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INTENSIFICATION OF THE CONSTRUCTION OF A DESLUDGING SITE DAM USING LOESS SOILS

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1. Introduction

The desludging site for permanent bedding of ashes from the power-producing operations is situated on the left side of the Danube river in the municipality of Štúrovo. The desludging site is partially flown through by surface waters, it is planar, with a circulation system of transport water, with dams on its southern, western and eastern sides. From the north, the desludging site is bounded by a natural slope. The relative position of the desludging site and Danube river is presented in Fig.1 (Google Earth). The original surface of the terrain was at the ground elevation of ~ 105,0 m altitude. The dam system of the desludging site consists of the basic dam with its crest at the elevation of 109,2 m altitude and of elevation dams with crests at elevations of 113,5 m and 116,2 m altitude, elevated by a method against water and built from local soils, with inclination of downstream slopes of 1:2,5. The lateral section across the dam system of the desludging site is presented in Fig.2. At the southern side, the dam system of the elevation dams is based upon the original flood bank of Danube. In the direction north – south it is divided by a dam into two cassettes. Deposition into the cassette No.1 was finished in the year 1983 at elevation ~ 120,0 m altitude and at present, only the cassette No. 2 is operated occasionally.

Fig.1 Situation of the desludging site

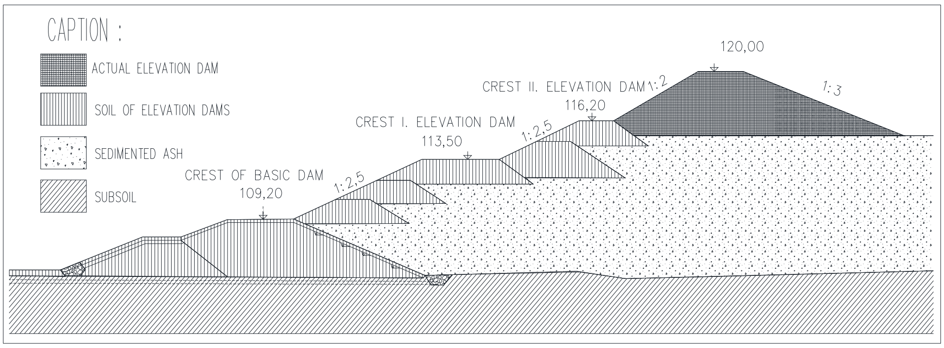

Fig.2 Lateral section across the dam system

2. Elevation of the ash desludging site via earth embankment

The ash desludging site was intensified in the cassette No.2 by dam elevation from the level of ~ 116,0 m altitude to the level of 120,0 m altitude, i. e. approximately by 4 m. The slope of the elevation dam was realized with inclination of downstream slopes of 1:2, at the upstream side 1:3 with the crest width of 4 m. At the selection of materials for elevation of the desludging site, the decision was made primarily according to two indicators with an economic aspect – the transportation distance and the increase of the accumulation volume of the desludging site. It was possible to fulfill those requirements in two ways:

- to elevate the dam system by the ash sediment from the desludging site;
- to accomplish the elevation from the soils found in the slope of the northern boundary of the desludging site.

Finally, the decisive criterion was the occurrence of the failure rate of the ash dam systems in comparison with the dams built from soils. At the elevation of the desludging site, as fill materials there were used the soils excavated from the borrow-pit forming the northern boundary of the cassette No.2. As the desludging site is situated in the immediate vicinity of the Danube river, safe and failure-free operation has the priority.

3. Properties of the soil being built in

For mining of soils to the elevation dam, in the northern part of the cassette No.2 a borrow-pit was opened, with a total area of 4300 m^2 with the mining depth of 7 to 9 m. The mining was preceded by exploration works which verified the geotechnical properties of soils and considered the suitability of their usage for the future ground construction. In the site of the prospective borrow-pit, three exploration wells were dug (to the depth of ~ 3 m) and, in its immediate vicinity, one drilled boring (to the depth of ~ 4.5 m), with a withdrawal of 6 disturbed and 4 non-disturbed samples of soils.

3.1 Grain size distribution and index characteristics of soil

The prospective borrow-pit consisted of loess soils – silts and sandy silts classified as silts with low plasticity (8 samples), respectively, of sandy silts (2 samples) of rigid to hard consistency. From the grain size distribution (Fig.3) it follows that the soils contain 8-18% of clayey grains, 52-64% of silt particles and 18-40% of sands. The determined geotechnical characteristics of the borrow-pit soils are given in Tab.1.

