICES. University of Illinois, Engineering Experiment Station (1112 Engineering Hall, Urbana, Ill. 61803), Bull. 480, 1965. 159 pp. $3.00.

The principles and practices of the Illinois Division of Highways in the treatment of interrelated highway and agricultural drainage and erosion control have been developed over a period of many years. The purpose of this study was to assemble and analyze data relating to the practices and procedures followed by highway authorities in controlling highway and agricultural drainage waters.

Information was collected from highway authorities, governmental agencies, consultants, and private individuals both in Illinois and in other states. Emphasis was placed on drainage practices and procedures rather than on design details. The resume of the practices followed by highway authorities and other together with the compilation of the drainage laws can provide highway and agricultural administrators with an important tool to assist in the establishment of sound drainage policies.

29. Adams, John E. INFLUENCE OF MULCHES ON RUNOFF, EROSION, AND SOIL MOISTURE. Proceedings, Soil Science Society of America (677 South Segoe Rd., Madison, Wis. 53711), Vol. 30, No. 1, pp. 110-114, Jan./Feb. 1966.

A 3-year study was conducted on Austin clay at Temple, Texas, to determine the effect of mulches of straw, gravel, and soil treated with dioctadecyl dimethyl ammonium chloride (DDAC) on runoff, erosion, and evaporation. Mulches were applied to 0.01-acre plots on a 4 percent slope. Plots were fallowed 2 yr and planted in grain sorghum (Sorghum vulgare) the third year. Runoff and erosion were greater from DDAC-treated soil than from bare-check soil. A surface cover of straw or gravel reduced runoff significantly and essentially eliminated erosion. Both the 2-in. straw mulch and the bare DDAC-treated soil reduced evaporation significantly from the 0-to 6 in. depth during a hot, rainless 10-day period. Straw, gravel, and DDAC-treated soil mulches were about equally effective in evaporation control over periods of a month or more. During high rainfall periods, straw and gravel mulches increased infiltration and movement of excess water below 54 in. The effect of chemical treatments on runoff and erosion should be considered in addition to their ability to reduce evaporation of soil moisture.

30. Blaser, R. E. and McKee, Jr., W. H., Virginia Polytechnic Institute. REGENERATION OF WOODY VEGETATION ALONG ROADSIDES.

The effects of climate, soil conditions, seed source, and management programs as related to the natural enroachment of woody vegetation on highway slopes on various established sods are discussed. When established grass sods are not mowed, changes in vegetation called plant succession occur naturally. Grass sods are practical and inexpensive ways of quickly producing a plant cover that is of good esthetic value, controls soil and water erosion, and encourages natural establishment of woody vegetation without man's help.

31. Hadden, William A., et al. Louisiana State University, Div. of Engineering Research (Baton Rouge, La.), Bull. No. 87, 1965. 80 pp. HERBICIDES FOR ROADSIDES IN LOUISIANA. INVESTIGATION OF METHODS FOR CONTROLLING WEEDS AND BRUSH AND RETARDING VEGETATIVE GROWTH CHEMICALLY.

The objective of this study was to determine the advantage to the Louisiana Department of Highways of engaging in a "Herbicides for Roadsides" program. Many states report effective use of herbicides on highway rights of way. Proper use of herbicides has resulted in improved safety conditions, reduced maintenance costs, reduced or eliminated hand mowing or trimming, and overall roadside beautification. Crews applying herbicides should be trained for most efficient application, and to prevent damage to adjacent crops or ornamentals and the health of those applying the herbicides. Trimming around obstructions can be eliminated by the use of herbicides. They can be applied with spray equipment now on the market with a minimum of modification. They should be applied when there is no wind, and at the lowest possible pressure, to prevent drift to adjacent property.

32. Dick-Peddie, W. A. and Campbell, C. J. ROADSIDE DEVELOPMENT. New Mexico State University (University Park, N.M.), Engineering Experiment Station Bull. 31, July 1965, 53 pp.

A four-year study was conducted on erosion control by vegetation along southern New Mexico highways. A number of techniques and pieces of equipment had to be designed both for planting and measuring water losses. Straw mulches were the most satisfactory for those areas which would get no other attention. For shrubs and trees, a layer of gravel was better than a commercial mulch, as the mulch disrupted the capillary action of the soil. Curbs along the edge of the road destroyed the water balance and created erosion problems at their spouts. This could be controlled by the use of bushes and trees, or native woody ground covers.

It was found that different areas presented different ecological problems which had to be taken into consideration when choosing the plant materials. Generally speaking, native plants were hardier and more satisfactory than exotics. Weeds can act as mulches and shades while other plants are being started. They should be mowed rather than dug up. Planting at the ends of bridges, etc., will not only control erosion but also help to break the monotony of the road.

The establishment of vegetation is expensive and time-consuming. Relative costs of other forms of erosion control should be carefully compared with that of plantings.

