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MANAGEMENT ACTIVITIES FOR CONSTRUCTION OF A DIKE

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ABSTRACT

The dike is an engineering construction and is a component part of the hydrotechnical arrangements. A case study regarding the management of the construction activities of a dike is described in this paper. Alternative mechanization options are presented, and their selection criteria were to fit into the execution period and financial efficiency. In this sense, a calculation of pre-measurements, required construction machines, number of hours of their operation, specific fuel consumption, working days for each activity is presented.

KEYWORDS: management, dike, work activities, construction machines, mechanization variants

1. INTRODUCTION

The term earthworks represents all the works with materials such as earth, aggregates or rocks, with which excavations or fillings are carried out with the aim of building different objectives, in accordance with the technical project of the respective construction works.

The embankments can be made in several ways, depending on the location of the works in relation to the natural land line, as follows: embankments in backfill, debleu or in a mixed profile.

When performing earthworks, it is necessary to take into account several basic principles, such as: ensuring the stability, durability and bearing capacity of the work to be carried out, by increasing the degree of mechanization, by implementing high-performance technologies, all this under the conditions of minimal investment.

Therefore, depending on all the construction and operational particularities of the site, as well as the specific zonal conditions (for example: relief, climatic, hydrological, geological, pedological and vegetation), the contractor will adopt through the technical project of the work to be executed, the most appropriate solutions regarding:

- the movement of earth masses from one place to another;
- the technology of execution of works;
- establishing the optimal technological parameters specific to the type of work (for example, when compacting soils, the optimal compaction humidity, the maximum thickness of the bedding layer, the number of passes, the speed of work, etc. must be taken into account);
- the choice of machines suitable for the specifics of the work (if possible, the best performing machines with high execution precision, low fuel consumption, control and regulation of work parameters, etc.);
- taking additional measures to stabilize and protect the embankments for the durability of the work performed.

It should also be specified that the platform on which an earthwork is carried out, it must be properly arranged, generally recommending leveling and compacting operations, which can also be carried out by steps, in the case of works with steeper slopes greater than 1:5.

2. CONSIDERATIONS ABOUT SITE MANAGEMENT

As regards the conditions for the technological development of earthworks in Romania, they are regulated in the normative C56-2002. In addition, HG 907 of 2016, model F3, is the basis for the preparation of quotations or lists of quantities of works.

Each item of work in the estimate is assigned a current number followed by the symbol of the item with its name and unit of measure.

The quantities of works in the list are determined according to each item of work in the unit of measure corresponding to it.

The selection of production norms and the technological planning of the mechanized execution of earthworks will be done taking into account some restrictive conditions related to the deployment spaces.

In order to carry out the technological process normally and to ensure the technological programming conditions, the working surface is divided into working sectors. Within a sector, the machine or convoy will perform the work on longitudinal or transverse tracks.

The distribution of the surface and the technological programming will be done in such a way as to create the possibility that as many activities as possible can be carried out simultaneously, ensuring the execution of the work in continuous flow.

On a working sector, the machine will move according to a mechanization scheme designed for a whole number of strips, transversely or longitudinally. Also, specific equipment and technological schemes are used for each type of work.

For the construction of a dike, first, the conditions for putting into operation all the necessary technological activities will be analyzed, based on the physical-mechanical characteristics of the land of the dike location, determined in advance through geotechnical investigations. In this case, the recommended soils are those in the category of sandy or dusty clays, clayey dusts, etc.

Depending on the proposed purpose, the complexity of the technological process (number of activities), as well as depending on the programming and calculation possibilities available to the company executing the technical project, the degree of detailing of the activities, respectively of the program, is established.

After specifying the number of activities, the list of activities and the analysis of their logical-technological and organizational sequence with the specific restrictions of the working conditions are drawn up.

When selecting the mechanization technological options, the multi-criteria method is used, which is done in two situations, as:

- either for the selection of the mechanization technological variants necessary for the execution of the works, based on the existing equipment;
- either for the selection of constructive types of machines in order to equip or complete the existing park.

