COMPUTERS IN SURVEYING AND DRAINAGE DESIGN

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Abstract

A new surveying technique to be used in obtaining the data for subsurface drainage plan is described. Benefits and drawbacks of the system are listed. The more irregular the field the better the new system is compared with traditional surveying methods. A computer-based drainage design system is presented. The greatest time-savings can be achieved when compiling the materials catalogue and calculating costs.

Introduction

The applicability of computers in surveying and drainage design has been tested during the last 12 months in the Finnish Field Drainage Centre. In principle, drainage design is well suited for computer applications. The objective of this paper is two-fold. First, the applicability of modern surveying instruments in producing the necessary topographical data is discussed. Second, the potential for computer use for map drawing and for production of a subsurface drainage plan is evaluated. The flow diagram of the whole system developed in the Finnish Field Drainage Centre as shown in Fig. 1 is elaborated upon in the text.

Field survey instruments

The measurement system is composed of an electronic total station (electronic tacheometer), reflecting prism and data collector. We have used the Topcon ET-1 total station which combines electronic angle and distance measurements in a single instrument. It measures and records automatically.

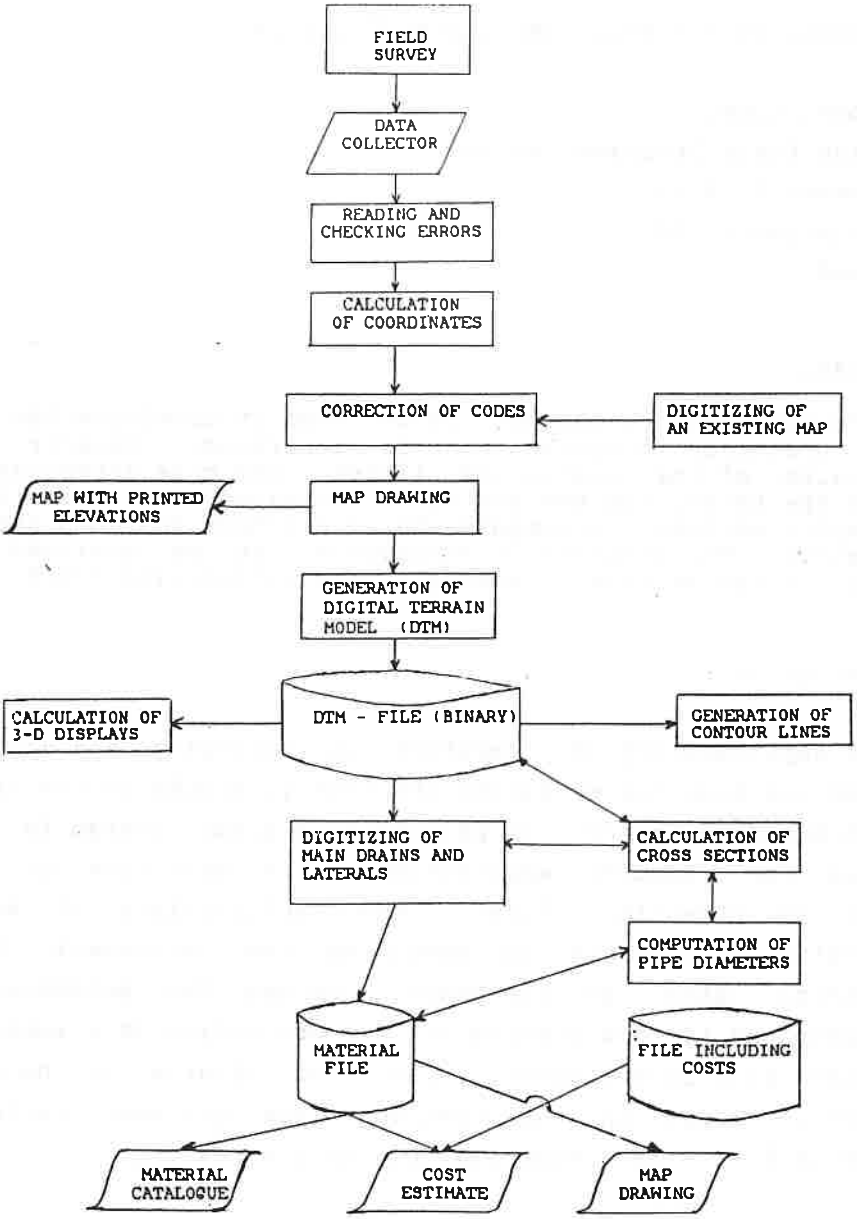

Fig. 1. Flow diagram of the computer based field survey and drainage design system.

