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SOFTWARE FOR DRAINAGE ARRANGEMENTS DESIGN

Rares HALBAC COTOARA

Politehnica University of Timişoara, Hydrotechnical Engineering Faculty, 1A G. Enescu Street, rares.halbac@gmail.com

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Abstract: An efficient agriculture, in climatic conditions as are in Romania, can be practice only with the help of the land reclamation and improvement systems which must present technical and economical performance. For Romania's western part, because of its large surface with soils affected by humidity excess, the surface drainage and drainage arrangements are indispensable. These lands must be reintegrated in agriculture in an efficient way. Terms as "efficient/ efficiency" must appear in all the stages of resolving the problems caused by excessive humidity. The multitude and the variability of the situation which can appear in practice lead to numerous computing methods and programs with different solutions, more or less suitable.
This paper will present some programs realized in Romania for drainage arrangements designing and will analyze some comparisons between the results obtained with these programs and similar programs from other countries. The Romanian programs which will be presented were realized at University "Politehnica" from Timişoara, Hydrotechnical Engineering Faculty, or were presented in some PhD thesis lead by professors from the mentioned institution. Also, the paper will comprise some discussions regarding the methodologies applied for the software which will be mentioned in the following chapters.

INTRODUCTION

Romania's territory presents numerous areas with humidity excess from different sources and which supposes a proper water management for a durable administration of these lands with the purpose of promoting a sustainable agriculture. An efficient agriculture, taking into consideration Romania's climatic conditions, can be practiced only with the support of land reclamation and improvement systems which are presenting technical and economical performant characteristics.

Surface drainage and drainage systems, by their hydroameliorative role, play an important role in touching this target. Their technical function, together with the economical role, presents the necessary role of reintegrating in the agricultural system these lands affected by humidity excess, the reintegration must being as efficient as possible. This term "efficiency" must appear in all the stages of resolving the humidity excess problem, starting with the areas selection for land improvement and finishing with the implementation of surface drainage and drainage systems and their proper and effective exploitation and maintenance.

The large scale of different situations which can appear challenge the researchers to create, develop and use numerous computing methods and procedures which are presenting solutions with different grades of efficiency. Manual methods are becoming less used because they present risks in computing different indicators, supposes high volumes of manual work and they are considering long periods of time in reaching the targets (systems design). The software, which are modeling the hydric relations and interactions from soil active layer, present efficiency because they are taking into consideration numerous elements involved in these processes. In designing hydroameliorative systems are considered climatic records and soil characteristics indicators being noticed the accuracy of details at daily and even hourly level. The approximations are very rare used and their influence upon final results is generally insignificant.

SOFTWARE USED IN ROMANIA

The Romanian drainage technique is based on a long practical experience but unfortunately remain poor regarding the drainage software development in order to sustain the surface drainage and drainage arrangements design. The existent programs allow the computation only for a few elements (as distance between drains) without offering a clear and wide image of the studied phenomenon. The researches which were realized, even they are presenting a satisfactory level of efficiency by putting in practice the results which were obtained, supposed a high volume of manual work in the conditions of specialized software total missing.

During some research programs, at University “Politehnica” from Timişoara, Hydrotechnical Engineering Faculty, Land Reclamation and Improvement Department, were studied many soils with humidity excess from the entire western part of Romania. They constitute a very valuable database which can be usefully for the actual programmers in understanding and reproducing on computer the real situation. The distances between drains were computed with the help of a small and relative primitive programs (in comparison with the existent programs at international level) zitastud.exe and distdren.exe.

As can be seen in the following picture the program interface is very unattractive, doesn’t offer an image for studied phenomenon and cannot detect possible errors of input data.

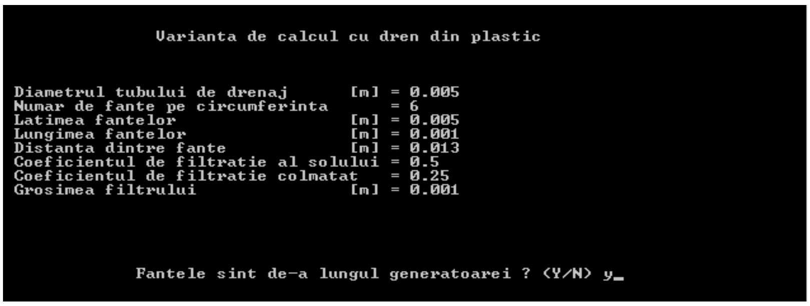

Figure 1
Zitastud.exe program used by Hydrotechnical Engineering Faculty from Timişoara

