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PROFILE LEVELING
for
4-H Farm Engineering Club Members

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INTRODUCTION

As a supplement to Bulletin No. 218 on terracing and Circular No. 219 on gully control, this circular will prove useful to 4-H Farm Engineering Club members who care to take the advanced work as described in the Outline of 4-H Farm Engineering Activities, Club No. 3. Farmers and others who desire to put their land into the best condition possible for economic production may also get some useful information through a study of these pages.

The application of sound business principles to farming is becoming more necessary each year as competition among growers becomes keener. Fields that are now low in fertility or that have little moisture holding capacity might profitably be left out of competitive production until these conditions have been remedied. These conditions are often found in sloping fields. The owners's first care should be to construct a well planned system of terracing on the slope to prevent further erosion and to help retain a greater amount of each rainfall. After terracing, (see Circular 218) soil improvement crops such as sweet clover, soybeans, or cowpeas could be grown, returning to the soil as much as possible of each crop until the fertility and moisture holding capacity of the field is such as to warrant it being used again for competitive production.

If Oklahoma farmers would profit by the experience of others and build their terraces fully two feet high and fully 25 feet wide at the base, much disappointment and wasted effort would be avoided. Terraces are not economical and safe on ordinary sloping land unless they are built to the dimensions given. A width less than 25 feet generally means land lost to cultivation, a lower height than two feet usually means washed out terraces. Our best farmers increase the size of their terraces each year by back furrowing to the ridge until the ability of the terraces to care for unusual rains and at the same time offer no hindrance to cultivation, has been demonstrated beyond doubt.

The problem of caring for the water from terrace outlets generally demands serious consideration and may necessitate some form of dam (see Circular 219 to prevent eating back of a ditch along the terrace line. Sometimes a public highway or fence line ditch must be depended upon to carry the water to a final outlet.

PROFILE LEVELING

The drainage of wet areas either by open ditches or by properly installed lines of drainage tile is usually a profitable undertaking as it makes available for production comparatively fertile areas upon which crops may be grown at a profit.

In all cases where water is to be carired in a ditch through rising ground, or where the tile drainage of wet areas is to be accomplished, some knowledge of profile leveling will be found useful.

The only equipment necessary for running profile lines is an instrument or level, and a leveling rod. This equipment meets the needs of most any farmer's surveying problems, as the running of terrace lines, ditch lines, fence lines, and in the setting of foundations for farm buildings. Hundreds of land owners in Oklahoma now regard the farm level and rod as essential parts of farm equipment in much the same way that plows, harrows and cultivators are considered essential.

Definitions and Discussions of Terms Used in Profile Leveling

Elevation. Throughout our discussion of profile leveling we shall have occasion to refer to certain points or places as having some definite elevation. By elevation of a point we mean the number of feet it is higher or lower than mean sea level, or some other level that may be arbitrarily chosen. Whether the level used is mean sea level or an assumed level, it has a zero elevation and is spoken of as the datum, or datum plane, and is the plane to which all of the heights or elevations in the survey are referred. When referring to grade at a certain point along a ditch line we mean the elevation of the bottom of the ditch at this particular point.

Bench Mark. A bench mark (B. M.) is a fixed point of more or less permanent character whose elevation is known or assumed. It is used as a reference point in obtaining the comparative heights of points, the elevations of which are unknown. A bench mark may be established on the farm by selecting some permanent object, such as a large boulder or section of a concrete curb, and marking on the object a definite and permanent point or spot upon which the rod may be held when doing survey work. A three or four foot length of iron pipe driven into the ground to within about one-half inch of the surface at a spot where it cannot be disturbed makes an excellent bench mark. The elevation chosen for such a bench mark is usually 100.

Backsight, or plus sight (+S). A backsight is a reading taken on a point of known elevation for the purpose of obtaining the height of the instrument, usually designated as "HI."

Height of Instrument, (HI). The height of the instrument is the elevation of the line of sight in the instrument and is obtained by adding the backsight reading to the elevataion of the point on which the reading is taken.

Foresight, or Minus Sight (−S.) A foresight is a reading taken on a new point to determine its elevation, which is obtained by subtracting the foresight from the "H. I."

Turning Point "T. P." A turning point, like a bench mark is a reference point used in determining the H. I. When the instrument is moved to a new location along the surveyed line, the T. P. is usually the last station point upon which a foresight is taken before moving the instrument.

Running the Profile Line

The purpose of profile leveling is to determine the elevations of a series of points on the surface of the ground along some definite line. In most instances where it is necessary to run a profile line the problem is usually one of draining a low wet spot in a field into a near by ravine or gully. In this case a survey of the area is made to determine the most desirable route for the ditch line. This will generally be the shortest distance between two points, the inlet and the outlet. After determining the approixmate location and direction of the drainage line it is then "stationed," i. e., marked with stakes at every fifty or one hundred foot intervals. Since the object is to obtain an outline or profile of the ground surface along this line, it is advisable to locate intermediate stakes at every high and every low point along the line. All stakes become rod stations at which rod readings are taken. Each stake is marked according to the distance it is located from the initial or beginning end of the line. The plus sign is employed in marking stakes; figures to the left of the plus indicate the number of hundred feet from the beginning end of the line; figures to the right of the plus sign indicate the number of feet in addition to the hundred figure on the left. Thus, the first stake on the line will be marked 0+00, no distance having been traveled at this point. If the next station is 50 feet away it is marked 0+50. When a stake is 100 feet from the start it is marked 1+00; if 275 feet it is marked 2+75, etc. These markings are entered in the station column of the field notes as shown on page 5.

