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Contribution to dimensioning of ditch with wall

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Abstract: In this paper it is proposed a new and more precise formula for the evaluation of the water, which may be retained, in ditch with wall used as hydro-technical construction for torrents control. This goal is realized through a rigorous geometrical shape calculation. Also it is given the balance between the extracted soil from the ditch and the deposited one in the wall. A comparison between the old and the new formulas and errors values are strong arguments for using the introduced formula especially for a large interval of earth surface inclination

Keywords: ditch, safe accumulation, environmental, modern

1. INTRODUCTION

The ditch with wall is a possibility for torrent control. If in the inflow basin of the torrent there are favorable natural conditions, the destructive effects of the torrents can be prevented by execution of some hydro-technical works, the most simple of these is the ditch with wall. This is realized by digging on the slopes overgrown by grass of some ditches that are parallel to the level curves in order to collect the waters from rainfall, that otherwise would be gathered by the torrent [3], [4].

The ditches have transversal section approximately trapeze-shaped. The soil removed through digging is stored on the downstream part of the ditch building a wall [5], [6].

2. CURRENTLY USED FORMULA

The quantity of water that can be retained by this ditch depends on the length of the ditch and on the area of the transversal section. The speciality literature offers the usual dimensions of the transversal section, Table 1 according to [1], [2] and its shape, figure 1, as well as the water volume that can be retained on the length unit of the ditch, q, relation (1). It can be remarked that the relation (1) approximates the area of the transversal section as triangle plus trapeze. This approximation is not always sufficiently precise, as shown below.

It is noticed that for this approach the variable remains the slope of the ground from shown in relation (1). The torrent control, keeping the standard cross section of the ditch and the walls- Table 1- depending on the slope angle of the ground**, α,** leads to areas of the transversal sections that differ very much from those found out when using relation (1).

Table 1. The usual dimensions of the ditch with wall [1]

Dimension	Notation	Type [m]	
		High	Small
Total height of the parapet	h_1	0,5	0,4
Efficient height of the parapet for soils :			
- clay- sandy and lattice	hon	0,25	0,2
- soils with clay and acid clay	hoe	0,3	0,25
- soils with acid clay	hoa	0,35	0,3
Width of the crown of the parapet	a_1	0,35	0,3
Width of the basis of the parapet	b_1	1,6	1,2
Width of median strip	a	0,4	0,4
Minimum depth of the ditch	h	0,75	0,5
Width at the ground of the ditch	b	0,35	0,3
Width at the upper part of the ditch	B	1,1	0,9

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Relation (1), in fact the area of the transversal section, expresses the unit of water volume, using the notations according to 1.