All readings with ET-1 can be stored automatically in a 60K data collector (Topcon FC-1) for later inputing into computers. The measurement accuracy is sufficient (on the order of millimeters). ET-1 can measure 1400 m with one prism and 2000 m with three. The data stored in the data collector are distance, vertical and horizontal angle.

The coding system used in surveying

During field survey each measurement point must have special code number so that the nature of the point can be recognized when the map is drawn by computer. The list of codes in use is shown in Table 1. An additional data needed from some points is an extra number which tells if the measured point is the starting point of the border of the field, for example. The data transferred from the data collector to the computer thus include five information items from each point: distance, vertical and horizontal angle, code and an additional number. Based on these data the computer can draw the map. Transfer of data to computer is done via a RS-232 communication port.

Digitizing of an existing map

In the case when it is not possible to use an electonic total station for surveying, we still want to use the computer for actual drainage design. In these cases an existing map can be digitized. The system includes three major components:

- an active surface tablet (either size A1 or A3)
- a digitizer processing unit
- a transducer (multi-button cursor or "mouse") which relays the positional data (XY coordinate pair)

After that it is possible to continue planning in the same way as if we had the data stored by total station. For example, it is possible to change the scale of the map. By digitizer it is also possible to store contour lines if it is not necessary for the computer to draw them.

Table 1. The codes used in field survey.

Code	Explanation
1	Ordinary point of the field
2	Border of the field (surrounded by open ditches)
3	Open ditch
4	Main ditch, left side
5	Main ditch, additional point from the cross-section (left side)
6	Main ditch, additional point from the cross-section (right side)
7	Main ditch, right side
8	Main ditch, bottom
9	Water level in main ditch
10	Open drain collecting additional waters
11	Stone
12	Stone soil or boulder soil
13	Spring area
14	Ochreous area
15	Test dig hole
16	Depth of bedrock
17	Depth of peat layer
18	Boundary of two different soil types
19	Direction of flow
20	Building
21	Road, left side (without open ditches)
22	Road, right side (without open ditches)
23	Border of the field (not surrounded by open ditches)
24	Pipeline
25	Fixed point
26	Direction of north
27	Road sided by open ditches (left)
28	Road sided by open ditches (right)
35	Surrounding area (additional data by an extra number)
36	Bedrock area (depth below 1.5 m)
37	Clay pit
44	Cable

Map drawing

So far we have used only a plotter that can draw maps of size A3. In Finland the scale of the subsurface drainage plans is 1:2000. If the area surveyed cannot be drawn on the scale 1:2000, it is first plotted on a smaller scale and later magnified to the proper scale. An example of a map drawn by our computer system is shown in Fig. 2. This map does not yet include subsurface drains but the existing open ditches only.

Digital terrain model and its applications

In the computer aided planning the elevation of each point in the field is needed. However, it not possible to measure all these. We must have a system by which the elevation of the desired points can be calculated based on actual measured points. This system is called the digital terrain model (DTM). It is necessary to have a DTM for calculation of contour lines, 3-D plots and cross-sections showing e.g. the burial depth of the drain.

Digital terrain model could be generated from a rectangular grid (a very dense measurement net is needed) or preferably a triangular grid. We have chosen the latter alternative, since it is possible to measure more points where needed and only a few points on very flat areas. An example of the triangular system is shown in Fig. 3.

Three basic applications of the DTM used in drainage planning are:

- calculation (and drawing) of contour map (Fig. 4.)
- development of 3-dimensional spatial displays, possibly from different angles (Fig. 5.)
- calculation (and displaying) of profiles of subsurface drains to insure proper installation depth