33. McHenry, J. Roger. USE OF TRACER TECHNIQUE IN SOIL EROSION RESEARCH. Isotopes and Radiation Technology (U. S. Govt. Print. Office, Washington, D. C. 20402), Vol. 6, No. 3, pp. 280-287, Spring 1969.

Techniques used to study erosion by tagging soil with radioactive tracers are analyzed and evaluated. Guidelines to be followed in the selection of a tracer are discussed, and methods of incorporating the isotope on the material to be traced are described. Studies are discussed in which both the movement of single grains of sand and the bulk movement of the soil are followed.

34. White, D. B. and Bailey, T. B. VEGETATION MAINTENANCE PRACTICES, PROGRAMS, AND EQUIPMENT ON MINNESOTA HIGHWAYS. University of Minnesota, Dept. of Horticultural Science, Investigation 619, Feb. 1969, 69 pp. Available: Clearinghouse for Fed. Sci. and Tech. Info. (Springfield, Va. 22151), PB 186 285. $3.00.

This report is offered to help highway personnel improve Minnesota highway turf maintenance programs. The report may also be useful for state, county, and municipal road engineers. Findings and observations from a review of the vegetative phase of maintenance programs and practices in selected areas in Minnesota are presented. A brief explanation of cultural requirements for grasses including examples of cost comparisons and other information pertinent to making judgments on turf maintenance operations is given.

35. FABRIC MESH CUTS EROSION PROBLEMS. Rural and Urban Roads (466 Lexington Ave., New York, N. Y. 10017), Vol. 2, No. 5, p. 49, May 1964.

The primary role of erosion control materials is the temporary stabilization of seeded or sodded areas. They are used during the critical period when seeded areas are developing a grass covering or sod is becoming firmly rooted. Slopes, ditch bottoms, highway medians, and watersheds have been protected by these materials in many states with success.

The fabric materials available for erosion control fall into three general categories--best described as heavyweight, middleweight and lightweight. All are fabric mesh installed with wire staples.

The heavy weight of the erosion control materials is a mesh made of thick jute yarns, put up in rolls approximately 48 in. wide and 75 yds long. This material is designed to hold seed and earth in place where heavy rains and fast runoff might normally cause serious damage. Mulching is not required with this mesh.

There are two middleweight erosion control materials, one designed for seeding without mulch in noncritical areas where moderate runoff is expected, and the other for holding newly laid sod in place. Both of these are woven-paper meshes 45 in. wide on 250 yd rolls.

Cost is the chief advantage of the woven-paper meshes over the jute mesh previously described. The installed cost of woven-paper mesh used without mulch is approximately 30 percent lower than jute mesh, which means that it would be about 50 percent lower than the comparable cost for sodding.

The middleweight mesh used over sod is, of course, designed to prevent failures on critical areas where the amount and velocity of water runoff are potentially greater than the sod can withstand.

The light mesh is similar to the middleweights, being a woven-paper material. The weave is wider, however, as it is designed specifically for use over mulch. It is the least expensive of the three types of mesh. In-place cost of the lightweight mesh, including 1/2 ton of straw mulch per acre, is roughly 75 percent less than sodding.

36. Culling, W. E. H. SOIL CREEP AND THE DEVELOPMENT OF HILLSIDE SLOPES. Journal of Geology (Univ. of Chicago Press, Chicago 37, Ill.), Vol. 71, No. 2, pp. 127-161, March 1963.

A mathematical theory of erosion on soil-covered slopes is proposed. The model is based on the hypothesis that soil particles subject to the influence of forces normally operative within soil covers execute randomly directed movements of minute extent. The distribution and characteristics of the pore space of the soil aggregate exert a restrictive influence and determine the nature and magnitude of the particle displacements. Macroscopically, the motion of the soil particles induces a rate of flow on the hillside slope proportional to the surface gradient. The model is used to supply a series of illustrations of the humid cycle of erosion.

37. Chepil, W. S., Woodruff, N. P., Siddoway, F. H., Fryrear, D. W., and Armbrust, D. V. VEGETATIVE AND NONVEGETATIVE MATERIALS TO CONTROL WIND AND WATER EROSION. Soil Science Society of America (677 S. Segoe Rd., Madison 11, Wis.), Proc., Vol. 27, No. 1, pp. 86-89, Jan.-Feb. 1963.

Fine, medium and coarse gravel spread uniformly at rates of 20, 50, and

100 tons per acre, respectively, adequately controlled wind erosion of smooth, bare, Sarpy sandy loam where no traffic was involved. Resin emulsion sprayed at 600 gallons of concentrate per acre and asphalt emulsion and cutback asphalt sprayed at 1,200 gallons of concentrate per acre adequately controlled wind erosion on level Sarpy sandy loam at estimated respective costs of $213, $247 and $335 per acre on a carload basis, in drums, at Manhattan, Kansas. Under similar conditions, 4,000 pounds of wheat straw mulch per acre anchored with a rolling disk packer was equally effective at an estimated cost of $89 per acre.