Figure 2
Distance between drained obtained using zitastud.exe

It must be mentioned that this program is based on the “Politehnica” University of Timişoara methodology developed by a group of researchers from Hydrotechnical

Engineering Faculty from Timişoara. This methodology use for the distance between drains computation the Ernst formula completed with the ζ_{if} coefficient for which Prof. I David from the mentioned institute obtained a complex formula. ζ_{if} coefficient represents the resistance coefficient of load loss at the filter drain entrance [Man, 2003].

$$\zeta_{if} = \alpha \cdot \left[\ln \frac{1}{\sin \frac{nb}{2d_0}} + \frac{1-\chi}{2\chi} \cdot \ln\left(A_1 + \sqrt{A_1^2+1}\right) \cdot \left(A_2 + \sqrt{A_2^2+1}\right) \right] + \beta \cdot \left[\ln \frac{1}{\sin \frac{\lambda}{2B}} + \frac{1-\chi}{2\chi} \cdot \ln\left(B_1 + \sqrt{B_1^2+1}\right) \cdot \left(B_2 + \sqrt{B_2^2+1}\right) \right]$$

The Ernst formula completed with the ζ_{if} coefficient will be:

$$h = \frac{q \cdot D_v}{K_1} + \frac{q \cdot L^2}{8 \cdot K_1 \cdot T_e} + \frac{q \cdot L}{K_1} \cdot \ln \frac{\alpha \cdot D_0}{U} + \frac{q \cdot L}{K_1} \cdot \zeta_{if}$$

In 2007, a new Romanian program, based on the same methodology, appear with a new interface, much improved in comparison with the previous software. Created and part of a PhD thesis, this new software study only the flow of groundwater to parallel field drains under steady-state conditions. The steady-state theory is based on the assumption that the rate of recharge to the groundwater is uniform and steady and that it equals the discharge through the drainage system. Thus, the water-table remains at the same height as long as the recharge continues.

DrenVSubIR application was developed in Borland Delphi Pascal v7.0 and was created for the calculation of drainage systems indicators and characteristics as distances between drains and their compatibility with sub-irrigation necessities [Bodog, 2007].

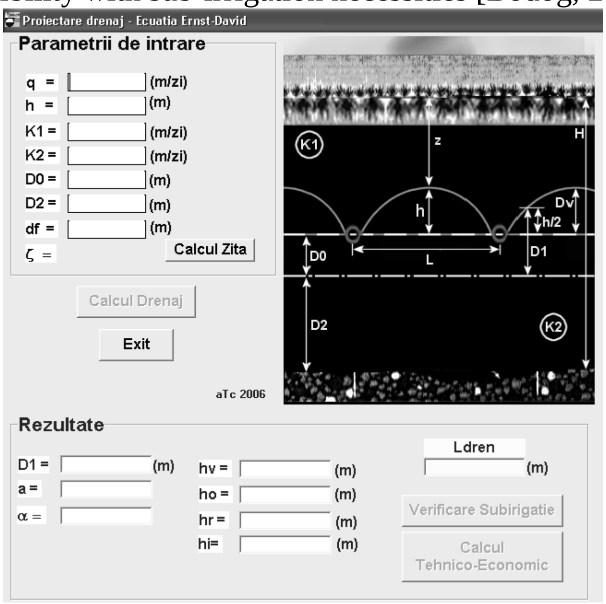

Figure 3

Distance between drained computation using *DrenVSubIR* application

This application doesn't verify the correctitude of distances between drains results studying only the steady-state conditions. The steady-state approach only describes a simplified, constant relationship between the water-table and the discharge. In reality, the recharge to the water-table varies with time, and consequently the flow of groundwater towards the drains is not steady. To describe the fluctuation of the water-table as a function of time, we use the unsteady-state approach. Unsteady-state equations are based on the differential equations for unsteady flow. Both the unsteady-state and the steady-state approach are based on the same (Dupuit-Forchheimer) assumptions. The only difference is the recharge, which in the unsteady-state approach varies with time [Ritzema, 1994].

The distance between drains can be verified using one of the following equations:

1. The Glover-Dumm Equation is used to describe a falling water-table after its sudden rise due to an instantaneous recharge. This is the typical situation in irrigated areas where the water-table often rises sharply during the application of irrigation water and than recedes more slowly.
2. The De Zeeuw-Hellinga Equation is used to describe a fluctuating water-table. In this approach, a non-uniform recharge is divided into shorter time periods in which the recharge to the groundwater can be assumed to be constant. This is the typical situation for humid areas with high-intensity rainfall concentrated in discrete storms.
3. The Kraijenhoff van de Leur-Maasland Equation, which is used to describe unsteady flow to drains with a steady recharge instead of an instantaneous recharge, is mainly used for research purposes and is beyond the scope of this book [Ritzema, 1994].