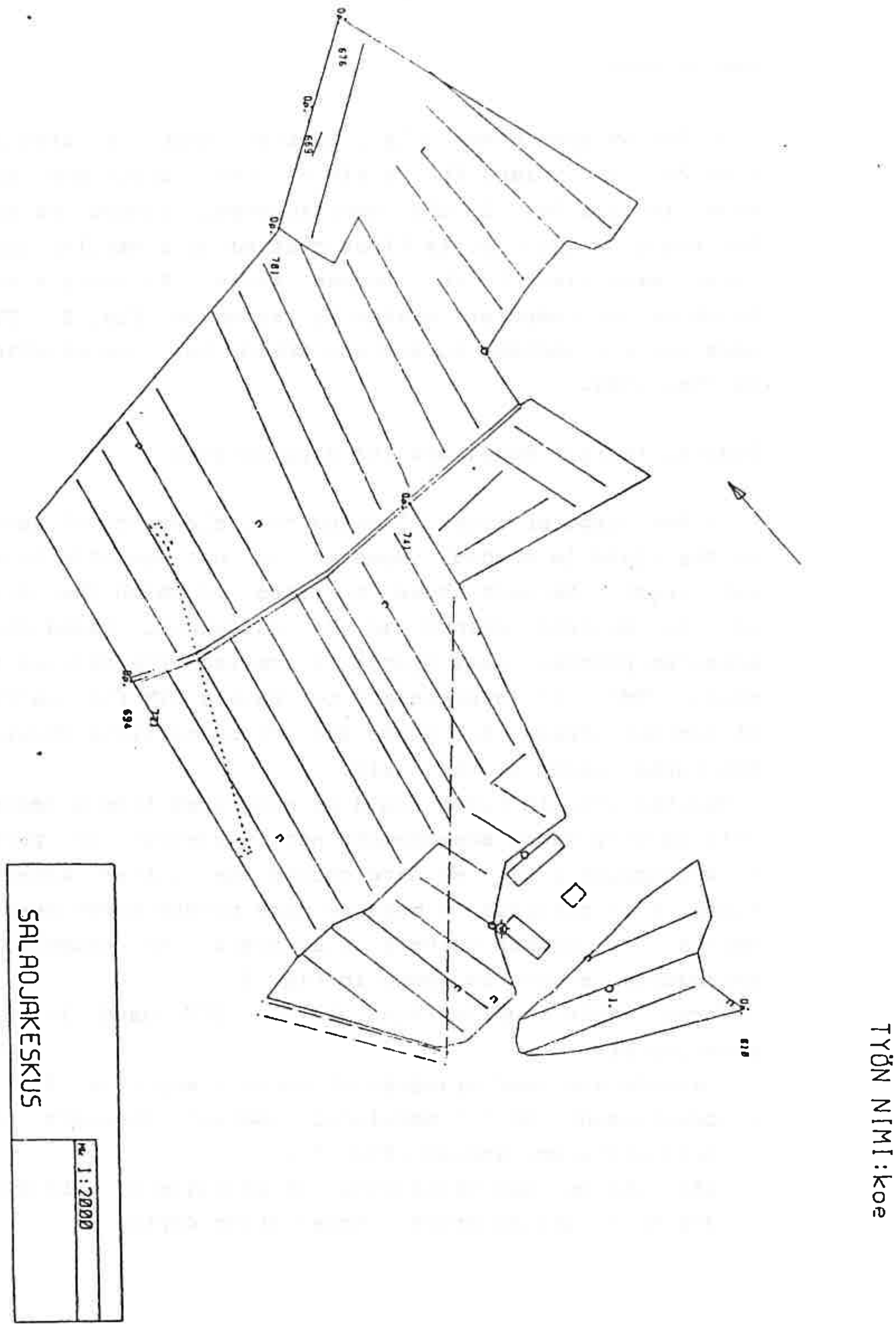

Fig. 2. An example of a map drawn by the computer system.

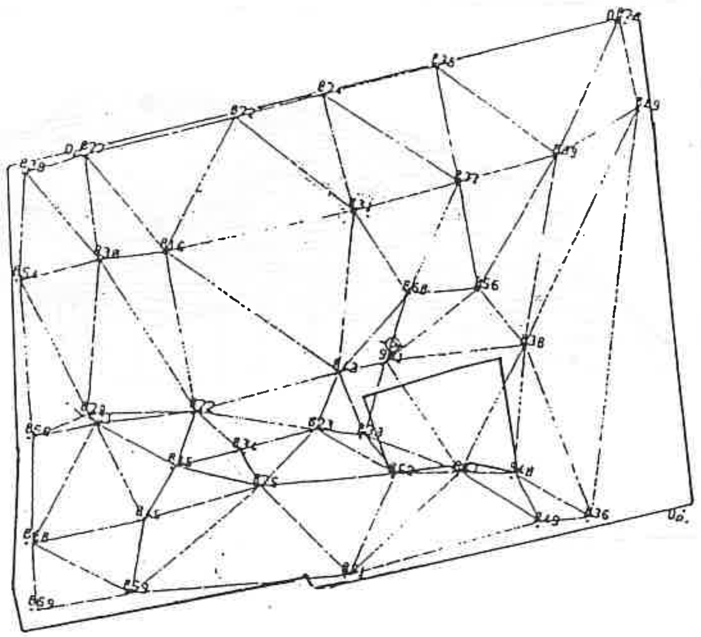

Fig 3. An example of the triangular system used in generation of digital terrain model.