Quantities of latex emulsion sprayed at rates up to 225 gallons of concentrate per acre were not sufficient to control wind or water erosion on level or sloping ground. Starch treatments were also ineffective to control wind erosion under the conditions of the experiment.

On a 3:1 construction slope, at least 1,200 gallons of asphalt emulsion per acre sprayed uniformly on the surface were needed to control rill erosion. The treatment cost $335 per acre. In previous experiments on a 3:1 construction slope, prairie hay mulch at 4,000 pounds per acre uniformly spread and anchored with 400 gallons of asphalt emulsion per acre was equally effective at a cost of about $200 per acre.

38. Diseker, E. G. and Richardson, E. C. EROSION RATES AND CONTROL METHODS ON HIGHWAY CUTS. American Society of Agricultural Engineers (420 Main St., St. Joseph, Mich.), Trans. 5:(2) 153-155, 1962. Agricultural Engineering, Vol. 44, No. 1, p. 35, January 1963.

Objectives and results of studies to determine (a) factors affecting rates of runoff, erosion, and sediment production from highway cuts and (b) most effective types of plant cover, as well as fertility and cultural requirements, for rapid establishment and adequate maintenance thereof.

39. GLASS FIBER MAT USED TO PROTECT NEWLY SEEDED WATERWAYS. Park Maintenance. (Madison Pub. Div., Editorial and Executive Offices, P. O. Box 409, Appleton, Wis.), Vol. 15, No. 11, p. 14, November 1962.

Glass fiber mat was the most effective of seven materials recently tested by the U.S. Department of Agriculture for use as temporary protection of newly seeded grass waterways.

Grassed waterways are used to carry flood runoff from terraced areas as well as from roadways and airports. Temporary protection of newly seeded channels--until the grass is established--prevents damage from runoff-producing rains, which can make regrading and reseeding necessary.

The channel-lining materials were rated according to the volume of water they withstood without damage to the waterway or to the material.

The glass fiber mat withstood more than four times as much water discharge as the next best material tested. The mat is a commercial product about one in. thick. It is made of fine glass fibers and is similar in appearance to insulation.

The materials were tested in a channel with a 6 percent slope. The channel had a shallow V cross-section, 10 ft wide and 6 in. deep. The test section was 100 ft long. Each material was subject to flows of increasing velocity. The tests lasted 40 min, unless channel damage occurred sooner.

The glass fiber mat withstood a water discharge rate of 4 cfs. Fine-mesh jute cloth withstood a discharge of 0.8 cfs. This cloth is made of 1/4-in. twisted yarn, with openings 3/8 x 5/8 in.

Close-weave paper mesh, asphalt emulsion with hay mulch, paper net with hay mulch, and coarse mesh jute cloth withstood flow of 0.3 cfs. Asphalt emulsion and paper fiber failed in the first test.

The hydraulic roughness (Manning's n value) of each material tested was determined. This is an index of the friction generated when water flows across the material. Knowing this value, an engineer can calculate the water velocity a material would withstand in any channel of known slope and dimensions. He can then select the most practical and economical lining from the materials tested.

40. DeBano, L. F. WATER REPELLENT SOILS: A WORLDWIDE CONCERN IN MANAGEMENT OF SOIL AND VEGETATION. Agricultural Science Review (U. S. Govt. Print. Office, Washington, D. C. 20402), Vol. 7, No. 2, pp. 11-18, Second quarter, 1969. Selected Water Resources Abstracts, Abstr. No. W70-02686, Vol. 3, No. 7, p. 26, April 1, 1970.

Water repellency affects the management of large areas throughout the world. Seemingly unrelated problems such as plant diseases, subsidence of peat bogs, and soil erosion may be caused by poor wettability in some situations. Organic substances produced by plants or microorganisms can induce water repellancy in soils. High soil temperatures may further intensify water repellency in soils. High soil temperatures may further intensify water repellency in areas burned by wildfires. Mechanical and chemical remedial treatments have been used to increase the wettability and productivity of these problem soils. Waterproofing soils artifically has been found beneficial for highway engineering and water-harvesting purposes.

41. Spooner, A. E. and Murdoch, C. L. Dept. of Agronomy, University of Arkansas, Highway Research Project No. 15, Final Rept. June 1970. 156 pp. Selected Water Resources Abstracts, Vol. 4, No. 4, Abst. W71-02051, p. 16, Feb. 15, 1971. Available: NTIS (Springfield, Va. 22151), PB 194 017. $3.00. EROSION CONTROL ON HIGHWAY RIGHTS-OF-WAY IN ARKANSAS.

Materials and methods for establishment, maintenance, and control of vegetation were investigated. Laboratory and field experiments indicate that a straw and/or wood cellulose fiber mulch is essential for establishment of vegetation. Prevention of erosion and maintenance of the necessary moisture relationship are the principal factors. The need for adequate fertility following seeding and for maintaining nutrient levels were investigated. Tall fescue, common Bermuda grass, weeping love grass, and Bahia grass are the most adaptable grass species for highway use in Arkansas.