It can be seen that to create software based on unsteady-state approach can be very difficult. Despiting the mentioned disadvantages of *DrenVSubIR* application, this program represents a remarkable realization of Romanian researchers and a good start in realizing more complex program.

SOFTWARE USED IN FOREIGN COUNTRIES

The scientific literature from the countries with intensive agriculture is full of researches regarding theories based on a long practical experience, theories which proved their efficiency in time regarding the water-air-plant-soil relations. Using complex and accurate equations, researchers from countries as USA, Holland, United Kingdom create programs which simulate the mentioned relations, with numerous procedures and sub-procedures, and which are offering, beside detailed prognosis, detailed simulations of the studied phenomenon [Hălbac, 2008].

One of the programs developed by HR Wallingford is *DrainSpace.exe*. This program allows the computation of distances between drains in steady-state approach (with the help of Hooghoudt equation) and also to verify the results which were obtained using unsteady-state equations (Glover-Dumm equation).

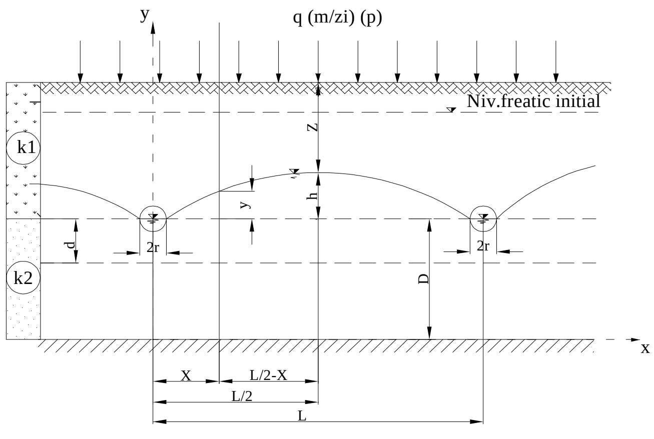

Figure 4

Hooghoudt drainage scheme

Hooghoudt equation is based on the Dupuit-Forchheimer assumptions which allow reducing the two-dimensional flow to a one-dimensional flow by assuming parallel and horizontal stream lines. Such a flow pattern will occur as long as the impervious subsoil is close to the drain. If the impervious layer does not coincide with the bottom of the drain, the flow in the vicinity of the drains will be radial and the Dupuit-Forchheimer assumptions cannot be applied. Hooghoudt solved this problem by introducing an imaginary impervious layer to take into account the extra head loss caused by the radial flow [Counsell, 2000; Ritzema, 1994].

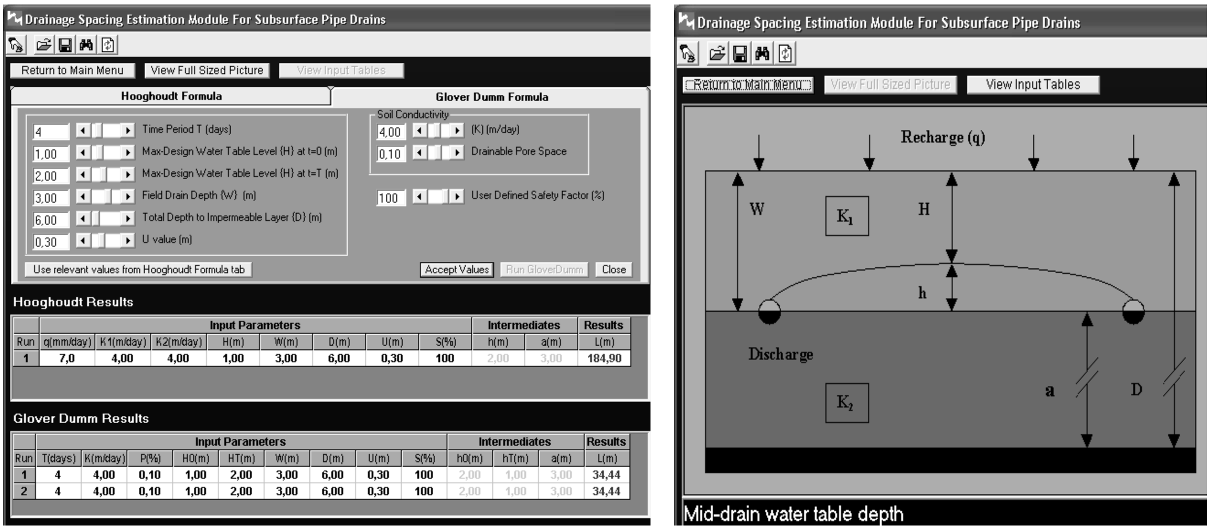

Figure 5

DrainSpace.exe working sheets

One major disadvantage of Hooghoudt equation is that he uses in the formula only the horizontal and the radial resistances in comparison with Ernst equation which is more complex. The distances between drains will be smaller in comparison with the results obtained by applying Ernst formula or Ernst completed with David's ζ_{if} coefficient [Hălbac, 2008].