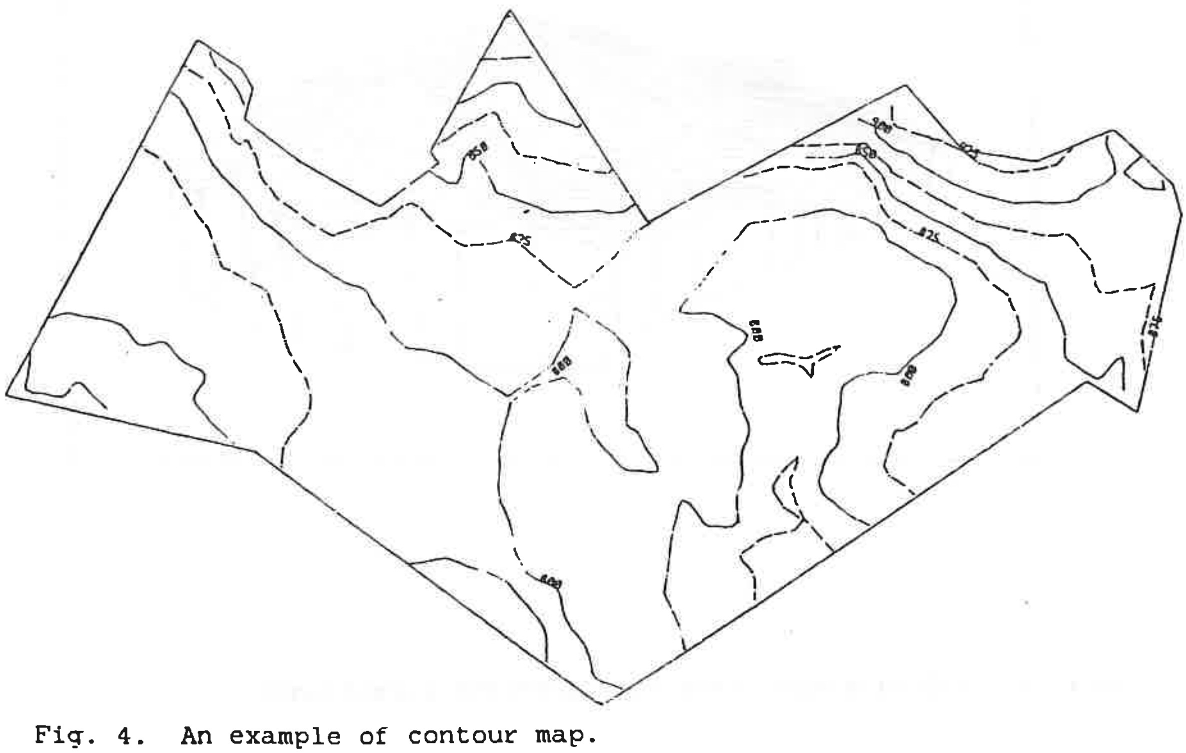

Fig. 4. An example of contour map.

