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Determining the Best Sizes of the Open Cut Canals Used in Hydroameliorations

Use of the computer for different works of land improvement should be efficient as much as possible, from designing problems to the most complex ones.

The dimensioning of the open cut canals used for bringing irrigation water or for evacuating the excess waters in case of draining systems is a constant preoccupation of many researchers and institutes because of the labourious necessary computing method. There are many solutions envisaging graphs, tables, slide rules for the dimensioning of these structures, being — generally — difficult to use, each of them having its particular seeking method. In the following, the authors proposed to elaborate a mathematical model which should solve the problem of the dimensioning of the irrigation canals in a number of cases frequently used in practice. The results will be presented in the form of tables.

The calculus was based on the classical formulas (1) and (2) and it pursued to obtain, for a number of given conditions (table 1), the corresponding, eventually the best sizes.

The basic formulas are the following:

$$\frac{Q}{\sqrt{i}} = f(m, h, b) \tag{1}$$

where:

Q represents the flow
i — slope of the water-table and the canal end (constant and uniform flow);
b — the small base of the considered section;

h — the average depth of the current;
m — the canal slope (the cotangent of the slope bent)

Table 1

Calculation conditions more frequently used in practice

Cases of problems	Data known	Values are sought for:	Examples of conditions
1.	h; b; i; m and n (rugosity)	Q	limit speed, etc.
2.	Q; h; b; m and n	i	limit speed, etc.
3.	Q; i; m; n	b; h	limit speed, etc.
4.	Q; i; m; n	b; h in relation to the economic optimum $\beta = 2\sqrt{1+m^2} - m$	limit speed, etc.

The speed condition u is

$$\bar{u} = \frac{Q}{S} \tag{2}$$

where:

S represents the water flowing surface.

This speed must not decrease or surpass certain values prescribed by the resistance of the material of which the canal is made.

The economic optimum condition is expressed by:

the b/h ratio, resulting from the finding of the minimum soaked perimeter.

$$\frac{\partial \chi}{\partial h} = \frac{\partial b}{\partial h} + 2\sqrt{1+m^2} \tag{3}$$

where:

χ represents the soaked parameter (the length measured on the transversal section of the water contact current with the soil).

The determining of the flow of the water (slow, critical or swift), established by the value of Froude's number, was also taken into consideration as part of the conditions.

$$Fr = \left(\frac{h_{crt}}{h}\right)^3$$

where:

Fr represents Froude's number $= \dfrac{\alpha Q^2}{S^2 g h}$;

α — Coriolis's number, equal to 1.1;

g — the acceleration of gravitation;

h_{crt} — the critical depth of the water resulting from the finding of the minimum of H (the specific energy of the section);

$$\frac{\partial H}{\partial h} = 1 - \frac{\alpha q^2}{g h^3}$$

q — the flow per canal width unit.

It is a well known fact that if $Fr < 1$, the flow of the water is slow; $Fr = 1$ is in a critical regime; $Fr > 1$ is in a swift regime; $Fr > 6$ the regime is torrential (Vedernikov). This distribution is important for the canals with big slopes, respectively high speeds and which raise special problems in canal level junctions, etc.

Cases 3 and 4 in table 1 can be solved with the CANALOPT programme. The solutions are presented in the two calculation schemes (Fig. 1 and Fig. 2).

In case 3 (Fig. 1), the seeking strategy consists in finding the h values corrresponding to some declared values of b.

In case 4 (Fig. 2), the seeking strategy has in view the allocation of interior generated values with small steps for b and h, the calculation being made only when

$$\frac{b}{h} = \beta$$

as shown above (3).

Figure 3 presents the calculation scheme of the critical depth.

RESULTS OBTAINED

The results arranged on formats requested by the beneficiary for case 3 and for case 4 (see table 2) and entitled, for practical reasons, grassed canals and respectively lined canals, are presented.

