The Relation of Engineering to Soil Conservation Programs

PROFESSOR O. J. TRENARY
Department of Agricultural Engineering, State College of Washington

Conservation in this country has differed in many respects from that in other countries, primarily due to our cherished custom known as Freedom. This so-called freedom, together with the lack of common sense in many farming practices, has brought about losses in our agricultural resources. The present unfortunate conditions could largely have been avoided by educating the farmers in regard to the need and suggesting methods to carry out a well rounded program in conservation.

There have been many changes in the flora and fauna in this country which were brought about in the development of these United States. The big problem before us now is to build back the ecological requirements which have been disturbed by our agricultural and forestry cropping.

The old world has many practices which are correct, some of which could be adopted by us; but care must be taken, since our topography, climatic conditions, and environment may differ from those in other regions. The same may be said of the several regions in this country, but the experiences of one locality are not used by another to the fullest possible extent.

The need for education is still evident in conservation. Demonstrations are likewise very essential, and especially those that are most successful. The place where these are most needed is without doubt on the land where man is in the best position to aid in bringing about such changes as are necessary.

The job of the engineer is to apply sound engineering principles and practices to this program of conservation. The structures for the individual farm or group of farms, require the same fundamentals of hydraulics, mathematics, physics, mechanics and other sciences as in the larger and more intricate reclamation projects. The engineer in this field must also have a good agricultural background, with proper training in soils, agronomy, farm management, and forestry if he is to be a success and of the greatest value to the organization. Many engineers without the proper training in agricultural subjects tend to limit their vision of specific problems to the immediate details of hydraulic and mathematical formulas and overlook the ultimate result and proper application of engineering in agriculture. The engineer then must be able to contribute into a pattern of which he is but one of the designers. Close cooperation with the other specialists is most essential.

There are many methods used for the control and conservation of our land resources. The field is so large that it will be necessary to consider but a few of the many. There are certain fundamental methods used in the control of cultivated land which should be fully appreciated as they must be analyzed by the engineer to more readily determine what he must do to accomplish the desired end. These methods are:

1. To intercept, divert or store the surface runoff.
2. To improve the structural characteristics of the soil.
3. To bind the soil in place through the use of vegetation.

These three methods, if properly coordinated by the engineer, will largely control the soil losses brought about by water and wind, and will result in the conservation of water in our arid and semi-arid regions.

The first method mentioned,—namely, to intercept, divert or store the surface run-off,—is the engineer's chief problem. In one part of the country it is important to conserve and store the water, while in other areas it must be led off the slopes in such a manner as to avoid damage to the soil by washing.

Proper and adequate disposal of the surface run-off is the major problem in the development of a satisfactory conservation plan. It is poor planning to expend funds and effort in securing proper land use and at the same time to neglect the drainageways which must convey the concentrated run-off. Gullying will occur and in many instances has quickly taken place in the neglected drainageways.

Mechanical structures provide effective control of run-off water, but the high cost of installation restricts their use in most cases to areas wnere erosion-resisting grasses cannot be grown. The use of mechanical structures has some distinct advantages over a grass outlet ditch on areas where land values are high. Less space is needed for the outlet channel, and it is ready for use as soon as the concrete is set. In many areas a type of grass may not be available, or the grass may be too aggressive for use in drainageways occurring in cultivated fields. The mechanical structure can serve in such instances as active overfalls may be eliminated and land which has already been destroyed through erosion can be utilized as a drainageway.

Oklahoma has done some experimental work in the casting of concrete slabs on the ground and, after they are set, using them to construct baffles in the drainageways that are eroding. This method costs less than masonry or monolithic concrete and can be installed with a small amount of labor.

The engineer has taken advantage of the work done by the agronomists in developing grasses for erosion control and is using the sod in the construction of sod dams. These are being used in the semi-arid as well as the arid regions of the United States. The dam is constructed across the small gullies with dirt, leaving a weir section in the center. The dam is then covered with sod. The sod serves as a mat over which the water flows.

The method of diverting the water out of a channel while some erosion-resisting grass is being established and then turning the water back into that channel after it has been stabilized has been practiced to a large extent, with considerable success.

An effort has also been made to construct temporary structures for gully control, with the idea in mind that grasses would eventually take over. This practice has not met with success, and the value of it has not been proven. The tendency now is not to use it as a generally recommended practice.

The concentration of water flowing down a slope produces erosion. The engineer, in his plan to shorten the surface run and prevent the increase in volume of flow suggests the use of terraces or diversion ditches to intercept this flow. The water is led to natural streams or prepared drainageways at non-erosive velocities.

He has used vegetated outlets and met with some success but again sufficient data was not avaiable for him to properly evaluate it and determine the limits of adaptability as an engineering material of construction. There are certain things he must know such as durability, dependability, behavior under water loading conditions that are needed for sufficient growth and time required for such growth to be attained. As this was not all recorded for his use, experimental layouts were set up. It was readily demonstrated silting would take place in these outlets along with scouring. The present trend is away from vegetated channels and toward one of the meadow strip design. This allows the spreading of the water over a larger area, use of the water to promote growth, gives some return in the form of hay and encourages maintenance work by the cooperator. The encouragement of proper maintenance work and educating the public of the need for such is, in itself, a problem.

