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STABILITY OF DUMP UNDER THE KRUŠNÉ HORY MOUNTAINS

[1] MIKOLÁŠ Milan, [2] FRAUS František, [3] KRET Ján,

[1] FACULTY OF MINING AND GEOLOGY, VŠB-TU OSTRAVA, [2] GEOTECHNIKA A BÁŇSKÉ INŽENÝRSTVÍ BŘEZOVÁ U SOKOLOVA, [3] FACULTY OF METALLURGY AND MATERIAL ENGINEERING, VŠB-TU OSTRAVA, CZECH REPUBLIC

ABSTRACT:
Brown coal open-pit mining within the Sokolov brown coal territory has been affected by a lack of dumping areas for overburden filling since the very beginning of its development. The territory affected by activity at the dump of Krušné Hory Mountains is situated on 8 cadastre areas within Sokolov district. Total surface of territory affected by mining sums to 1957,1 hectares. Dump length in direction west – east is 8,3 km and its width is 2,3 km. In total there was filled approximately 886000000 m^3 of overburden material on the dump. Mining arrangement of dump techniques on the dump underwent to six substantial surveys by stability assessments. 22 assessments have been successively elaborated since 1966. Prospecting works was under way in various periods. The works were the most intensive especially between years 1989 – 1991. Hydrogeological and geotechnical prospecting was the basis of stability assessment. Suitable reclamation of dump area under the Krušné Hory Mountains is necessary especially in view of unfavourable ecological and natural conditions of the entire Sokolov region affected not only with mining activity but high concentration of industry (mechanical engineering, chemistry, etc.) as well.
KEYWORDS:
dumping areas, open pit mines, stability, Krušné Hory Mountains

1. PROBLEMS OF DUMPING AREAS OF OPEN PIT MINES WITHIN THE SOKOLOV BROWN COAL TERRITORY

Brown coal open-pit mining within the Sokolov brown coal territory has been affected by a lack of dumping areas for overburden filling since the very beginning of its development.

Upper seam Antonín has been and still it is an object of open pit mining. Anežka seam, that has been almost completely mined out in past, has been mined also in an open pit manner in recent years. Residual pillars and old workings after underground mining have been mined as well. The lowest seam Josef has been mined within mining areas of the largest open pit mines in the western part of Sokolov brown coal territory (open pit mine Medard – Libík). It has been mined independently in separate localities – open pit mine Lipnice, open pit mine Erika. Its mining is finished at the present.

Dumping management contends practically permanently with stressful balance of dump areas. Therefore it was necessary to pay attention to a maximum utilization of dumping areas. A number of measures were developed to it. It is

possible to state that without these measures it would not been possible to solve many difficult conditions of dump buildings within the territory and to a large extent to secure reliability of dumping capacities of the territory (Fig.1.).

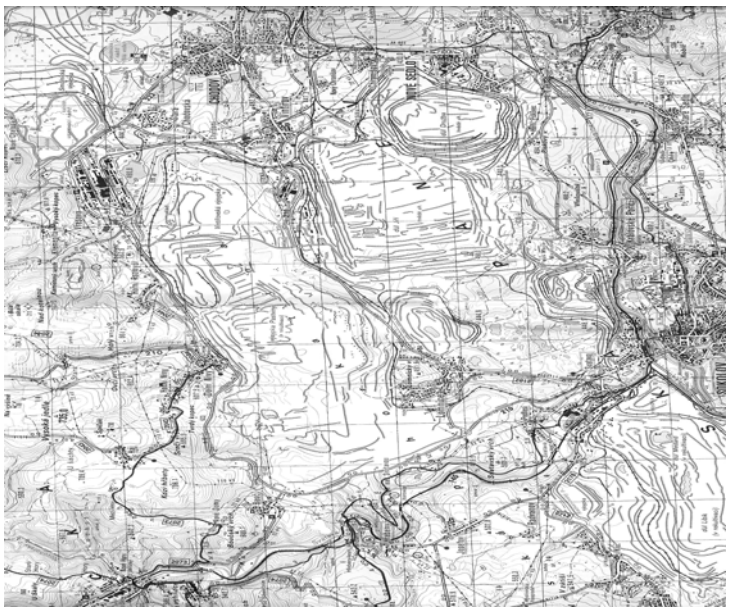


Fig.1. Map of territory

2. OBJECT TERRITORY

2.1. Sum up of original, present and future landscape

The dump under the Krušné Hory Mountains is situated in the landscape with significant geomorphologic segmentation on a boundary at foot of Krušné Hory Mountains and northern part of Sokolov basin. Forests with variable representation of beech, oak and with substantial proportion of coniferous trees especially pine and fir tree initially formed this territory according to historical documents. The landscape was initially very jagged and this segmentation has remained the same due to processed mining – building of dump under the Krušné Hory Mountains.