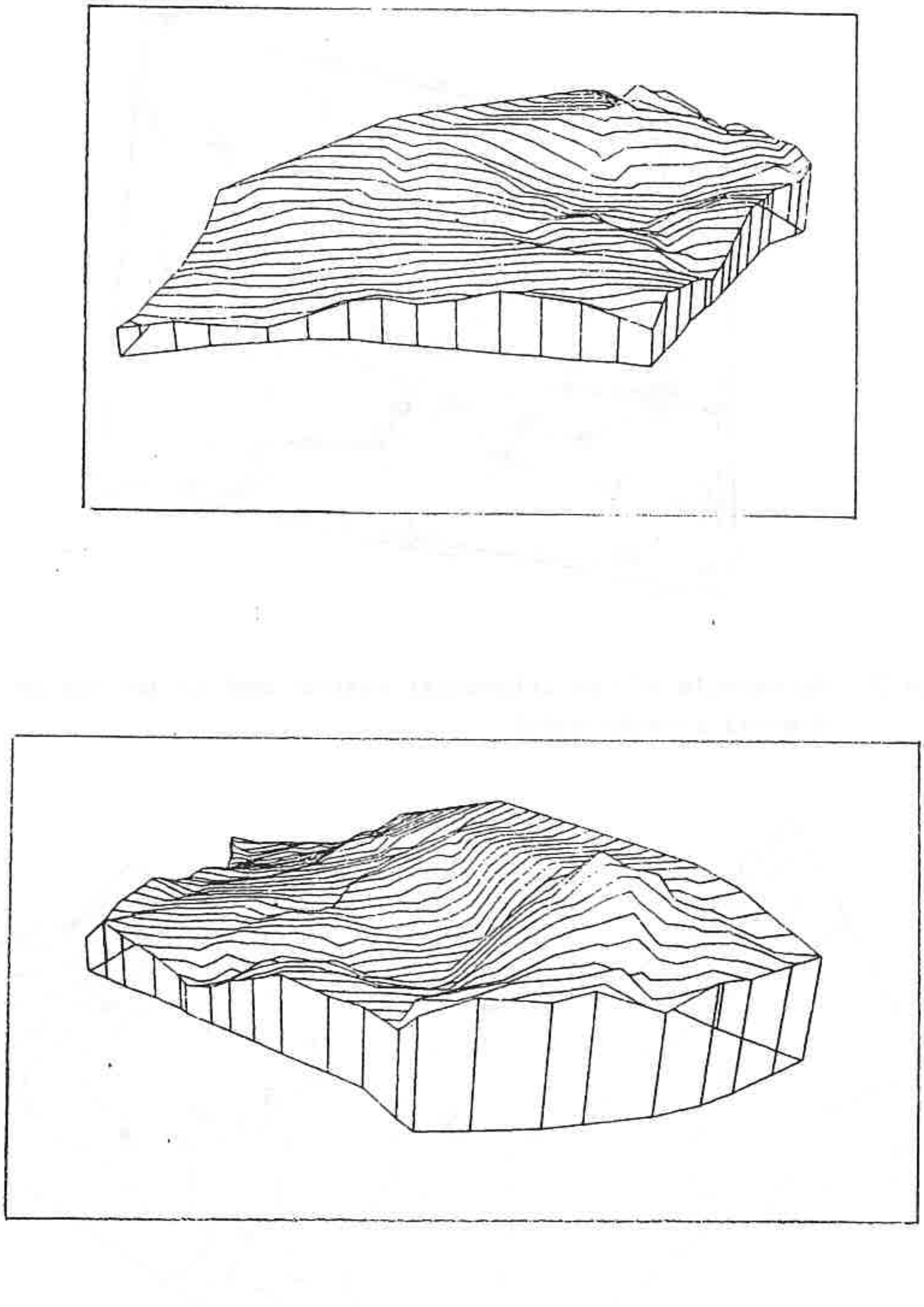

Fig. 5. 3-D displays (from two different directions).

Digitizing of subsurface drains

In the computer aided planning system it is assumed that the designer locates the outlet, mainlines and sublaterals as well as all the wells used in planning. The location is done with a cursor using a "menu" so that the computer system knows what type of information is given. The user "picks" e.g. an outlet from the menu and locates it on the map which is fixed on the active surface of the digitizer. The elevation of the outlet is given. Then the designer shows the main drain from the menu and locates it on the map. The computer suggests a grade and displays automatically the cross-section of the drain on a graphic terminal. The user can change the grade of the drain so that burial depth of the drain is greater than the allowed minimum and smaller than the allowed maximum value. It is also possible to divide the suggested main drain into several parts in cases where the grade is different in each part. The configuration of the drainage system is completely arbitrary. The digitizing of lateral drains can be performed in two basic ways: 1) Location of each sublateral is digitized individually, or 2) Equally spaced laterals can be digitized when drain spacing and the direction of the first lateral are known.

Subsurface plan production

The final sursurface plan delivered to the farmer includes the map, catalogue of pipes required and their sizes and estimation of material and installation costs of the total system. As shown in the flow diagram of Fig. 1, the material needed in the system is collected in a file during the digitizing phase. The computation of the pipe line diameters is based on the data collected in this file. The same file is also used when cost estimate is calculated. This file also includes all wells and other special structures used in planning.

In the next stage the final map is drawn by plotter and all other output data needed by the farmer is printed. After that the plan is archived in digital form (on diskettes).