42. GET THE DROP ON EROSION CONTROL. Construction Equipment (205 E. 42nd St., New York, N. Y. 10017), Vol. 43, No. 2, pp. 35-38, Feb. 1971.

Erosion control takes three general forms: permanent control items specified in the contract, such as vegetation cover the drains, dikes, dams, and culverts; temporary control measures specified in the contract, either generally or as bid items; and temporary control measures, not in the contract, which become necessary as work progresses. Three new developments to control erosion without planting are described. Sediment traps, 5 to 12 ft wide, 50 ft long, and 3 to 4 ft deep, slow water so it drops its sediment; these are usually located just before a drainage inlet. On fills, success is reported with flexible neopreme pipe that connects to a safe discharge area where water drains out without eroding. On cuts, the serrated cut program borrowed from the Forest Service may be used.

43. Hadley, R. F. and Rolfe, B. N. DEVELOPMENT AND SIGNIFICANCE OF SEEPAGE STEPS IN SLOPE EROSION. Transactions, American Geophysical Union, Vol. 36, No. 5, pp. 792-804, October 1955. Highway Research Abstracts, March 1956.

This study offers an hypothesis, based on field and laboratory data, for the development of one type of erosional scarplets on hillslopes in the semiarid Great Plains. The scarplets are crescent-shaped and are generally less than two feet in height. They have four integral parts: (1) tread, (2) seepage face, (3) base, and (4) debris-slope. Mapping shows that these features are developed roughly parallel to the stream channels and in some cases follow a slope continuously nearly on contour for as much as a quarter of a mile.

The scarplets are developed in surficial mantel material overlying a fine-grained, weathered bedrock surface. Infiltration tests show that a zone of relatively low permeability exists at the contact between the surficial mantle and the weathered bedrock which causes a seepage of subsurface flow whereever the contact is exposed on a free face. These features have been called seepage steps by the authors. After a step is initiated it migrates upslope nearly on contour.

Particle-size analyses of soil samples taken in seepage steps do not reveal large differences in the texture of the material of the tread and base; but the surficial material, which is mainly alluvium and colluvium, is made more permeable by transport.

X-ray studies of the mineral constituents in soil samples show that downslope migration of soil material is a fundamental part of step formation. Very young soil profiles in a semiarid region may acquire the characteristics of a more mature soil by the erosional processes involved in seepage-step formation. Seepage-step studies emphasize the significance of subsurface hydrology in slope development and soil formation.

44. Buchanan, Cedric H., District Engineer, Bureau of Public Roads. GRAVEL STABILIZED SHOULDERS FOR TURF ON THE NATCHEZ TRACE PARKWAY.

This paper presents the results obtained from construction designed to provide turf cover of appearance suitable to the Natchez Trace Parkway on shoulders stabilized for off-pavement parking. One 35-mile section is on submarginal land between the Bermuda grass and Kentucky bluegrass areas, the other is a 15-mile section on clay 100 miles to the south in a Bermuda grass area.

45. Blaser, R. E., Virginia Council of Highway Investigation and Research. SODS ON HIGHWAY SLOPES AS INFLUENCED BY LIME, FERTILIZER, AND ADAPTATION OF SPECIES.

Sod establishment and maintenance on roadside slopes are being investigated in five locations to sample different soils and climatic and biotic environments. Difficult sites for turf establishment on cuts were intentionally selected in different areas in Virginia.

Lime requirements vary for regions as well as for soils within a region. Liberal phosphate fertilization with low nitrogen has favored the stands of legumes in grasses. Fertilizers with a 1-2-1, N - P_2O_5 - K_2O ratio have given good to excellent results. Best clover-grass growth occurred from a 1-4-2 ratio on a Coastal Plain soil. Heavy rates of fertilizer have produced better results than low rates, even though there is seedling plasmolysis with the higher rate. It is not possible to maintain good sods with one initial application of fertilizer for establishment. Fertilizer movement to basal areas of slopes appears serious.

The report gives considerable detail on species adaptation for different climatic, biotic, and soil conditions. The aggressiveness of seedlings is associated with competition with companion crops and time required for establishing. Rye grass and cereals are very aggressive during seedling development and thus harmful to perennial sod-forming species.

Fertilizer solutions as used for the hydro seeding method have not been injurious to germination except for two species tested. There is a tendency for the hydro method to distribute more fertilizer at the basal portion than the top section of slopes. Heavy mulching often retards seedling growth.

46. Duich, J. M. and Musser, H. B., Pennsylvania State College; and Hottenstein, W. L., Pennsylvania Dept. of Highways. THE ESTABLISHMENT OF CROWN VETCH AND BIRDSFOOT TREFOIL ON HIGHWAY SLOPES WITH VARIOUS COMPANION GRASSES AND RATES OF SEEDING.