2.2. Territory characteristics

Initial terrain configuration was in the southern part at elevation points approximately 460 – 480 m above the sea level and in the north part at elevation points approximately 460 – 530 m above the sea level. The terrain descended from the north to the south and to the southwest at general inclination not exceeding 2 degrees. Boučský and Hluboký creeks flew in the western part of territory in widely opened valley that narrowed in the southern part into deep canyon. Lomnický creek flew between western and eastern part of the dump in shallow valley and territory had a character of elevation that created good conditions for rainwater outflow. Lipnický creek flew on boundary of central and eastern part of the dump in a valley directed from north to the south that formed depressions with overflow of surface as well as underground water in its central part. Vintířovský creek flew through eastern part of the territory in a valley directed from northwest to the southeast. Eastern part of the initial terrain was relatively flat with plain at elevation approximately 480 m above the sea level. In the eastern part the open pit mine Lipnice was mined out and its mining area has been cancelled. Bottom of former open pit mine Lomnice and west and north part descends generally in longitudinal direction north – south and in the southern and eastern parts in general inclination north – north. Open pit mine Erika was mined out in the southwestern part of present dump. Bottom of open

pit mine descends from north and west to the south to the deepest place at elevation 429 m above the sea level that was situated in central part of open pit mine. Older dumps covered both mined out open pit mines. At the present time filling is finished on the whole dump in line with effective projects.

Total surface area of terrain affected by dump is 1957,10 hectares.

Surfaces suitable for formation of regional bio-centre (RBC) have been chosen within dump territory with provision for terrain geomorphology, water and climate conditions, natural succession and potential natural vegetation of the territory. The surfaces are monitored by scientific and research institutions (ENKI, public beneficial company Třeboň and the Agricultural Faculty of South-Bohemia University České Budějovice).

There are situated monitoring drill holes and bore holes in the western part of the interested territory, especially to the north of Lomnice village (areas with decreased stability). Performed monitoring has been permanently evaluated. The system consists of hydro geologic bore holes and drill holes, pore pressure indicators, inclinometric probes and geodetic points.

There is located deposited topsoil along the dump perimeter. The topsoil will be used for the purpose of agricultural reclamation. Total registered volume of the topsoil is more than 400 000 m^3.

2.3. Characteristics of natural conditions

2.3.1. Geologic and soil scientific conditions

From global geological standpoint the interested territory belongs to the region of Krušné Hory Mountains crystallinity.

2.3.1.1. Crystallinity

Rock massif of crystallinity consists of two-micaceous muscovitic schist, with a large proportion of quartz; there are phylitic rocks in some locations. Crystallinity surface is affected by intensive kaolinitic weathering into considerable depths. Weathering parts was often redeposited and they form locations of coarse sandy, micaceous kaolinitic clays up to fine-grained sands.

2.3.1.2. Tertiary era

Sediments of old-saddle formation that are deposited on denunded crystallinity surface represent older tertiary period. Sandstones, quartzites and conglomerates of this formation have been preserved only in some places along south and southeast border of the interested territory.

Formation of seam Josef represents younger tertiary period.

2.3.1.3. Quarternary era

Quarternary sediments are mostly developed in irregular relatively small thicknesses on the dump territory. They are formed by hillside soils with low content of quartz, sandstone and mica schist fragments. There are peat sands and peat with relatively small thickness in local depressions. Immediate dump subsoil is mostly formed from little thick layer of soils, respectively sandy clays with quartz and mica schist fragments. Locations of completely or partly decomposed mica schists occur under the subsoil. It follows from analysis of results of all prospective works performed within the territory, that subsoil is suitable surroundings with occurrence of unacceptable stratigraphic locations from geomechanical standpoint.

2.3.1.4. Recent loose soil

Dump soils are formed for the less part by tuffitic clays with the lowest values of specific resistance QST = 0,5 – 1,0 MPa. They occur in heel of the dump, where shovel excavators E25 have deposited them.

Dump soil formed by cypress clays and claystones shows values of specific resistance QST = 1,0 – 2,0 MPa if soil lumpiness is preserved. Specific penetration resistance increase up to values QST = 2.0 –4,0 MPa together with the increasing depth of penetration prospecting.

Varied mixture of cypress clays and claystones with positions of quarternary clays, coal clays, coal as well as gravelled materials forms western part of the dump in the whole geological profile of the body. There were deposited tuffitic claystones and quarternary clays from overburden faces of open pit mine Medard – Libík in the northern part. Central and eastern parts of the dump are mostly formed from brown and grey cypress clays and claystones from overburden faces of open pit mine Jiří.