Computer facilities

The complete computer system must have the following components (in parentheses is listed the currently used equipment by the Drainage Centre):

- computer (Micro-VAX I, and Micro-PDP)
- graphic terminal (2 XK-1 terminals)
- plotter (2 DMP29 plotters, A3)
- digitizer (Calcomp 9000 series, A1 and A3)
- printer (2 LA-100 from DEC)

About 80-90 % of the programs have been made in the Drainage Centre. The programming language used is Fortran.

Experiences, benefits and drawbacks

The first version of the new surveyig technique was tested during summer 1985 . Numerous difficulties were encountered with the coding system and error checking programs. The first error checking program was time-consuming When the number of measured points was about 400, the computation time in Micro-PDP was 3 hours. By making some slight modifications to this part of the program the time could be reduced to a couple of minutes. This was the general trend with the whole system. The newest version of this surveying system has nothing in common with the first version; in fact, everything had to be changed with a much better result. After completing the first version, three technicians have been testing the system and making correction proposals. This interactive way to develop the system has proved to be successful. The technicians are much more interested in accepting new techniques if they can influence actual working procedure in the field. They also know much better than the programmer how the field survey should be carried out. Although progress may be slower with this interactive method, the final system is better and easier to use.

Based on the experience obtained it is already possible to list some benefits of the new surveying technique:

- the more irregular the field, the better the new technique is compared with traditional surveying methods
- differences in elevation have no bearing on the time used for field survey
- the accuracy of the system is high
- computers can be used in map drawing and contour plotting
- testing of new measurement techniques adds to technician motivation

Unfortunately, there are also some drawbacks:

- during field work the technician cannot draw the map (in the so-called traditional method he draws the map during the survey)
- it is necessary to drive to the office almost daily to transfer the data from collector to computer memory (this too takes time)
- in contour plotting the computer is sometimes "blind"

We have not yet enough experience to list all the drawbacks and benefits of the computer aided plan production (dizitizing of drains etc.). Based on the limited experiences obtained so far, it seems that greatest time savings can be obtained in the computation of cost estimate and in making the catalogue of pipes (and their size) needed. This topic will receive more attention at the end of 1986.

However,it is quite obvious that by affecting the mechanical aspects of drainage design (field survey, map drawing, contour plotting, location of drains) the total cost of the drainage system can reduced very little, if at all. The quality of the maps produced by the total station is better due to the fact that more points can be measured where required (the measument net need not rectangular as is the case when "old" methods are used). Because the aim is to reduce the total cost of the drainage system, in future it is equally important to concentrate research on the proper choice of design parameters, especially drain spacing and the drainage coefficient. The drainage coefficient generally used in Finland is 1.0 l/s/ha (= 8.64 mm/d). The potential to use smaller values should be immediately studied.

Future trends

The greatest possible benefit from the technique developed in the Drainage Centre could be obtained if digital data were transferred directly to contractors. Physically this would involve using a diskett containing all information needed (elevation of outlets, grades etc.). A drainage machine equipped with laser-aided depth-control could use this digital data so that marking of drain depth with pegs would eliminated.

More research should be addressed to finding proper drain spacing, drain depth and drainage coefficient. The possible influence of these parameters on the reduction of the total cost of drainage system is most essential.

Conclusions

In the Finnish Field Drainage Centre the applicability of modern computer-based technique in producing subsurface drainage plans has been evaluated. The conclusions drawn were:

1) Field survey can be successfully and accurately performed by an electonic total station and field data collector. The quality of the maps produced by combined use of electronic total station and computer is better compared to maps surveyed by traditional methods due to the fact that all essential points can be measured (restriction of regtangular measurement net is eliminated in the new system).
2) By affecting to the mechanical aspect of drainage design very little can be done to reduce the total cost of the system. In this respect the computer-based system does not offer great savings. More attention should be devoted to finding proper drain spacing and drainage coefficient.
3) The quality of the plan can be influenced in two ways. First, the elevations of the map are more accurate. Second, with the aid of computer-based system it is possible to insure proper installation depth by displaying cross-sectional profiles of subsurface drains.

4) The best possible improvement would be a direct transfer of data from designer to contractor in digital form (on diskettes). This could reduce total costs because marking of drain depth with pegs would then be unnecessary.

5) Interactive working with the programmer and technician in developing the computer-based system proved to be superior. A first version of the system should be completed soon. Following this the users test the system and put forward correction proposals, making the final system better and easier to use. Moreover, technicians are more willing to accept new working methods if they can influence the final computer system.