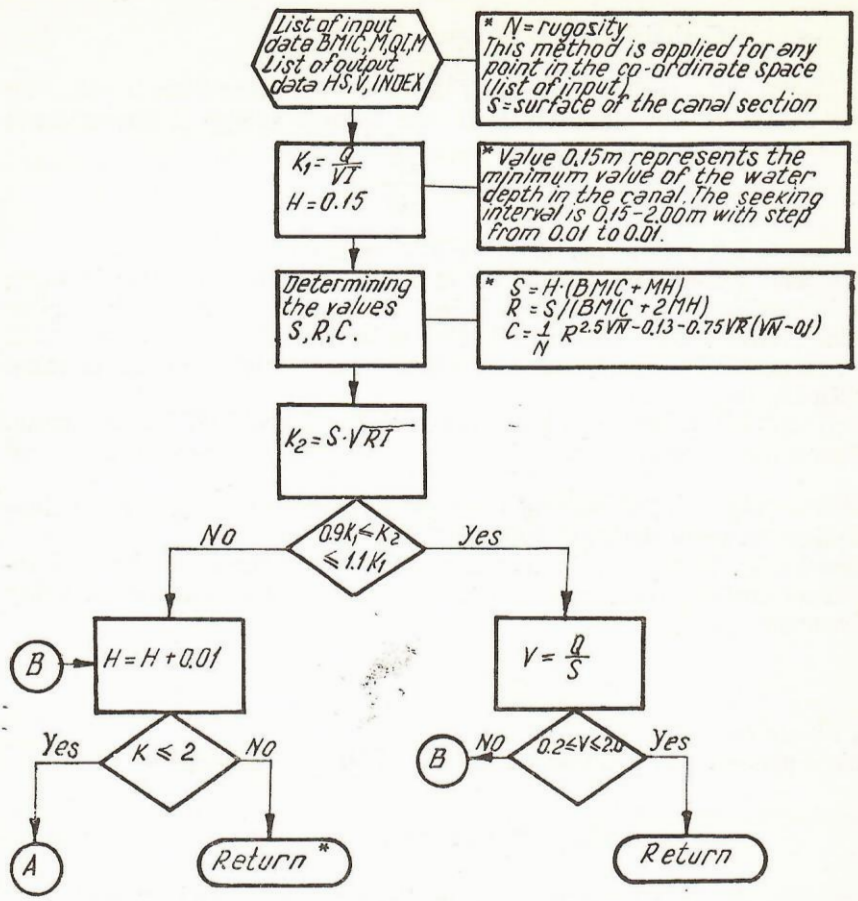
The way of indicating the optimum sections with letter E and of the state of motion of the critical water with asterisk, rapid with R and torrential with V is noted.

The precision of calculation is different in case 3, because of the calculation conditions. In case 4, having to find values b/h according to relation (3), an interval of $\pm$ 1% had to be established.

$$0.99 \cdot (2\sqrt{1+m^2} - m) < \frac{b}{h} < 1.01 \cdot (2\sqrt{1+m^2} - m).$$

This condition alters by about $\pm$ 10% the relation between the flow, speed and section in various calculated variants. Upon request, this margin

CALCULATION DIAGRAM IN CASE 3 FOR DETERMINING THE VALUES OF THE WATER DEPTH IN THE CANAL, H, FOR ANY SECTION SMALL BASE



Notations

B,M,IC = b = the section small base; M = m the canal slope; Q = flow; I = i = the canal slope; N = rugosity; H = h = depth of the water; S = canal section; V = v = water speed; R = hydraulic radius; C = Chezy's coefficient. H, I are given. $0.2 < V < 2.0$ - the speed restriction. If no value was found which should satisfy equation (1) in the text, the appealing programme is announced by the cell INDEX which assumes the value 0. Otherwise INDEX = 1.

Figure 1

CALCULATION DIAGRAM FOR CASE 4
(For selecting the optimum variants)