2.3.2. Hydrogeological conditions of subsoil and dump body

It follows from results of engineering-geological surveys, that:

Contact of the dump with subsoil is not coherently water-bearing.

2.3.2.1. Western part

Dump subsoil is dewatered by a catch drains system, situated predominantly at routes of former water streams or otherwise morphologically critical places.

Local water-bearing levels with free level of underground water that are renewed from atmospheric rainfalls through preferential zones occur in the dump body. They are not substantial from the standpoint of evaluation of general hydrogeological situation in this part of the territory.

In the area of former open pit mine Erika are not favourable hydrological conditions that could exist as a consequence of deposition of unsuitable loose soil composition onto non-bearing and unarranged subsoil.

2.3.2.2. Central part

Taking into consideration subsoil characteristics, filling technique and original terrain morphology that determines general direction of underground water flow in the direction from north to the south there are formed conditions for natural water outflow through dump subsoil in western part of the dump Pastviny. On that account this part can be considered as a territory with hydrological more favourable conditions. Eastern part of the dump Pastviny is the opposite; this part of the territory is unfavourable from hydrogeological standpoint. This part is permanently filled with inflows of underground water, which result in concentrated water rising and area soaks at heel of hillside. Loose soil in this area has got slushy consistence and permanently worsens stability of the territory.

2.3.2.3. Eastern part

It follows from hydrogeological characteristics of subsoil that there is formed significant water-bearing collector in eastern part of the territory within the area of former open pit mine Lipnice. Underground water flows through collector of gravel, sandy clay and sandstone towards north closing hillside of open pit mine through corridor delimited from wall with low permeable rocks of weathered granite and mica schist. Subsoil has been covered with loose soil consisting mostly of brown and grey cypress clays and claystones that are distinguished by low permeability. Filling and different consolidation create conditions for formation coherent water-bearing levels or local levels in the course of time. It depends on occurrence of preferential permeable zones. Infiltration of rainfalls into dump body participates significantly in dump saturation. Predominant part of underground water outflows through shallow preferential zones towards heel of the dump where it rises.

2.3.3. Climate and hydrological conditions

According to climate characteristics interested territory belongs to the area of slightly warm sub-area, slightly humid till dry, mostly with moderate winter. Wind directions are locally very changeable that depends on terrain segmentation.

Table 1: Average air temperatures (°C)

Extreme air temperatures:	
Absolute max.	36,2 °C (in August)
Absolute min.	-27,6 °C (in February)

Table 2: Average amount of rainfalls (mm)

Average amount of rainfalls is 703 mm within the dump territory

3. MINING ACTIVITY AND INDUSTRIAL BUILDINGS

There are industrial buildings of plant for brown coal utilization in Vřesová (to the northeast of the dump) and plants of open pit mine grounds Jiří in the tight closeness of the dump. Both industrial buildings belong to joint-stock company Sokolovská uhelná, a.s. Sokolov. To the south of dump territory gigant open pit mine Jiří is situated, to the north of dump territory stone quarry Horní Rozmyšl is situated and sandpit Erika is situated to the west. Grounds of industrial plant Liapor, joint-stock company, Vintířov that partly uses overburden clays from open pit mines Družba and Jiří for its production are situated to the southeast approximately 4700 m of the dump near Vintířov village.

3.1. Dump filling

Three different techniques were used at filling on the dump:

a) Excavator dumps were filled by shovel excavators. Shovel excavator dumping was used at dump part Týn. Face dumping height of excavator dump – up to 10 m.
b) Technological unit TC 2/1 with overburden conveyer dumping machine ZP 6600/12 moved on behind faces of excavator dumps. Technological unit TC 2/2 with overburden dumping machine ZP 6600/17 moved on higher horizons of the dump with the output approximately 9 000 000 m^3 per year. Overburden dumping machine ZP 6600/12 filled bottom and top faces. Overburden dumping machine ZP 6600/17 made lowered corridor at the dump in an area above Lomnice village by its progress so that passage for venting of Lomnice village was preserved according to conclusions of climatic study. Filling of technological units TC 2/1 and TC 2/2 was realized in dump part Pastviny – Boučí – Týn.
c) Third technology used at filling on the dump under the Krušné Hory Mountains was overburden railway dumping machine ZD 2100/3 that was filling within the part of the dump called Vintířov dump.

3.2. Dewatering

Dewatering of subsoil of the dump under the Krušné Hory Mountain – parts Pastviny, Boučí, Týn and Vintířov is realized by a system of catch drains. Amount of water run off drains is regularly monitored.