Previous experiments and practical experience have demonstrated the high value of crown vetch for use as a permanent herbaceous protective cover on the slopes of highway cut and fill sections. However, crown vetch seeded alone did not provide satisfactory early slope protection because of its slow rate of establishment. These trials showed also that certain grasses were effective in providing quick slope protection. Best results were secured with tall fescue (variety Ky. 31), red fescue, and domestic rye grass.

Studies reported in this paper were undertaken to determine the rates of seeding of these grasses with crown vetch and birdsfoot trefoil that would provide immediate slope protection without suppressing the legumes to such an extent that their development into a permanent cover was prevented or seriously checked.

Field plot trials were established in July, 1952, using 3 rates of seeding of the above grasses (25, 40, 60 pounds per acre) and 2 rates for the legumes (20 and 30 pounds and 15 and 25 pounds respectively for crown vetch and birdsfoot trefoil). The seeding rates for grasses and legumes were in all possible combinations. Plots were 5 feet wide and 20 feet on the slope. They were located on a cut section of a highway that had an average gradient of 1-1/2 on 1. All treatments were completely randomized in 3 replications.

Data is submitted showing the quality of the grass cover and initial legume stand in the fall of 1952 and through the 1953 and 1954 seasons.

Results to date show material difference in survival of crown vetch and birdsfoot trefoil at the various seeding rates of the grasses.

47. Mendel, M. A., West Virginia Turnpike Commission. SLOPE STABILIZATION OF THE WEST VIRGINIA TURNPIKE COMMISSION.

A highway to breach the mountainous area in the southern part of West

Virginia has for years been the dream of engineers and contractors who are engaged in the highway construction of this state. In 1949 with the appointment of a Commission of five men, thinking crystallized into action and during the next three years after long study and planning, the money was obtained for this first link in a turnpike system through the state. In August 1952, the first grading contract was let and on November 8, 1954, the final fifty-three miles was opened and the first link of a modern north-south highway was a reality.

To build this highway, 31,750,000 yards of excavation were required, 76 bridges had to be built, one of which is 284 feet above the stream bed. A bridge over the Kanawha River is 2,166 feet long and 70 feet above pool stage. The Memorial Tunnel, 2,655 feet in length, linking two parallel valleys, was another of the major items.

In order to preserve the grades and alignment desired for proper travel, thirty-five miles of existing state roads had to be relocated and rebuilt and 14.4 miles of creeks rechanneled. With all of this massive construction underway, the planners, in keeping with the new look, realized that with cuts up to 256 feet and embankments up to 110 feet, something must be done to prevent excessive erosion and thus Roadside Development came into the picture.

In March 1954, the Roadside Development Department went into action utilizing improved equipment and methods. Mulch spreaders with asphaltic spray attachments were used not only to spread the straw, but to apply minute quantities of asphalt at the same time to tie the mass together. We realized that even this new revolutionary high speed method was not the solution to our problem and soon found that we still had a long way to go to reach the tops of some cuts. In our effort to speed up the work as well as cut excessive labor, we developed an 8-inch aluminum irrigation pipe as an extension to the blow pipe of the machine. This pipe, even in 20-foot lengths, was light enouch for one man to handle on the steep slopes. After the straw was placed, it was sprayed with asphalt at the rate of 75 gallons per acre which has proven adequate to tie the straw into a cohesive mat. In many cases, mulch on the upper sections was spread by hand, using the pipe to send the fluffed straw as far as possible. Asphalt emulsion was carried up the slope 400 feet in a 1/2-inch hose utilizing the pump on the blower which furnished sufficient pressure to atomize the asphalt at the nozzle. No mulch has been placed on this project without asphalt, and to date the losses by wind and water have been negligible.

In general, seeding was done hydraulically following the placement of the mulch and gave excellent results. The development and use of a new hydro-seeder are described in this report. Some unusual techniques in applying fertilizer also are explained. The seed mixtures for cut and fill slopes are given.

As mentioned before, most of the seeding and fertilizing was done after the mulch was in place, but some experimental test sections were installed as follows: Cut No. 1 was seeded and then mulched; Cut No. 2 was mulched and then seeded; Cut No. 3 was mulched and then seeded with seed treated against soil organisms; and Cut No. 4 was seeded and then mulched with treated seed. Of these, the cut that was mulched and then seeded, was best. Numerous additional observations and conclusions are cited.

Details pertaining to equipment and the organization of Roadside Department Personnel are given in appendices to the report.

48. Yoder, Eldon J. TOPSOIL AND SEEDING STUDIES AT PURDUE UNIVERSITY, INDIANA. U. S. Waterways Experiment Station, Vicksburg, Miss., Technical Memorandum No. 3-392, July 1954. Highway Research Abstracts, October 1954.

In accordance with the contract between the Engineering Experiment Station of Purdue University and the Waterways Experiment Station, Vicksburg, Mississippi, a turf test plot measuring 60 feet by 80 feet was constructed at the Joint Highway Research Project Test Road Site.