A form of notes of this kind is necessary for accuracy and to permit a check on any part of the work to be made at any stage of the proceedings.

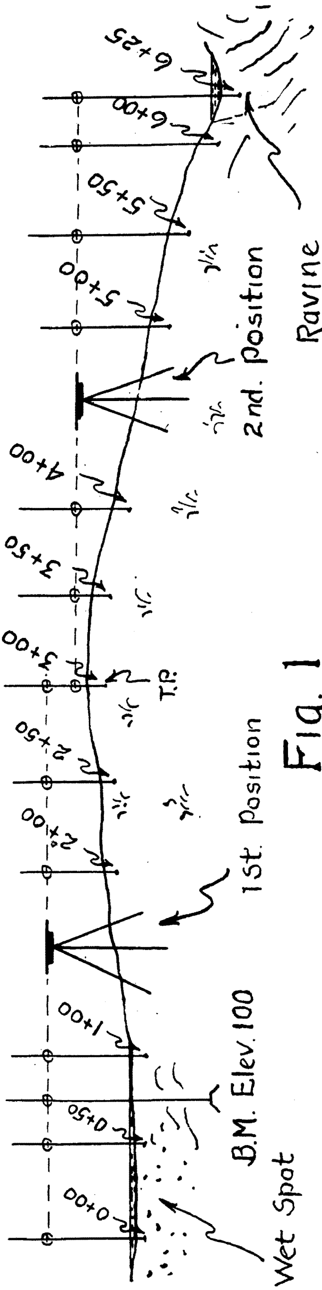

Fig. 1

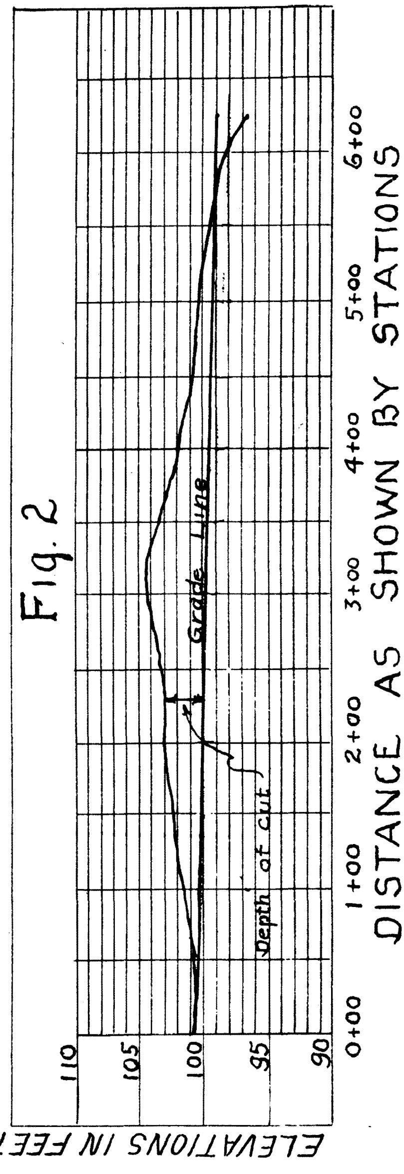

Fig. 2

Field Notes Obtained from Profile, Figure 1

(Grade Used .24%)

Station	+ B. S.	H. I.	−F. S.	Elevation	Elevation of Grade	Cut
B. M.	7.42	107.42		100.00		
0+00			6.75	100.67	100.67	0.00
0+50			6.67	100.75	100.55	0.20
1+00			5.50	101.92	100.43	1.49
2+00			4.42	103.00	100.19	2.81
2+50			4.25	103.17	100.07	3.10
3+00			3.08	104.34	99.95	4.39
T. P.	1.58	105.92	-----	-----	-----	-----
3+50			2.75	103.17	99.83	3.34
4+00			3.92	102.00	99.71	2.29
5+00			5.67	100.25	99.47	0.78
5+50			6.17	99.75	99.35	0.40
6+00			7.42	98.50	99.23	−0.73
6+25			9.34	96.58	99.17	−2.59

NOTE—B. S.=Backsight. H. I.=Height of instrument. F. S.=Foresight. Elevation=Elevation of ground surface. Elevation of Grade=Elevation of ditch bottom. The (+) sign in the backsight column and the minus (−) sign in the foresight column serve as reminders that Elev. +B. S.=H. I. and H. I.−F. S.= Elev.