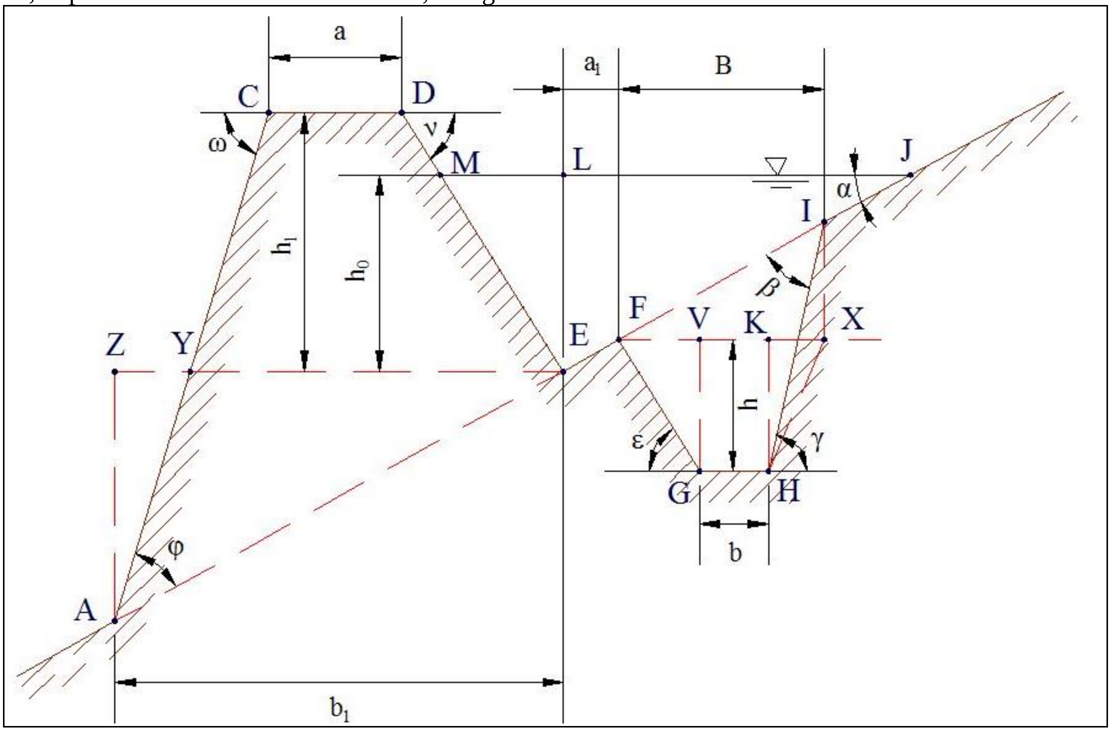

Fig. 1 Transversal section through a ditch with wall

$$q=\frac{1}{2}\cdot\left[\frac{h_o^2}{tg(\alpha)}+(b+B)\cdot h\right] \quad (1)$$

3. PROPOSED FORMULA

The analyses of formula (1) shows that it represents the area consisting in the sum of the area of the trapeze FGHX plus the area of the triangle EJL and this is not equal to the area EGHIJM occupied by the water. The apparent compensation between the area of triangle HKX, that supplementary appears in relation (1), with the area of the triangle ELM that misses from this relation is only approximate and dependent on the slope of the flanks of the zone where torrent control is applied.

In order to obtain a unique solution the following hypothesis are introduced:

$$\angle\omega=\angle\nu=\angle\varepsilon=\angle\gamma \quad (2)$$

The area occupied by the water has the following section value:

AEGHHIJM=AELJ+AMLE+AFGHK+AFKI (3)

Developing depending on the dimensions of the ditch with wall, according to figure 1, it will be obtained:

$$A_{EFGHIJM}=\frac{h_0^2}{\sin(2\cdot\alpha)}+\left[b+h\cdot tg(\alpha)\right]\cdot h+ +\frac{B\cdot tg(\alpha)\cdot\left[B+2\cdot h\cdot tg(\alpha)\right]}{2} \quad (4)$$

The difference between the real area and that given by relation (1) is:

ΔAa = AEFGHIJM- q (5)

The relative error introduced by application of the currently used formula will be:

$$\varepsilon_a=\frac{\Delta A_a}{A_{EGHIJM}}\cdot 100 \quad \% \quad (6)$$

Subsequently a quantitative evaluation of the ration between the volume excavated of the ditch versus the wall volume will be made. In the transversal section this means to compare the area of the excavated soil FGHI with the area of the wall ACDE.

$$A_{FGHI}=A_{FGHK}+A_{FIK}=h\cdot\left[b+h\cdot tg(\alpha)\right]+ +\frac{B\cdot tg(\alpha)\cdot\left[B+2\cdot h\cdot tg(\alpha)\right]}{2} \quad (7)$$

$$A_{ACDE}=A_{AEY}+A_{CDEY}= =\frac{b_1\cdot tg(\alpha)\left[a+2\cdot h_1\cdot tg(\alpha)\right]}{2}+h_1\cdot\left[a+h_1\cdot tg(\alpha)\right] \quad (8)$$

The difference between the soil in the ditch and that put on the wall is:

ΔAp= AFGHI – AACDE (9)

The percentage difference is:

$$\varepsilon_p=\frac{\Delta A_p}{A_{FGHI}}\cdot 100 \quad \% \quad (10)$$

and the positive values mean excessive soil, the negative values means that soil must be completed from other sources.

4. CASE STUDY

The numerical application was realized for a reasonable interval of reception basin slopes where hydro-technical works for torrent control are foreseen.

So for two types of dimensions of the ditch with wall, large and small, the interval α = 0…300 has been accepted and for the soil there have been considered three cases: soil with clay and sand, soil with clay and acid clay and soil with acid clay. The discrete values for the ditch with wall, large, are computed and presented below in the Table s 2, 3 and 4.