The test plot includes 16 sections, 5 feet in width and 60 feet in length. Four materials, a clay, clay gravel, sand gravel, and silty sand were placed in the sections at 3- and 6-inch depths. Duplicate soil rows were constructed for each of the materials. After placing, the entire plot was fertilized and seeded with a mixture of Kentucky bluegrass and Alta Fescue grass seed. A layer of straw was then placed on top.

This report covers the construction of the test plots as well as observations and ratings made of the topsoils for the period of October 20, 1950 to May 31, 1952. The primary purposes of the topsoil and seeding studies are: (1) the establishment of criteria for the determination of suitability of a range of soil type for the production of turf grasses, (2) the relation of the depth of topsoil to economy in the establishment and maintenance of turf grasses, (3) the relation of permeability of soil to economy of turf production, (4) the determination of economically effective seeding and fertilizer rates on various soils, and (5) the assembly of data into a manual.

A number of general conclusions can be made from observations of the turf growth:

1. If ample fertilizer is applied, adequate turf can be grown on granular materials. Although quantity of fines was not introduced as a variable, the effect of varying the fines is noticed primarily from the standpoint of leaching and water retention. Some difference was noted when comparing the various granular materials early in the investigations; however, they were of about equal merit by May 1952.

2. Nitrogen fertilization was by far the most-important variable. Repeated light nitrogen treatment 1 lb. per 1,000 sq. ft. is needed to maintain good turf. Heavy nitrogen treatment on the materials did not materially increase the turf growth over that of lighter treatments.

3. Quantity of seed affected the ratings soon after germination: however, as time progressed the intermediate treatment (5.4 lb. per 1,000 sq. ft.) showed practically the same turf development as double this amount.

4. Depth of granular topsoil is important from the standpoint of water retention and leaching of the chemicals. The 3-inch depth was better than 6-inch depth in the majority of the ratings. The differences, however, were relatively small.

49. SOIL EROSION RESEARCH. Budocks Technical Digest (U.S. Navy, Bureau of Yards and Docks), No. 32, p. 21, February-March, 1953. Highway Research Abstracts, May 1953.

The bureau currently has one research contract with Ohio State University for the investigation and development of improved methods of controlling soil erosion. Under this contract, a rainfall applicator has been designed and built to duplicate natural rainfall and to permit accurate precipitation control. The device is being used to determine, in the laboratory, the effectiveness of various soil additives for erosion control. In addition, experimental field slopes are being maintained for full-scale evaluation of erosion-control additives.

The basic approach has been concerned primarily with the examination of various additives and methods of application that will stabilize erodible slopes during the period required to establish suitable covers of vegetation as permanent projection. A number of proprietary materials have been or are being evaluated for this purpose. These include Monsanto CRD-189, Monsanto CRD-186, DuPont Orchem DV-71, DuPont Elechem-1089, and American Cyanamid Aerotil. Aggregation of soil by hardening with cement and crushing to size has also been included in the study.

These investigations indicate that several of the treatments are quite effective on certain types of soil, but additional work will be required before accurate prediction of their effectiveness for specific areas can be made. Further exploration also will be required to determine the best methods of application and treatment level for the various types of soil. The results obtained to date, however, have been quite encouraging.

50. Goodman, L. J. EROSION CONTROL IN ENGINEERING WORKS. Presented at the Annual Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 17, 1951. Highway Research Abstracts, Feb. 1952.

This report gives the principal findings of a laboratory and field study of the effect of Krilium (sodium salt of hydrolyzed polyacrylonitile) in preventing soil erosion. The laboratory study consisted of exposting soils placed in splash cups to drip water from a mat of chicken wire covered with muslin holding yarn strings to facilitate uniform spacing of drops. Three different Krilium contents were used, namely 0.2, 0.4 and 0.6 percent by dry weight. The chemical additive was thoroughly mixed with the dry soil. Enough water was added to dissolve the chemical. The soil was then dried, and placed in the splash cup. The cup was placed on a jar which carried a cotton wick to permit water to be drawn up into the sample and thus standardize the method of saturation. The specimen was then exposed to the artificial rainfall.

Test plots were established in several sections of the country to obtain field and laboratory correlation. The Krilium was either sprinkled on the surface or raked in and then wetted.

The author summarized his findings in part as follows: From data obtained on most soils investigated in the field, treatment with Krilium was effective. Two practical methods of applying the chemicals to soil plots were determined: (1) sprinkle evenly on surface and (2) rake in to approximately 3/4 inch depth. In both methods wet down thoroughly but avoid runoff.

Low weight concentrations of the chemical are extremely effective in reducing splash loss. Recommended concentrations as of this writing are: (1) 1/3 to 1 lb. per 100 sq. ft. for the surface treatment and (2) 3/4 to 1-1/2 lb. per 100 sq. ft. for the rake in treatment.

Based on the many splash tests run to this date, it appears that there is a possibility of eventually setting up a chart to tell the amounts of additives to use on each different soil and slope.

It appears that the chemicals may also prove effective as dust controllers.