With the line of stakes established and marked, the next step is to determine the elevation of the surface of the ground at each station. Whether the line over which the profile is run is to be used for surface drainage or for tile drainage will determine the accuracy that should be employed in getting surface elevations at the rod stations along the line. Elevations for surface drainage might well be taken directly on the surface of the ground, while for tile drainage elevations should be taken on top of "grade hubs" which are stakes driven by the side of the rod stations so their tops are about level with the ground surface. The reason for greater accuracy in determining rod station elevations for tile drainage is of course obvious when we know that a smooth easy flow of water through a tile line cannot be secured unless the ditch is dug smooth and true to grade.

Referring to Figure 1, let us suppose that we wish to construct an open drainage ditch for the purpose of draining the low wet spot into the nearby ravine. First, the distance from the lowest point in the wet spot to the ravine is stationed and by measurement is found to be six hundred twenty-five feet. The instrument is now set up in the first position and a backsight reading taken on B. M. We record this reading 7.42, in the B. S. column of the field notes and the value 100.00 assumed for B. M. in the elevation column, opposite station B. M. We next read the rod held at station 0+00, 0+50, and so on to

3+00. These are foresight readings and each is subtracted from the H. I., 107.42, to obtain the elevation of the station on which the reading was taken. All elevations are entered in the elevation column opposite their respective stations.

The instrument is now moved to the second position. (It should be noted that the leveling instrument is not set on the line when taking rod readings, but should be in a position from which a reasonable number of stations may be sighted). Station 3+00 whose elevation was found to be 104.34, now becomes a turning point. The back sight reading, 1.58, taken on the T. P. is added to 104.34 to obtain the new H. I., 105.92. The elevations of the remaining stations are now obtained by subtracting their foresight readings from the new H. I.

It is noted that all rod readings are recorded in feet and hundredths instead of feet and inches. This system is preferable because additions and subtractions and all arithmetical calculations can be made much quicker and with less chances for error than when the feet and inch system is used. It is an easy matter to record inches in hundredths by remembering that 3", 6" and 9" have decimal values of .25, .50 and .75 respectively, and that if either one or two inches is to be added to any of these values, it is just a matter of adding either .08 or .17. If readings are to be more accurate than to the nearest inch, as in the establishing of a grade for tile, it is easy to remember that one-eighth of an inch is equivalent to .01 of a foot.

After obtaining the elevations of each of the station points as shown in the sample field notes we now determine the available fall between the initial and final points. This is found by getting the difference between the elevations of the two points which, in this case, is 4.09 feet. Then the per cent of fall available is:

$$\frac{\text{Total fall}}{\text{Total distance}} = \frac{4.09}{625} = .0065 = .65\%$$

For an open drainage ditch this amount of fall is great enough to cause excessive eroding of the ditch bottom. A grade of .25% or .25 of a foot fall per 100 feet is a better grade to use and will also lessen considerably the necessary amount of excavating.

In order to make the figuring of grade much easier we may use .24% instead of .25%. This will give a fall of .12 of a foot in 50 feet and .06 in 25 feet. The elevation of grade at station 0+00 will be the same as its elevation, 100.67, since the bottom of the ditch need not be deeper than the lowest point in the wet spot. The elevation of grade at 0+50 will be 100.67 less .12=100.55, and elevation of grade at station 1+00=100.55−.12=100.43. Grade elevation at 2+00=100.43 less .24=100.19, etc.

If tile were being installed in the drainage ditch, allowance would be made at station 0+00 for plow depth and for tile diameter. Assuming four inch tile to be laid below a twelve inch plow depth, the tile having an outside diameter of about six inches or .5 of a foot, station 0+00 would have a grade elevation of 100.67 less 1.50=99.17. Then station 0+50 would have a grade elevation of 99.17 less .12=99.05, etc.

After all of the elevations of grade have been found, the next step is to find the necessary cut at each of the station points. This is found at any station by subtracting the elevation of grade from the elevation. Notice should be made of the cuts at the last two stations. The negative quantities mean that in order to maintain the .24% grade, fills would have to be made at these stations. This, of course, would be an impractical solution for a problem of this kind. As shown in the profile Figure 2, the grade line will come to the surface of the ground just before reaching station 6+00. To prevent eroding back up the ditch line a concrete drop might be installed to drop the water to the level of the bottom of the ravine.

Plotting the Profile

The elevations obtained from the field notes are plotted on graph or profile paper, using a vertical line or axis for elevation values and a horizontal line or axis for distance values as shown by stations. See Fig. 2 which represents the profile of Figure 1.

Plotted profiles are of great value in the installation of the tile drains, and in building roads, ditches, etc. They picture the lay of the ground and enable one to select the grade best suited for a given piece of work. They also serve as a check against the field notes in determining elevations and cuts.

Testing the Level

Good work with the farm level is impossible if the level is out of adjustment.

All 4-H Farm Engineering Terracing Club members should be able to make the two following tests of the farm level.

First, test the bubble tube by leveling the instrument and noticing whether the bubble exactly centers the tube for all positions of the telescope.

Second, test the line of sight to see if it is parallel with the leveling plate.

The above tests and any necessary adjustments of the farm level should be made according to the directions of the manufacturer. These directions are usually attached to the inside of the lid of the box in which the instrument is carried.