Table 2. Ditch with wall, large type, soil with clay and sand and the data of Table 1

α	**q**	**$A_{EFGHIJM}$**	**ε_a**
degree	m^2	m^2	%
1	2,33	2,07	- 12,56
5	0,90	0,73	- 23,28
10	0,72	0,676	- 6,51
15	0,66	0,759	+ 13.04
20	0,63	0,894	+ 29,53
25	0,61	1,067	+ 42,83
30	0,597	1,28	+ 53,35

Table 3. Ditch with wall, large type, soil with clay and acid clay and the data of Table 1

α	**q**	**$A_{EFGHIJM}$**	**ε_a**
degree	m^2	m^2	%
1	3,121	2,86	- 9,13
5	1,05	0,889	- 18,11
10	0,7989	0,757	- 5,54
15	0,711	0,81	+ 12,22
20	0,667	0,936	+ 28,74
25	0,64	1,1	+ 41,82
30	0,621	1,31	+ 52,60

Table 4. Ditch with wall, large type, soil with acid clay and the data of Table 1

α	**q**	**$A_{EFGHIJM}$**	**ε_a**
degree	m^2	m^2	%
1	4,05	3,79	- 6,86
5	1,24	1,07	- 15,89
10	0,89	0,85	- 4,71
15	0,77	0,87	+ 11,49
20	0,71	0,98	+ 27,55
25	0,675	1,1	+ 38,64
30	0,649	1,35	+ 51,93

The computations for the ditch with wall, small type, are graphically represented in the figures 2. The results have the same tendencies as for the large type and for different types of soil of the parapet.

From the graphics and Table s it is noticed that the numerical results for the two formulas are equal only for a value of the flank's slope between 11 and 12 degrees. For example, for the ditch with wall – large type and soil with acid clay this value is $\alpha_{critic} = 11^0\ 23'\ 58''$.

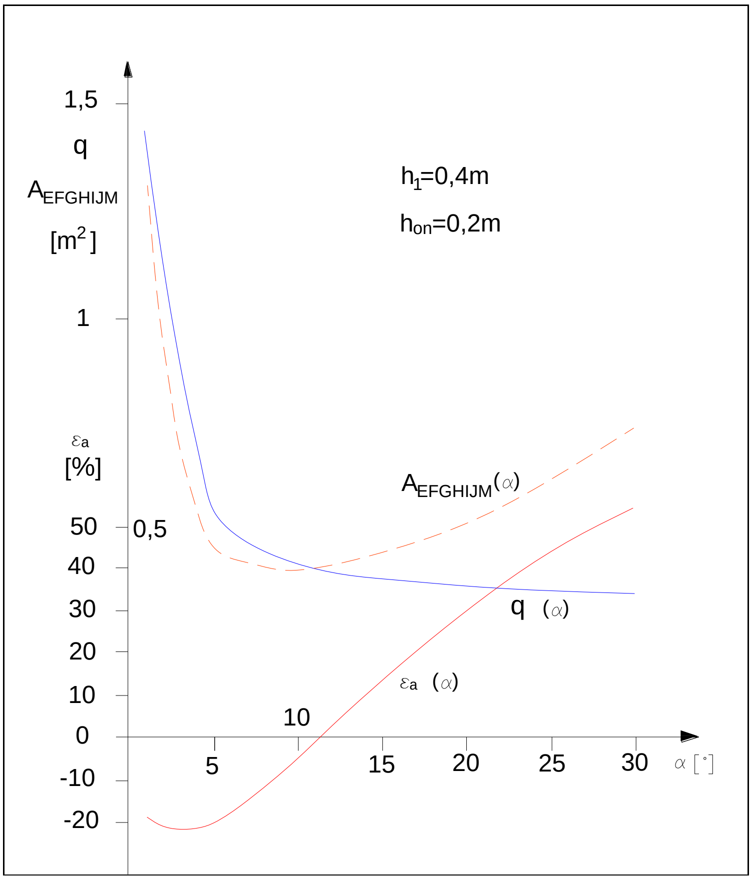

Fig.2 Transversal areas of the ditch with water and relative error depending on the slope of the flank. [q(α) – according to rel. (1) ; AEFGHIJM(α) – according to rel. (4)]. Small type, soil with clay and sand

The evaluation of the excavated soil quantity during realization of the ditch with wall- large type- not depending on the type of soil is computed and the results are numerically given in Table 5 and graphically presented in figure 3.

From the Table and the graphic it is noticed that there is about 35% excessive soil for the ditch with wall, large type, respectively 45% for the ditch with wall, small type.