DISCUSSIONS

Agriculture and, consequently, food production depend, among other factors, on the proper management of water. Land drainage, an integral component of water management, is well known to have ameliorated salinity and water-logging problems in rainfed and irrigated agriculture. In so doing, it has contributed substantially to sustainable agricultural development through enabling increased crop production, decreased farming costs, and the maintaining of soil quality. In areas where rainfall is excessive, it is necessary to manage land drainage, both surface and subsurface, in order to prevent water-logging. In areas where rainfall is deficient, drainage management is still important in order to minimize soil salinization [Molden, 2007].

In subsurface drainage, field drains are used to control the depth of the water-table and the level of salinity in the rootzone by evacuating excess groundwater. An important element in drainage systems design is represented by the distance between drains. Generally, the distance between drains is computed in the steady-state approach and the results are verified using unsteady-state principles.

At first sight, the unsteady-state approach offers major advantages compared with the steady-state approach (is a representation very closed to the real situation), but various assumptions restrict the use of the unsteady-state equations. Firstly, both the Glover-Dumm and the De Zeeuw-Hellinga Equation can only be applied in soil with a homogeneous profile. Secondly, the flow in the region above the drains is not taken into account. When the depth of the water-table above drain level (h) is large compared with the depth to the impervious layer (D), an error may be introduced. By far the biggest restriction, however, is the introduction of the drainable pore space into the equations. Beside the fact that this soil property is very hard to measure, it also varies spatially. So, introducing a constant value for the drainable pore space could result in considerable errors. As a consequence, the unsteady-state equations are hardly ever used directly in the design of subsurface drainage systems, but only in combination with steady-state equations. Nevertheless, unsteady-state equations are useful tools when one is studying the variation in time of such parameters as the elevation of the water-table, and drain discharges as a result of rainfall or irrigation [Ritzema, 1994].

The programs based on unsteady-state approach will be more complex than the software developed on steady-state equations. This approach will conduct us to accurate results but in the same time will suppose increase costs in realizing the necessary software and will requests improved hardware systems. Anyway, the costs will be recovered by applying proper drainage systems with a positive and effective impact on the humidity excess which will result in higher agricultural productions [Hălbac, 2008].

CONCLUSIONS

The development of electronic computer allow the appliance of different types of models in almost all agricultural sectors and not only. For drainage purposes, a lot of models are used in research and engineering. Universities (among them being “Politehnica” University of Timişoara) and research institutes have developed useful complex and sophisticated models using various calculation methodologies for drainage arrangements design.

Romanian researchers, even they had a rich experience in drainage field, must improve their efficiency in drainage design work by developing or adopting more complex programs. With 8 million hectares affected by humidity excess, Romania is a country which imperative requests sustainable, efficient and effective drainage arrangements. These systems must improve the hydric soil conditions and in the same time must offer prognosis regarding water-table fluctuations in order to avoid damages on environment.

REFERENCES

1. Bodog, Marinela, 2007, Irrigation-drain interaction and their impact on environment in Criş Rivers Basin, PhD Thesis, “Politehnica” University Publishing House, Timişoara.
2. Counsell, C., T. Hess, 2000, WaSim User Manual, HR Wallingford, United Kingdom.
3. Hălbac, Cotoară R., 2008, Drainage studies efficient technical and economical for fields with humidity excess, PhD Thesis, manuscript.
4. Man, T. E., 2003, Research project „Drainage studies synthesis with proposals of drainage pipes, filtering materials and drainage solutions for areas with humidity excess in Romania’s western counties: Timiş, Arad, Bihor, Maramureş and Satu Mare”, Theme no. 6 Code 519. Contract no. 40535/ 2003, Director: Prof. Dr. Eng. Man Teodor Eugen.
5. Molden, van der W.H., J.M. Beltran, W. J. Ochs, 2007, Guidelines and computer programs for the planning and design of land drainage systems, FAO, Rome.
6. Ritzema, H. P., 1994, Drainage Principles and Applications, I.L.R.I. Publication 16, Second Edition, Holland.