Since silty soils are susceptible to frost heave and because the additives bond the fine-grained particles into large aggregates, it seems advisable to study the effects of these additives in controlling frost action.

Cut and fill sections will tolerate steeper slopes when treated with these chemicals. This may represent an important technique for reducing construction and maintenance on high slopes.

51. Goodman, Louis J., Asst. Professor of Civil Engineering, The Ohio State University. SOIL ADDITIVES FOR EROSION CONTROL* *This work was supported, in part, by a contract between the Bureau of Yards and Docks of the Dept. of the Navy, and the Ohio State University Research Foundation.

Erosion is one of the most serious problems encountered by engineers and soil conservationists. Highway cut and fill sections, upstream faces of earth dams, and other types of earth slopes must be protected against erosion. Current control methods are either too expensive or detrimental to vegetation, which is the simplest means for protection of most slopes. Many fine-grained soils, which are not conducive to vegetation, are highly susceptible to erosional damage.

This paper summarizes an extensive search for soil additives that can reduce the damaging effects of rainfall on steep slopes and thereby curb erosion. Described are laboratory testing procedures which were developed for the purpose of making hydro-mechanical studies of soil erosion and for evaluating the various soil additives studied. As a check on the laboratory work, field slopes have been set up in several sections of the country and observations on these have been quite encouraging.

Although no <u>entirely</u> successful material was found during these investigations, one has proved to be very effective on certain soil types. Several other additives have shown good possibilities on one or two soil types. In order of their effectiveness based on current test data these are: (1) Monsanto CRD-189, (2) Monsanto CRD-186, (3) soil-cement aggregates, (4) Du Pont Orchem DV-71, (5) Aerotil, and (6) Du Pont Elchem-1089.

As a result of this study, two practical methods of application were evolved:

1. Spread additives on surface uniformly and wet down. (This surface treatment has been the more effective.)
2. Rake in additive to a depth of 1/2 $\pm$ inches and set down.

52. Krusekopf, H. H. EFFECT OF SLOPE ON SOIL EROSION. Missouri Agricultural Experiment Station, Research Bulletin 363; Brit. Abs., B.III., 1949, (October), 406. Building Science Abstracts, Vol. XXII (New Series), No. 12, December, 1949, London. Highway Research Abstracts, June 1951.

An increase in slope from 6 to 8.48 percent increased run-off by about 35 percent and approximately doubled the amount of erosion. The cropping system was the most important factor affecting run-off and erosion. The degree of slope and the amount and intensity of rainfall also affected erosion, but to a variable extent, and their influence was greatly modified by the cover. Vegetation was more effective in reducing erosion than in reducing run-off. Under good cover the length of slope was the least significant factor affecting run-off and erosion.

53. EROSION CONTROL ON CALIFORNIA STATE HIGHWAYS. Reprint of a series of articles published in "California Highways and Public Works". Highway Research Abstracts, Feb. 1951.

The most successful erosion control methods have proved to be those which reproduce most closely conditions which are to be found on natural slopes. Mechanical or unnatural methods of control, while sometimes immediately effective, deteriorate with time and show up poorly in the long run as compared with methods that follow natural vegetative processes. If we work with Nature, erosion control problems are simplified and the probability of success becomes more certain than if we disregard the examples of successful natural stablilization to be found on every hillside and proceed to attack the problem from a mechanical angle.

By artifically speeding up the stabilization process, thereby creating conditions in one season which Nature could not duplicate in several years, we find that we can shorten the time required for complete control.

Much of the value of slope stabilization treatment is lost unless proper maintenance can be given during the all-important first and second years after installation, and as required thereafter. Cost of timely maintenance is not high, but neglect can bring about increased and unnecessary expenditures due to the necessity of cleaning gutters and repairing gullies which threaten the traveled way, and of frequently rebuilding portion of roadways at fill locations.

Highway construction standards now encourage the use of flatter slopes in erosion-prone soils. Flatter slopes allow the use of thicker blankets of topsoil which can support a more vigorous growth of vegetation without tending to slump when saturated. Control problems are eased considerably, and the need for maintenance reduced.

As new successful erosion control projects are completed and the consequent reduction in maintenance cost for repair of erosion-caused damage becomes more evident, highway employees are taking a greater interest in the program. Highway engineers have been particularly cooperative in developing methods which would be both practical and effective and highway maintenance forces have become more conscious of the value of prevention. There is still a decided need for continued educational work, however, especially in regard to effective methods for repair of old eroded slopes, and it is believed that eventually this work will be done as a matter of course.

Experimental work will be continued. Even though it is felt that considerable progress has been made, too many questions remain unanswered and too many partial failures result from high-intensity rains to allow us to believe that the most effective methods have yet been developed.

54. Dong, S. B., Hasson, C., and Westmann, R. A., University of California, Los Angeles. EMBANKMENT ANALYSIS AND FIELD CORRELATION. Highway Research Abstracts, Dec. 1967.