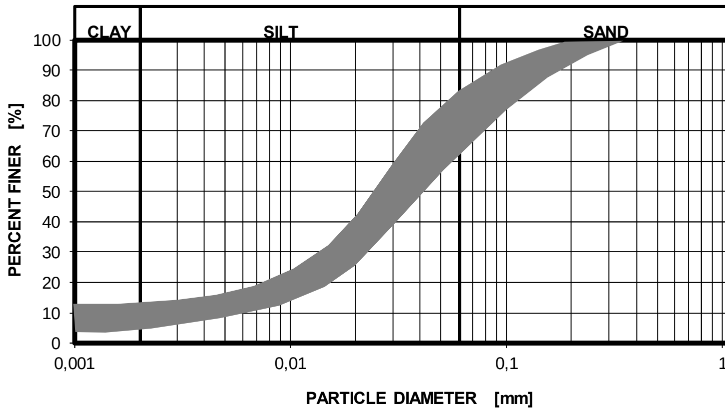

Fig.3 Grain size distribution of soils in the borrow-pit

Tab.1 Geotechnical characteristics of soils in the borrow-pit

Variable / dimension	**Soils in the original bedding (low plasticity silts - 4 samples)**			**Compacted soils (low plasticity silts - 4 samples sandy silts - 2 samples)**		
	Average	**Value span**	**qty**	**Average**	**Value span**	**qty**
γ_n [kN.m^{-3}]	17,4	⟨16,6;18,2⟩	3			
γ_d [kN.m^{-3}]	15,7	⟨15,0;16,3⟩	3			
ρ_s [g.cm^{-3}]		2,67	1			
w [%]	12,3	⟨10,9;14,7⟩	4	10,2	⟨7,6;12,9⟩	6
n [%]		43,8	1			
w_p [%]	22,6	⟨22,1;23,1⟩	4	22,7	⟨21,7;23,5⟩	6
w_L [%]	26,3	⟨25,0;28,6⟩	4	25,6	⟨24,3; 27,2⟩	6
I_p [%]	3,7	⟨2,6;5,8⟩	4	2,9	⟨1,9;4,3⟩	6
I_c [-]	4,2	⟨2,4;5,5⟩	4	5,6	⟨4,0;7,6⟩	6
O_m [%]				0,32	⟨0,25;0,39⟩	3
O_u [%]				29,4	⟨28,4;30,9⟩	3
s [%]				0,268	⟨0,231;0,297⟩	3
$k_{t=10°C}$ [m.s^{-1}]				2,2.10^{-9}	⟨0,89-3,37.10^{-9}⟩	3
w_{opt} [%]				13,5	⟨13,2;15,0⟩	6
ρ_d^{max} [kg.m^{-3}]				1750	⟨1725;1800⟩	6
φ_{ef} [°] c_{ef} [kPa]	28,0 13,3	⟨27,1;28,9⟩ ⟨6,7;19,9⟩	2 tests n=8	33,1 16,3	⟨31,6;35,4⟩ ⟨8,9;20,2⟩	4 tests n=16
E_{oed} [MPa]	7,8-13,6	⟨7,2;13,6⟩	2	10,7-20,2	⟨9,0;22,5⟩	6

The contents of carbonates specified in the laboratory ranged between O_u = 28-31%. The contents of organic substances is small, within the interval of O_m = 0,25-0,39%, t. e. it does not reach the limit norm value of 5% (soils with organic substances contents > 5% are not appropriate for the fillings). Another positive fact was shown by the tests of shrinkability. The soils are practically non-shrinkable, they are volumetrically stable, shrinkage ratio s = 0,231-0,297%.

3.2 Mechanical properties of the soils

In the course of building of the ground construction it is very important to determine by experimental measurements the parameters of compactibility (ρ_d^{max}; w_{opt}) of the soils found in the borrow-pit. The tests of compatibility were performed by the Proctor-Standard method at six soil samples (two samples each from every borrow-pit well). The value of the optimal moisture content ranged between w_{opt}=13,2-15,0% and the achieved maximum dry density ρ_d^{max}=1725-1800kg.m^{-3} From all six measure-ments, the average parameters of soils compactibility w_{opt} = 13,5%; ρ_d^{max} = 1750kg.m^{-3} (Fig. 4) were determined.