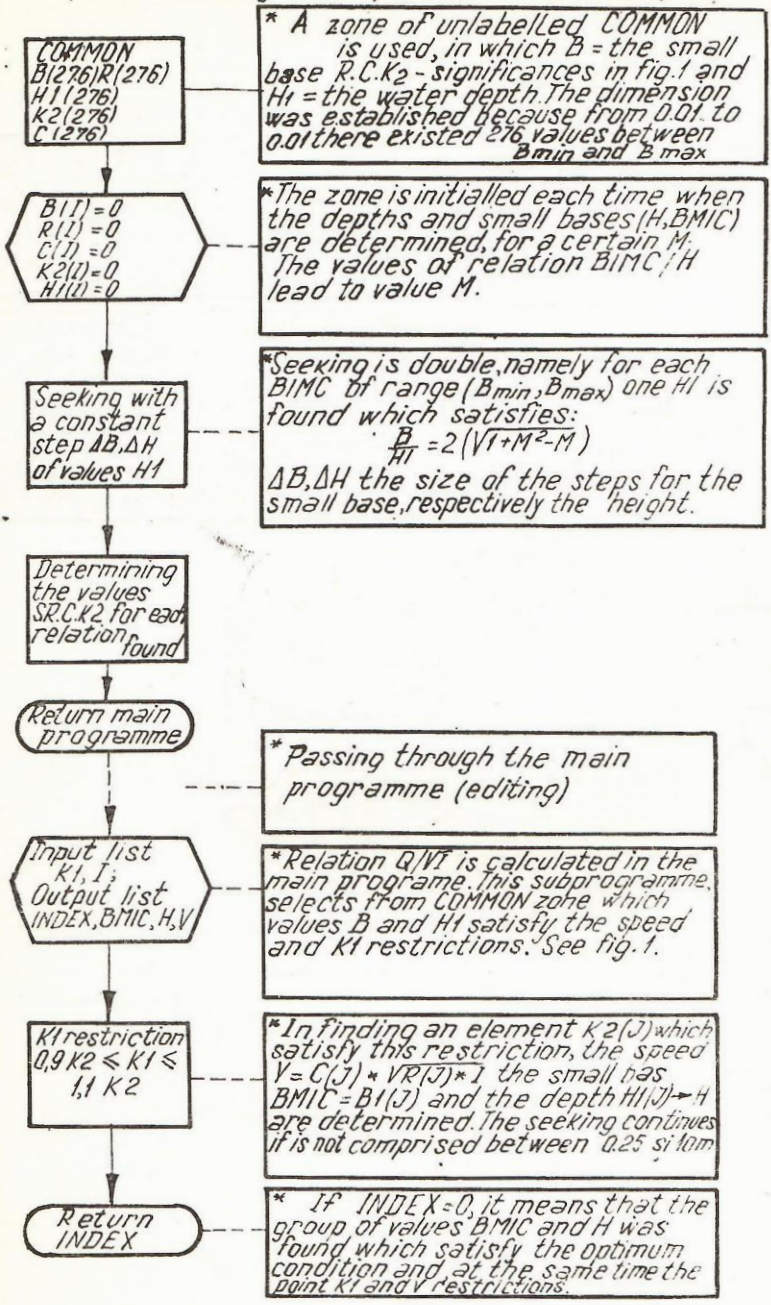
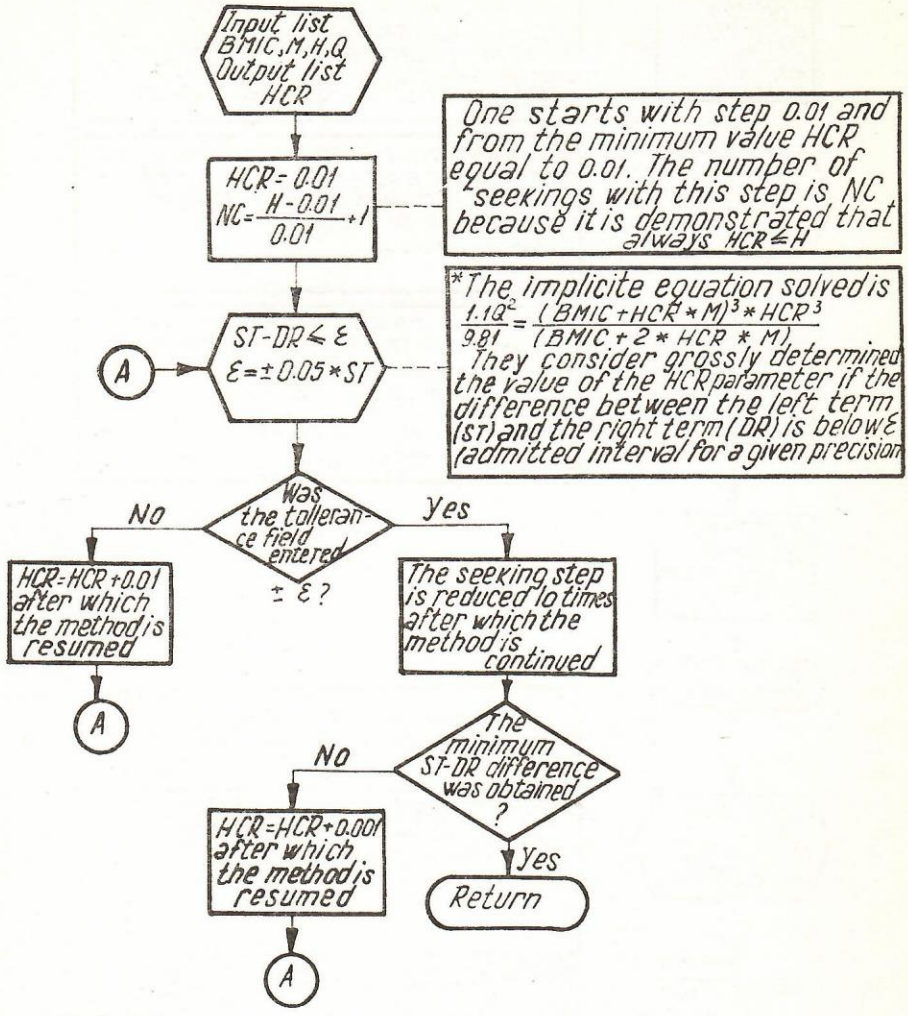