3. CASE STUDY: THE CONSTRUCTION OF A DIKE

In the case study presented in this paper, the mechanized execution of the construction works on the structure of a dike (Figure 1) with the following characteristics is considered:

- nature of mineral aggregates: fat clay mixed with broken stone and gravel up to 15% by volume;
- length of the dike: 0.85 km;
- dike width: 10 m;
- height of the pier: 1.4 m;
- crown: 3 m;
- slopes with slopes m_1 = 1:2 and m_2 = 1:3;
- thickness of the vegetal layer: 30 cm;
- transport distance of materials: 1.5 km;
- transport distance of vegetal layer: 1.5 km;
- terrain category: II;
- term of execution of the work: 2 months.

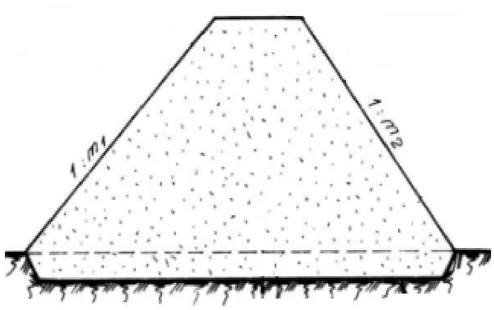

Fig.1. Cross section of the dike

Analyzing first the conditions for putting into operation all the technological activities necessary for the construction of the dike, the physical-mechanical characteristics of the terrain of the dike location must be known. In this case, the recommended soils are those in the category of sandy or dusty clays, clayey dusts, etc.

The slopes of the embankment have different inclinations of the type 1:m1 and, respectively, 1:m2, usually included with values of m=1…3, depending on the nature and characteristics of the construction soil from which to make the body of the embankment with the available equipment.

The surface of the foundation terrain results from the removal of the vegetation layer to embed the body of the dike in the unalterable foundation land and it is H=0.65 m.

For this case study, the variant of the individual criterion for mechanization, optimization was chosen, using the selection criterion of the amount of the unit costs of all the resources involved in the construction of the dike.

In table 1, the technological activities that will be carried out for the construction of the dike are centralized in order.

Table 1 The order of technological activities

No.	Name of activities	Mechanization variants
01	Digging up the vegetation layer and gathering it in a pile	Auto-scraper 621 G
		Crawler bulldozer D9
02	Loading the vegetation layer in transport machines	Wheel loader L522
		Crawler loader LR626
03	Mechanized soil excavation for the shape of the embankment foundation and its loading	Crawler excavator PC180
		Crawler excavator S/SM802
04	Mechanical excavation of the soil at the borrow pit	Wheel excavator PC450
		Crawler bulldozer D9
05	Loading the excavated soil at the borrow pit in transport machines	Wheel loader WA320-3
		Crawler loader LR641

In preliminary measurements, the quantities of works corresponding to each technological activity were established. These quantities are expressed in representative measurement units (in m3) provided by the indicator of resource consumption per budget item.

The pre-measurement is given in table 2.

Table 2. Establishing the quantities of activities

No.	Activity name	Value, m^3
01	Digging of the vegetation layer	2450
02	Loading of the vegetation layer	2950
03	Mechanical digging of soil for the foundation of the dike	3250
04	Mechanical digging of soil at the borrow pit	8500
05	Soil loading digging at the borrow pit	10650

To express the expenses involved in the machinery in the work process, the total cost was used, which has two components: variable costs and, respectively, equivalent fixed costs.

Variable costs consist of:

- the cost of renting the equipment;
- the cost of fuels and lubricants;
- cost of additional labor.

In Romania, the rationing of fuel and lubricant consumption of means of transport is applied to the equivalent distance (1/100 equivalent km).

The standard indicator, regarding the cost of hourly fuel consumption established on the basis of experimentally determined consumption, can be calculated with the relation:

$$C_c = Q_{hc} P_c \text{ [Ron/hour]} \quad (1)$$

in which: *Qhc* is the average hourly fuel consumption, in l/hour; *P* is the unit price of fuel, site loco, which also includes the cost of transport and handling for refilling, in Ron/l.