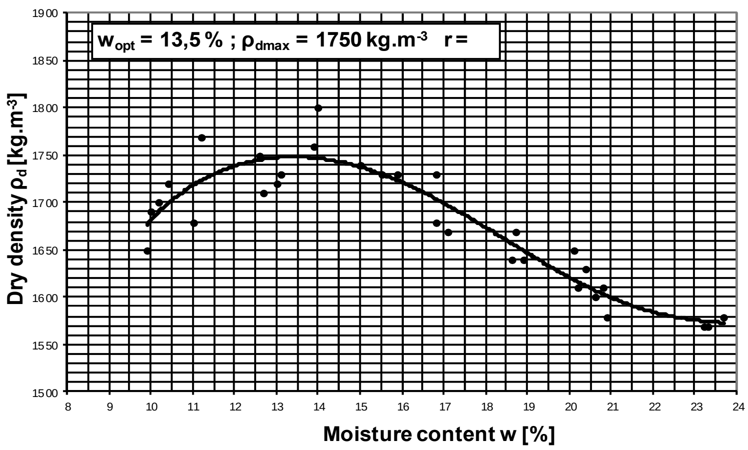

Fig. 4 Determination of average parameters of soils compactibility

The parameters of shear strength of soils that determine the feasibility of the stability prognoses were determined by the direct shear tests (each test on 4 testing samples, dimensions 60/60/25 mm), at actuation of a normal stress 20-250kPa and speed of direct shear testing 0,00975mm.min^{-1}. The shear strength of soils was determined on four samples, prepared by compacting by Proctor-Standard energy at approximately optimal moisture content, and on two non-disturbed soil samples in the original bedding. The average parameters of the shear strength of the compacted samples of soils were φ_{ef} = 33,1°; c_{ef} = 16,3kPa; and of the soils in original bedding φ_{ef} = 28,0°; c_{ef} = 13,3kPa (Fig. 5). The influence of compacting is evident, the measured average angle of internal friction has increased by 5,1° and the average cohesion by 3,0kPa.

The deformation properties of soils were determined in oedometers with a diameter of ϕ = 100,0mm and sample height of 30,0mm at three samples prepared by compacting by Proctor-Standard energy at approximately optimal moisture content, and on one non-disturbed soil sample in the original bedding. The stepwise additional load of the compacted samples was done in steps of 0→50→150→350kPa, and at the non-disturbed sample in the original bedding in steps of 0→25→75→175→375kPa. The average values of the oedometric modules of the compacted samples and of the non-disturbed sample of soil are evaluated in Fig. 6. The deformation characteristics will be influenced by compacting positively; the oedometric modulus of the compacted samples will increase by 1,3-1,5-multiple of the oedometric modulus of the non-disturbed soil in original bedding.