Table 5. Ditch with wall, large type and the data of Table 1

α	**A_{FGHI}**	**A_{ACDE}**	**ΔA_p**	**ε_a**
degrees	m^2	m^2	m^2	%
1	0,283	0,210	0,073	25,79
5	0,37	0,255	0,115	31,08
10	0,494	0,325	0,169	34,21
15	0,634	0,410	0,224	35,33
20	0,796	0,513	0,283	35,55
25	0,986	0,639	0,347	35,19
30	1,211	0,795	0,416	34,35

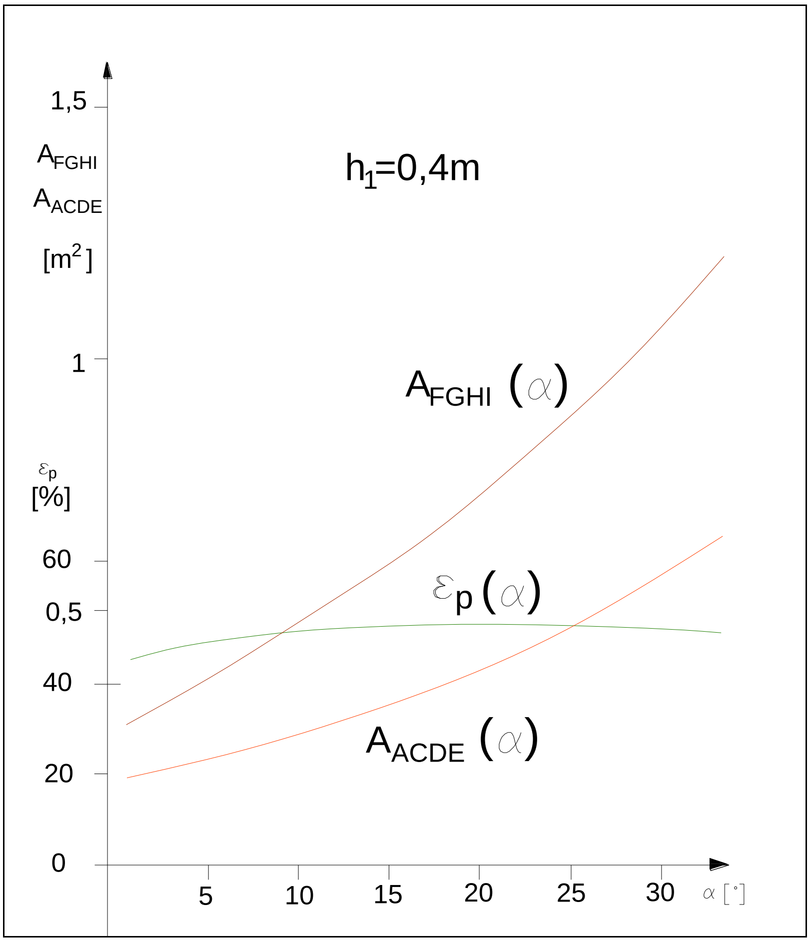

Fig. 3 Unit soil volume deposited on the wall, A_{ACDE} , and unit soil volume excavated of the ditch, A_{FGHI},and relative soil excess, $\varepsilon_{a,}$, depending on the slope of the flank, α . Ditch with wall, small type.

5. CONCLUSIONS

1) The paper settles an exact formula– relation (4) – for determination of the water volume that can be safely accumulated in a ditch with wall.

2) The settled formula is valid for an interval of usual slopes of the flanks between 0 and 25...30 degrees. Exceeding this interval spoils the geometry of the transversal section considered in fig.2.

3) For slopes of the flanks α = 11…12 degrees, the formula indicated in the literature (1) and the formula settled herein (4) offers the same result.

4) For slopes of the flanks in smaller (α = 1…10 degrees) and larger (α = 13…30 degrees) intervals than the values mentioned at conclusion 3) the absolute and relative errors are large, reaching up to 50%.

5) The quantity of soil excavated of the ditch is sufficient for realization of the wall; there is about 35% more solid material at disposal for the large version and about 45% for the small version.

So the relative values are approximately constant. The absolute values increase with increase of the slope of the ground.

6) The constructive types of the ditch with wall, large and small, are not in geometric similitude, but are closed from constructive point of view and have the same tendencies for the operational parameters.

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