The average hourly fuel consumption also depends on the working regime of the construction machine. Thus, three work regimes will be considered: light, medium and heavy [1].

For the case considered in this project, we have chosen the average work regime because work activities are carried out in approximately constant cycles, in a normal request regime, with normal breaks of up to 20% of the program time, in category II terrain for earthmoving machines.

The standard indicator for the cost of hourly lubricant consumption is determined for each construction machine (Table 3).

Table 3. Hourly consumption energy of machines

Machine name	Engine power (CP)	Energy consumption kgcc/hour
Bulldozer D9	140	15.21
Auto-scraper 621G	2x180	42.10
Loader L522	101	12.67
Loader LR621	120	11.51
Excavator S/SM802	90	8.86
Excavator PC450	180	13.13
Loader WA320	180	14.66
Loader LR641	219	19.88

When choosing the type of transport, the following data were known: transport distance (1.5 km), soil nature (category II), working area (field), density of the soil (1.8 t/m3), filling coefficient (1.1), looseness coefficient (1.25).

The selected machines for transport were analyzed according to the following criteria [2]: rental rate, additional labor, fuel and lubricant consumption, transport cost (see Table 3 and 4). The cost of transport has been established for a maximum distance of 100 km.

The number of machines to serve a loader resulted as follows:

- for transporting the excavated vegetation layer: 7 trucks or 5 dumpers;
- for transporting soil from the borrow pit: 4 trucks or 4 dumpers.

Table 4.Characteristics of the transport machine

Transport machine	Mass [t]	Volume [m^3]	Diesel fuel l/100km]	Engine oil [l/100km]
Truck Mercedes Benz Atego	10.7	7.0	29	0.2
Dumper TEREX TA 25	20	13.0	38.7	0.22

Finally, the selected equipment and primary calculation data are given in Table 5.

Tabel 5. Transport variants

Variant	Transport machine system	Partial unit costs [RON/100m^3]
I	Truck 10,5 t	11875.5
	Dumper 20t	5755
II	**Truck 10,5 t**	8874
	Dumper 20t	24063

Each type of activity was taken into account with the two mechanization options, and the results are centralized in the table 6 for construction machines and, respectively, in the table 7 the total costs that are involved in this project.

Table 6. Calculation of the number of machines-days and activity durations

Activity code	Equipment	Workload, [ore/m^3]	Rental hours, [hours]	Efective work hours, [hours]	Work of operation,[hours]	Number of machines/day	Number of machines	Activity time
01	621 G	6.2	151.9	66.88	102.5	18.98	2	9
	D9	2.25	55.12	35.5	37.2	55.12	1	7
02	L522	2.57	75.81	22.42	51.17	9.47	2	5
	LR626	1.86	54.87	45.13	37.03	6.85	2	3
03	PCI80	1.6	52	38.57	35.1	6.5	2	3
	S/SM802	1.6	52	59.15	35.1	6.5	2	3
04	PC450	1.6	136	111.35	91.8	13.91	2	7
	D9	2.25	191.25	140.25	129	23.9	2	12
05	WA320	1.44	153.36	139.5	103.5	19.17	2	10
	LR641	2.32	247	78.81	166.7	30.87	2	15

Table 7. Comparative variants of mechanization schemes

Mechanization variant	Machine system formation	Partial unit costs [RON/100m^3]	Total unit costs [Ron/100m^3]
I	Auto-scraper 621 G	7986.5	86806
	Excavator PC 180	7378.2	
	Loader L522	5256.5	
	Excavator PC450	24737.1	
	Loader WA 320-3	35692.6	
	Dumper 20t	5755	
II	Bulldozer D9	56956.2	114715
	Loader LR626	8736.8	
	Excavator S/SM802	10755.1	
	Loader LR641	29393	
	Truck 10,5 t	8874	

4. CONCLUSIONS

Based on the centralized data in table 7, the machine system is chosen, corresponding to the first mechanization option for the execution of the dike (34 working days, compared to 40 days with the second option), respecting the required execution period and financial efficiency.

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