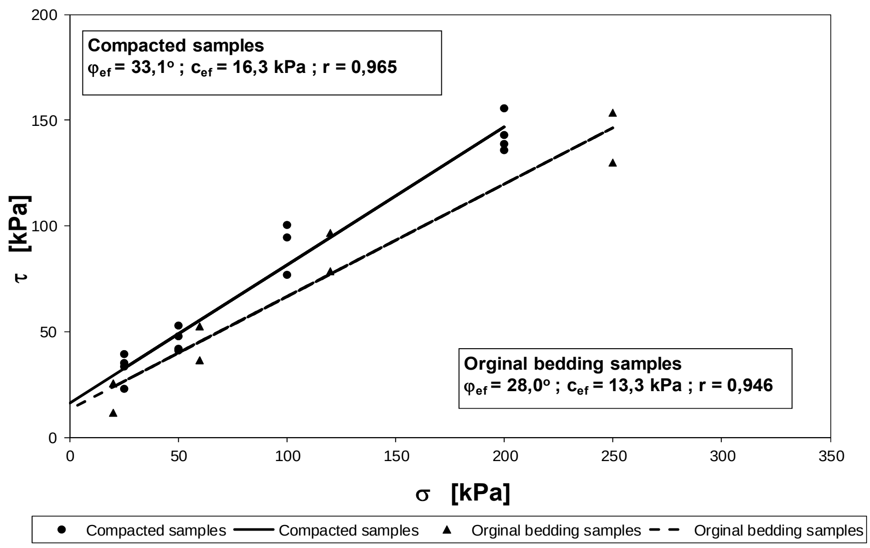

Fig.5 Determination of average parameters of shear strength

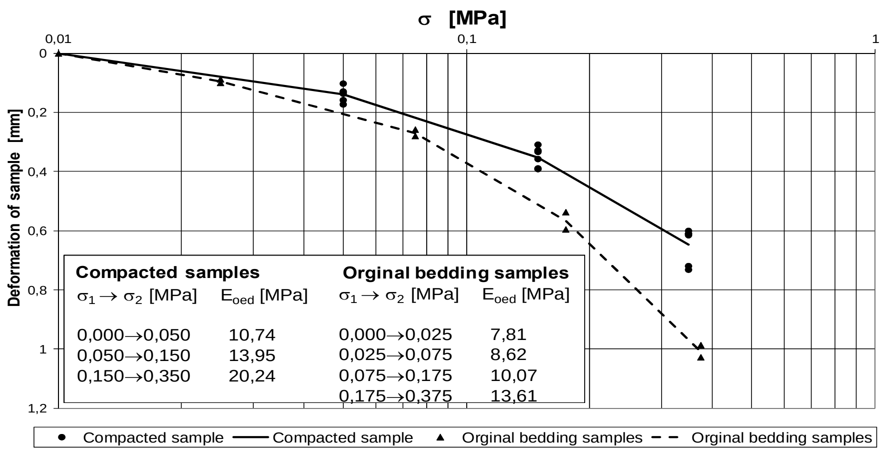

Fig.6 Determination of average oedometric modules

4. Technologic procedure of building a soil construction

At incorporation of the soils into the elevation dam of the desludging site, at the beginning a smooth-surfaced vibratory roller VV 1100D was used (weight 11495kg; vibration amplitudes 1,85/1,15kN; vibration frequencies 32/35Hz). Later, compacting was accomplished by a taper foot (trader) put-on of the smooth roller. The soil has been fed into the elevation body at natural moisture, since the difference between the average value of moisture of the samples taken of the borrow-pit (w = 10,2-12,3%) and the average value of optimal moisture content (w_{opt} = 13,5%) was only 1-3%. The thickness of the layer was 50cm at the beginning, and later on the basis of the results of the compacting process in situ it has been modified to 40cm. The number of roller travels through one layer was 8-10 at the maximum value of vibration. In the initial phase of dam elevation, a compacting experiment was accomplished in situ, to verify effectiveness and the necessary number of travels of the used compacting instrument to achieve the required degree of compacting (the project required a degree of compacting of D ≥92%).

Tab.2 Results of a compacting experiment in situ

Achieved degree of compacting D [%]	Number of roller travels						
	2	4	6	8	10	12	14
	86	88	89	91	91	91	91

The degree of compacting has been measured after bringing in and spreading of a 50cm thick layer of soil excavated from the borrow-pit at natural moisture after 2 - 14 travels of the VV 1100D roller. The measurement results are shown in Tab.2. From the results of the compacting experiment in situ there came out a recommendation for the optimum number of roller travels – 10 – and a decrease of the thickness of the layer from 50 to 40cm.

4. Conclusion

Desludging sites are technical works influencing the quality of environment, therefore they demand increased attention from the viewpoint of the whole society. The construction of elevation of dams of cassette No.2 of the ash desludging is an example of professional approach and cooperation of the investor, project engineer and, most of all, the contractor. The quality of the extensive ground works is documented not only by the final state, but also by the results of the proven and control checks of compacting of soils built into the elevation of the dam of the ash desludging site, as well as its further smooth and trouble-free operation.

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NADVÝŠENIE HRÁDZE POPOLOVÉHO ODKALISKA ZO SPRAŠOIDNÝCH ZEMÍN

Anotácia

Príspevok sa zaoberá nadvýšením hrádze popolového odkaliska zemnou konštrukciou vybudovanou zo sprašoidných zemín. Prezentované a vzájomne porovnané sú geotechnické charakteristiky sprašoidných zemín v pôvodnom uložení v zemníku a zemín zabudovaných technológiou hutnenia. Na záver sú uvedené výsledky jednoduchého zhutňovacieho veľkopokusu in situ.