Earlier approaches to the analysis of earth embankments have necessarily focused attention on slope stability. Development of techniques to determine possible states of plastic equilibrium permits estimates of the ultimate performance and safety of the earth structure. Until recently, however, little effort has been devoted to evaluation of stress and deformation states in embankments during construction and prior to failure.

The recent development of computer techniques now permits the solution of geometrically complicated boundry-value problems. These methods include the techniques of finite differences and finite elements. The finite element method (FEM) has recently attracted the attention of many structural analysis. This is primarily due to its inherent versatility and to the ease with which the technique can be applied to problems heretofore considered intractable. Extension of the FEM to include the effects of nonlinear materials has been made as well. This clearly indicates the possibility of a quantitatively meaningful stress and deformation analysis of earth embankments.

In a recent construction program, the Materials and Research Department of Division of Highways, State of California, placed and instrumented some high earth embankments. It was a program intended to develop accurate and reliable instrumentations for stress and deformation measurements and acquire technical experience in placing these gages. Assuming the integrity of these field measurements (within reasonable experimental scatter), these experimental results afford an excellent opportunity to assess the validity of the mathematical model.

It is the purpose of this paper to perform the necessary numerical analyses for a particular embankement and compare the results with the field measurements. This comparison then permits an assessment of the accuracy of the mathematical model and prediction technique.

In the next section the details of the mathematical model are presented along with a brief outline of the solution method. Numerical results are then presented for the embankment and these are compared with the field measurements. The final section concludes with a discussion and some recommendations.

55. Higgins, Charles M., Louisiana Dept. of Highways. PRESSUREMETER CORRELATION STUDY. HR Abstracts Dec. 1968.

This study is an evaluation of the Menard pressuremeter system for determining in-situ soil strengths for cohesive soils at construction sites. Results from the pressure-meter were compared to results obtained from use of the unconfined compressive strength test and the consolidated undrained triaxial test. Data indicated that for very soft cohesive soils, the correlation between pressuremeter-derived shear strengths and conventional shear strengths for this study was good. It is substantiated by the results at the Houma and Plaquemine test sites and has been noted in investigations by other researchers. At the Sorrento test site, there was a not completely explained increase (not present for conventional tests) in pressuremeter shear strengths with depth. This trend has been noted by other investigators; it is probable that the pressuremeter shear strengths may be closer to the true in-situ strength of the soil than those obtained by conventional methods using open drive sampling techniques. At the Perkins Road and Lake Charles test sites, there were considerable differences between pressuremeter-derived shear strengths and conventionally obtained shear strengths, with the pressuremeter results being consistently higher. When the in-place conditions of the soil (as shown by radiographs, photographs and remolded samples) are considered, it seems highly probable that the pressuremeter shear strengths may be more representative of true in-situ conditions than shear strengths obtained by conventional tests. For soils in which small strata of a different material, whatever its nature, are interspersed within a core, however, the strengths estimated probably lie somewhere between the strength of the weakest material and that of the strongest within the test segment. This requires particular attention in any situation where stability against sliding is critical since slip planes could conceivably form along the strata of weak material. Testing on noncohesive soils with the pressuremeter requires equipment not normally used by the Louisiana Department of Highways. Constant caving of these materials caused difficulties so that no acceptable tests were made during this study.

56. Alban, E. Kenneth and Reisch, Kenneth W. A STUDY OF ROADSIDE MAINTENANCE AND LANDSCAPE PLANT ESTABLISHMENT. Ohio State Univ., Engineering Experiment Station (Columbus, Ohio 43210), Transportation Research Center Report EES 285-2. June 1968. 56 pp., HR Abstract Nov. 1968.

The object of this study was to develop safer methods of herbicide application, while reducing costs of weed control, erosion control, maintenance and plant care. Specifications for planting procedures for both ornamental and functional plants were created. Cost data were accumulated and analyzed in order to establish the best practices for roadside development. Results of the tests are reported. A short bibliography is included.

57. GRASS SOIL STABILIZATION. Road and Transport Contracting (Breckell & Nicholls Ltd., Apirana Ave., Glen Innes, Auckland, New Zealand), Vo. 15, No. 8, p. 43, Aug. 1967, HR Abstracts Jan. 1968.

The problem of erosion on the sides of new cuts has caused concern to engineers for many years. If this surface erosion could be eliminated by the promotion of grass growth, great savings in time and money could be made. Recent research carried out in this country has shown that a certain chemical of the latex type will fix the seed and the surface soil to such a degree that they will not be affected by adverse weather conditions, nor will seed germination be inhibited. The physical action is to tie all surface particles of soil and seed together in such a manner that under even heavy rainfall or high wind conditions no movement can occur, and yet moisture is allowed through, and subsequent evaporation takes place. The chemical is a viscous liquid which readily mixes with water forming a stable emulsion. Application of 6 gallons, with water as a carrier, per 1000 sq yd has given the desired result. Even coverage is essential. The need for mulch of straw or hay is obviated by this chemical's abilities. Tentative trial work in progress at present indicates this chemical has dust supressant possibilities.