4. STABILITY OF THE DUMP AND ITS TREND

4.1. Stability of the dump and its trend

Mining arrangement of dump techniques on the dump underwent to six substantial surveys by stability assessments. 22 assessments have been successively

elaborated since 1966. They were focused on an assessment of general slopes of the whole dump and on a solution of partial problems at dump in the course of its filling as well. Considerable attention was applied to securing safety and stability of the dump above Lomnice village and above valley of Bezejmenný and Boučský creeks. Mainly specialists of Brown Coal Research Institute, joint-stock company in Most and specialists of Báňské projekty, joint-stock company, have developed stability solution. A large number of landslides affected the dump; the most significant ones have affected the dump in turn of 1986 and 1987 and in 1990.

Basic physical and descriptive strength, deformational and technological parameters were determined at laboratory tests on all types of samples. Geotechnical laboratory tests were carried out as large-volume tests for determination of shearing strength and compressibility parameters.

It results from carried out test that quarternary soils have got significantly higher parameters of shearing strength than tuffitic clays. Higher values for red-brown tuffitic clays opposite to grey-white tuffitic clays are evident at comparison of obtained strengths data. Values of cohesion did not significantly changed at overconsolidation of tested samples at large-volume tests. Resulted values of internal friction angle for investigated samples show relatively low values (φ = 8 – 9°) in relation to material classification and consistency conditions.

Prospect holes and static penetration probes were performed on the territory according to project of engineering geological survey. Prospect holes were carried out by rotary drilling with current casing. Mostly they were stopped at provable dump subsoil.

4.2. Prospecting probes of static penetration

Static penetration probes and sets of experimental geophysical and in-situ tests of soil mechanics were carried out at sever different profiles. Static penetration was realized in total length 1867,6 m, i.e. 9338 tests. Further 1375,6 m of G-G logging, i.e. 13756 measurements were realized. Verticality of penetration probes with depth more than 15 m was controlled by 273 inclinometric measurements in total.

Calculation parameters of shearing strengths applied to stability solution were determined on the basis of analyses of present development of dump stability conditions. Some analyses were performed at a number of written assessments. It follows from these facts that:

a. Shearing strength (φ = 2,6°, c = 5 kPa) of slushy soils is lower than the lowest value from measured values. These slushy soils were not taken at shearing tests with a view to their unsuitable consistency.
b. Strength (φ = 3°, c = 10 kPa) and strengths increased by 20 % respectively 50 % appear at area of the lowest measured values of residual strengths. They characterize shearing strength on boundary of the dump and subsoil with various extents of saturation and fracture.
c. Strength (φ = 6°, c = 10 kPa) and (φ = 14°, c = 20 kPa) characterize shearing strength of fresh loose soil. They appear approximately in the middle of peak values span.

Draft of the final shape of dump body was projected with reference to requirements of regulation of Czech Mining Authority No. 26/1989 of Code. Stability assessment of top dump was performed at a number of profiles. North inclination of dump hillsides ranges from inclinations 1:12,6 to 1:17,7 (south and southwest dump hillsides) and 1:8 (north dump hillsides). It is evident from these facts that hillsides stability was verified in much detail. Determined security coefficients kb are mostly from 1,5 to 1,9 and dump shape complies with requirements of above mentioned regulation of the Czech Mining Authority.

This study originated within the framework of the project solution of GAČR, reg. no 105/07/1438

4.3. Monitoring system

There is used an extensive monitoring system at the dump territory under the Krušné Hory Mountains:

- geodetic monitoring of dump surface and measurement at deeply anchored surveying pillars (Fig.2., Fig.3.)
- measurement of underground water level at the dump (Fig.4, Fig.5.)
- pore pressure measurement
- precise inclinometry for deep monitoring of deformations
- measurement of amount of water outflows from drain systems (Fig.6.)
- monitoring and recording of local instabilities
- static penetration at designated points

