Microcomputers for Design and Analysis of Land Grading for Drainage

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Heavy soils and flat slopes result in drainage problems on many fields in the Red River Valley. Spring runoff stands in natural depressions causing delays and inconveniences at planting time. Often heavy rains during the growing season result in drowned-out areas and reduced yields. Wet areas in the fall may cause harvest losses and inconveniences.

Land grading, cutting and filling areas of a field to produce a uniform slope, has been used for many years on irrigated land to improve water flow and distribution. However, its application for drainage on non-irrigated land has been limited because of its relatively high cost. Recent developments in laser surveying equipment and computer applications have reduced the cost of land grading to make it feasible for drainage in the Red River Valley in some cases.

Approximately 2,000 acres have been graded in the valley in the past two years at costs of from $100 to $150 per acre. The benefits of land grading can readily be observed on these fields. While fields adjacent to the graded fields have drowned out areas and stunted growth because of excess water, the graded fields have uniform stands. Other possible benefits such as less erosion, less runoff and more uniform retention of chemicals are not as readily observed but may be equally important.

Design

Land grading design involves fitting uniform slopes to the field with sufficient gradient to give good surface drainage. The design surfaces of the field must be positioned so that there is a balance of volume of cuts and volume of fills.

Elevations from a topographic survey of the field are entered into the computer. With this data the computer uses the method of least squares to calculate slopes and elevations of a plane surface that will require the minimum volume of cuts and fills on the field. The computer then compares the design elevations with the original ground elevations and determines the necessary cut or fill at points on the field to provide this surface.

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Because of compaction by the construction equipment it is necessary to have a greater volume of cuts than fills. After the plane of best fit is determined the computer adjusts the elevation of the design plane to give the specified cut/fill ratio. The cut/fill ratio must be specified by the designer and will depend on soil type, soil moisture, and construction methods. Cut/fill ratios of 1.4 to 1.6 have been used for Red River Valley soils.

After the land grading design has been done, the computer will print out the information needed for control of construction. This includes a contour map of the original field, design slopes for the field, depth of cuts and fills at grid points on the field, total volume of cuts and fills on the field, and volume of cuts and fills on blocks of the field. With this information the field can be staked, or if laser-controlled equipment is used the slopes can be set on the laser. The field block volumes of cut and fill are used to plan travel patterns during construction.

Cost Analysis

A computer program was developed to aid in determining the economic feasibility of land leveling. The program evaluates the cost of leveling and calculates the potential increase in revenue due to increased yields realized from improved surface drainage. It allows the user to evaluate the potential paybacks on land leveling for a three-crop rotation for a period of 15 years. The program uses net present value analysis to account for the distribution of cash flows over the full life of the investment. The program also calculates a benefit cost ratio which measures the number of dollars returned for every dollar invested.

As an example, this program was used to analyze a 70-acre field near Georgetown, Minnesota, that was graded in 1984. The cost of grading this field was $205.50 per acre which is somewhat higher than average. The average area of crop loss due to poor drainage was 10 acres.

Figure 1 shows the computer output for the analysis of this field. Benefit/cost ratio was greater than 1.00 after the eighth year and benefit/cost ratio after 15 years was 1.35. This analysis considers only the benefit of increased income due to increased productive areas because of better surface drainage. It does not consider other possible benefits such as timeliness of planting, convenience, less harvest losses, and more uniform moisture and nutrient distribution.

Conclusions

Computer programs have been developed to design land grading for drainage and to analyze the economic feasibility of such practices. The design program determines optimum slopes for the field and the cuts and fills necessary for construction of this design. Computer output provides information that is useful in planning and carrying out construction at minimum cost.

The program for economic feasibility provides information for the farmer to help decide whether or not to grade his field and if he does what management practices will give him the greatest return on his investment.

Figure 1. Net Present Value Analysis for Laser Land Leveling

Cash Flows	Before Tax Amounts	After Tax Amounts 25.00%	Year	Present Value Amount	Present Value B/C Ratio
Outflows:					
Initial Investment	$14,385.00	$11,885.00	0	$11,885.00	
Total Costs (Outflows)				$11,885.00	
Inflows:					
Yield Increase	$ 2,654.17	$ 1,990.63	1	$ 1,777.34	0.15
	$ 4,293.33	$ 3,220.00	2	$ 2,566.96	0.37
	$ 2,479.17	$ 1,859.38	3	$ 1,323.47	0.48
	$ 2,654.17	$ 1,990.63	4	$ 1,265.08	0.58
	$ 4,293.33	$ 3,220.00	5	$ 1,827.11	0.74
	$ 2,479.17	$ 1,859.38	6	$ 942.02	0.82
	$ 2,654.17	$ 1,990.63	7	$ 900.46	0.89
	$ 4,293.33	$ 3,220.00	8	$ 1,300.50	1.00
	$ 2,479.17	$ 1,859.38	9	$ 670.51	1.06
	$ 2,654.17	$ 1,990.63	10	$ 640.93	1.11
	$ 4,293.33	$ 3,220.00	11	$ 925.67	1.19
	$ 2,479.17	$ 1,859.38	12	$ 477.26	1.23
	$ 2,654.17	$ 1,990.63	13	$ 456.20	1.27
	$ 4,293.33	$ 3,220.00	14	$ 658.88	1.32
	$ 2,479.17	$ 1,859.38	15	$ 339.70	1.35
Total Benefits (inflows):				$16,072.09	
The Net Present Value of benefits is:				$ 4,187.09	
The Benefit/Cost Ratio is:				1.35	

The Benefit/Cost Ratio measures the number of dollars returned for every dollar invested. A Benefit/Cost ratio greater than one means that land leveling is a profitable investment.