Figure 2

CALCULATION DIAGRAM OF THE CRITICAL DEPTH HCR THE VALUES OF H BEING KNOWN



Notations:
HCR = h_{crt} = critical depth
NC = counter number

Figure 3

TRAPEZOIDAL LINED CANALS SLOPE M = 1.00 RUGOSITY N = 0.014 RELATION SMALL BASE/DEPTH = 0.8

CANAL SLOPE %	FLOW 0.10 MC/SEC					FLOW 0.20 MC/SEC				
	Depth of water in canal H M	Speed of water in canal V M/SEC	Surface of the canal section S MP	Slope surface ST MP	Supplementary cubing MC	Depth of water in canal H M	Speed of water in canal V M/SEC	Surface of the canal section S MP	Slope surface ST MP	Supplementary cubing MC
1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CANAL SLOPE %	FLOW 0.30 MC/SEC					FLOW 0.40 MC/SEC				
	Depth of water in canal H M	Speed of water in canal V M/SEC	Surface of the canal section S MP	Slope surface ST MP	Supplementary cubing MC	Depth of water in canal H M	Speed of water in canal V M/SEC	Surface of the canal section S MP	Slope surface ST MP	Supplementary cubing MC
1.00	0.0	0.0	0.0	0.0	0.0	0.33	2.2R	0.20	0.9	0.3

KEY

* = Section properly used hydraulically
R = The water flow in the outlet is made rapidly
V = The water flow in the outlet is made torrentially

Multiply the supplementary cubing column with the quantities	0.07	0.16	0.25	0.35	0.47	0.61
if the hill slope is	0.05	0.10	0.15	0.20	0.25	0.30

may be reduced by diminishing the interval of the seeking of the values b/h provided that the steps generated for these values should be smaller. In this case, the calculation time is considerably growing.

CONCLUSIONS

1. The CANALOPT programme comprises two modules corresponding to the strategies for seeking the dimensions of the canal for cases 3 and 4— other corresponding modules having to be created for the other cases.
2. The programme has grasped the main water motion conditions.
3. The programme allows the change in the result editing formats.

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DETERMINATION DES DIMENSIONS OPTIMES DES CANAUX OUVERTS UTILISES DANS LES HYDROAMELIORATIONS

La nécessité de calculer certaines sections de canaux économiques apparaît souvent dans la pratique des travaux d'améliorations foncières. C'est pourquoi les auteurs proposent un programme CANALOPT à deux modules correspondant à deux cas de conditions de calcul. Le programme est utilisé dans la projection des canaux ouverts dans les grands travaux d'améliorations foncières.

ОПРЕДЕЛЕНИЕ ОПТИМАЛЬНЫХ РАЗМЕРОВ ОТКРЫТЫХ КАНАЛОВ, ПРИМЕНЯЕМЫХ В ГИДРОМЕЛИОРАЦИИ

В практике мелиорационных работ часто возникает необходимость расчета экономичных сечений каналов. Авторы настоящей статьи предлагают в этом отношении программу КАНАЛОПТ с двумя модулями, соответствующими двум случаям условий расчета. Программа применяется при проектировании открытых каналов в больших мелиорационных работах.