Fig. 2. Pilar to observation

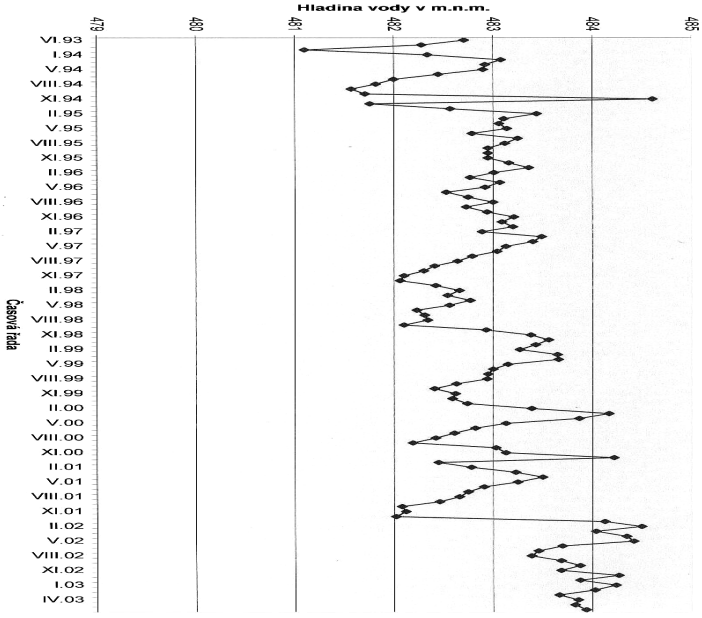


Fig. 3. Settlement measuring on the dump

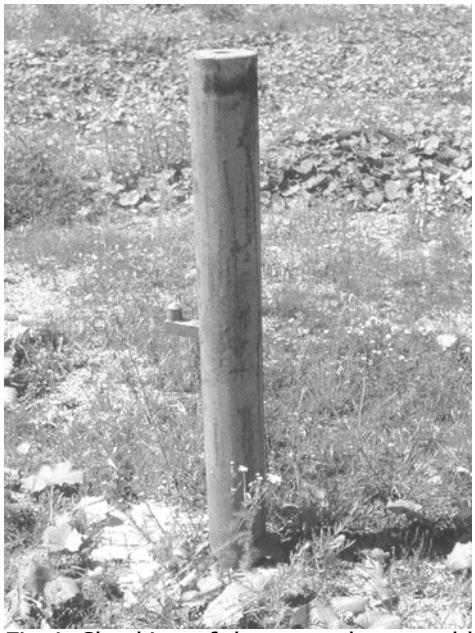
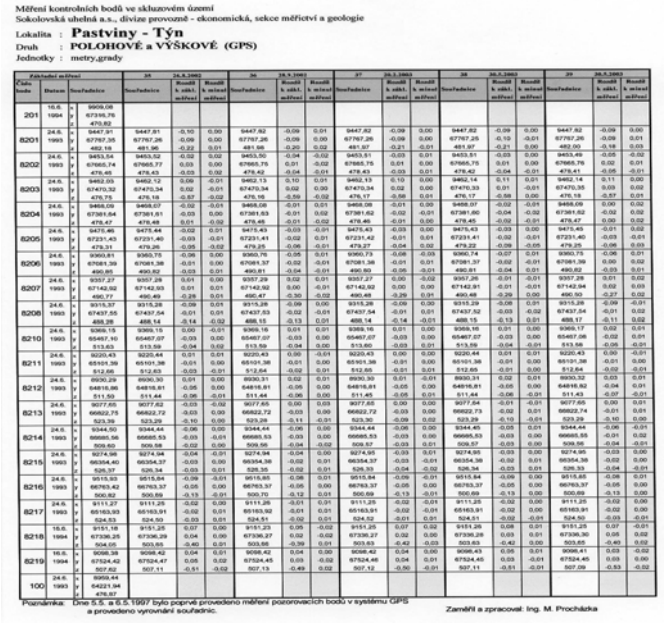


Fig.4. Checking of the groundwater table


Měření kontrolních bodů ve sklužovém území
Sokolovská uhelná a.s., divize provozně - ekonomická, sekce měřictví a geologie
Lokalita : **Pastviny - Týn**
Druh : **POLOHOVÉ a VÝŠKOVÉ (GPS)**
Jednotky : metry,grady

Poznámka: Dne 5.5. a 6.5.1997 bylo poprvé provedeno měření pozorovacích bodů v systému GPS a provedeno vyrovnání souřadnic.

Zaměřil a zpracoval: Ing. M. Procházka

Fig.5. The motion of groundwater in the dump

Fig.6. Rubble drain in the base of dump

5. FURTHER UTILIZATION OF DUMP TERRITORY UNDER KRUŠNÉ HORY MOUNTAINS

Suitable reclamation of dump area under the Krušné Hory Mountains is necessary especially in view of unfavourable ecological and natural conditions of the entire Sokolov region affected not only with mining activity but high concentration of industry (mechanical engineering, chemistry, etc.) as well.

After finishing of mining activity at the dump territory under the Krušné Hory Mountains there will be established conditions for reclamation at region that gradually restores whole affected territory to natural conditions. This study was elaborated with the purpose of successful reclamation of the whole territory in view. It ensures coordination of interests and solution complexity in succession of reclamation works on mining activity.

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