In a recent survey made by the Soil Conservation Service in the Middle West, it was found that more failures in the various methods used in conservation practices were due to the lack of proper maintenance work and the failure of the cooperator to realize the necessity for it, than any other one factor.

In the construction of diversions and diversion terraces, the silting in of the channels was found to be a factor of considerable importance. Here the engineer has adapted the use of a grass strip above the channel of sufficient width to filter out the silt from the surface water before it enters the channel. Here again more work needs to be done on breeding or finding a selection of grasses that will successfully withstand this silting. It also requires more work on the prevention of the concentration of water through the filter due to the dropping of the silt as the water strikes the strip and building up a dike.

The scientific answer to many questions must await the results of additional years of research, but as time passes the problems have and will continue to shape themselves into such a form as to present some clear features.

Terracing has withstood the test of time, having been used in Biblical times; but we are in need of better coordination of principles and less rule-of-thumb practices. Carelessness and ignorance exercised when making a terrace layout has brought about many failures avoidable through more research and knowledge of the factors determining the extent of run-off.

The resistance to dislodgement of individual soil particles is of importance in conservation. This dislodgement is depending upon dispersivity, moisture equivalent, and colloid content. The porosity and friability under normal cropping practices are insufficient to absorb the rain as it falls so surface run-off is bound to follow. This run-off causes the soil loss and the amount is a function of the characteristics just mentioned. Here may lie the answer to many difficulties encountered in the spacing of terraces.

In the pastures considerable work has been done on the construction of contour furrows for moisture conservation. In a recent survey made on a series of farms, the vegetation was much improved in the furrow and for a short distance below the furrow. This survey would point toward the closing up of the space between the furrows thus bringing about a better distribution of the water.

Some interesting work was carried on by Professor J. H. Neal of the Department of Agricultural Engineering of the University of Minnesota on the effect of degree of slope and rainfall characteristics on run-off and soil erosion in which he made the following conclusions. Infiltration was not affected by either slope or the rainfall intensity, but varied inversely as the initial soil moisture content. Percentage of slope had no apparent effect on the percentage of run-off for slopes above one per cent. Percentages of run-off increased as the rain intensity increased, but at a decreasing rate. When the soil was dry before a rain, run-off did not occur until several minutes after the rain started. The time elapsing between the beginning of the rain and the time when run-off occurred decreased as both the slope and the rain intensity increased. After run-off started there was a continual increase in the rate until the infiltration rate had become approximately constant. This occurred 1 to 2 hours after the beginning of the rain.

Density of the run-off material decreased during the first hour of rain. When the rain continued longer, the density remained approximately constant.

From 1½ to 2 times as much run-off was required to remove a pound of soil at the end of one hour as at the beginning of the rain.

Relative density of the run-off material increased as both the slope and the rainfall intensity increased.

Soil losses from a saturated soil increase as the .7 power of the slope, the

2.2 power of the rain intensity and directly as the time of duration of the rain.

The amount of erosion from a soil which was in a dry condition at the beginning of the rain was affected by the initial soil moisture content and the condition of the soil surface, in addition to the degree of slope, the rain intensity and the duration of the rain.

A soil in a dry, pulverized condition or one in a dry, rough condition will absorb much more rainfall than one in a smooth, hard, packed condition.

It is research of this nature combined with that found in other fields which is needed to remove the uncertainties in conservation engineering.

The use of vegetation to bind the soil in place and retard surface flow is used by the agronomist and forester in controlling water and wind erosion. As mentioned earlier in this paper, the engineer finds use for it in developing drainageways and serving as a filter above diversion terraces and ditches. He likewise finds use for grasses, vines, and shrubs in the prevention of erosion in cut and fill slopes on highways, gully banks, earth dams, and to stabilize spillways sections of low dams serving small drainage areas.

The agronomist and forester supply the directions for the adaptation and growth of the vegetation but the enginees has contributed materially in improving methods of transplanting and the reshaping and preparation of cross sections to ensure more successful plant growth.

The improvement of the physical condition of the soil is of value to the engineer since he is interested in the ability of the soil to hold water. Through the use of legumes, crop rotations, liming and others the absorption and the quantity of rainfall storage can be increased. The engineer can contribute to this item through the use of machinery to break up the tight subsurface, and improve tillage practices. This will all help him in reducing the run-off and increase protection to any structural measures.

I have mentioned only a few of the many contributions the engineer has made and can make in the field of conservation.

His importance in this field can perhaps best be illustrated in the number employed by theSoil Conservation Service as of November, 1940, in comparison to those in other professions. The number is as follows: Agronomists, 646; Soils Men, 690; Foresters, 301; Engineers, 1227; Soil Conservations, 1635. Engineers also comprise a part of the number classified as soil conservationists.

The engineer must at all times be alert to the interrelation between the technical and human problems involved in his work. He must contribute his share to the field of conservation comprised of all branches of agriculture. That contribution must be along the agricultural phase as well as the engineering, or he will slowly pass from the picture.

1941 Meeting

Dates for the 1941 meeting of the Northwest Scientific Association are December 29 and 30 at the Davenport Hotel in Spokane.