



Completion and Utilization of the Rehabilitated Central Tailing Heap of Jan Šverma Mine in Žaclěř

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Abstract

In the article, the authors focus on the continuation of restoration and rehabilitation in the west part of the Central Heap and on the completion of rehabilitation work on the Central Heap, which is connected with the evaluation of subsequent use of rehabilitated land. In [1][2], the results of the first stage of restoration and rehabilitation of the Central Heap of the Jan Šverma Mine in Žaclěř with the climax in the year 2009, when 11 hectares of total 18 hectares were grassed down, were already presented.

This introductory part was followed by other rehabilitation works focused on reshaping the Heap to create stable slopes with safe slope conditions. Earthworks are described. In connection with the earthworks in the framework of ground shaping, a drainage system was completed and the whole area of interest was grassed; increased attention being paid to adequate irrigation.

The utilization of the rehabilitated Central Heap after the completion of rehabilitation by hydroseeding and after the rest period was described.

Keywords: grassing the Heap, maintenance of seeded areas, drainage of the Central Heap, utilization of the Heap, costs of completion of rehabilitation works

1. Introduction

In underground mining, at first the deposit has to be opened by means of openings from the surface along which the mined mineral is transported to the surface. However, accompanying rocks, so-called tailings, are mined together with the mineral. They are separated and subsequently deposited on the heap. Although the tailings were often used for backfilling shafts and levelling the ground, they could not be used like that completely owing to the increasing production of coal, and thus also of tailings. The tailings were deposited as close to the mining shaft as possible. Tailing heaps were dominant features in the landscape. The landscape was devastated and the morphological relief was fundamentally changed.

In [1][2], the results of the first stage of restoration and rehabilitation of the Central Heap of the Jan Šverma Mine in Žaclěř with the climax in the year 2009, when 11 hectares of total 18 hectares were grassed down, were already presented.

The aim of further work was the completion of restoration and rehabilitation works in the main part of the Central Heap, in the lower part of west and southwest slopes, where these works had not been performed yet.

The completion of rehabilitation of the Central Heap took another five years; two years of construction work and three years of after-care.

2. The Central Heap

In March 1995, the Municipal Authority in Žaclěř, more specifically the Department of Building, Town Planning and the Environment issued a planning permission for the restoration and rehabilitation of the Central Heap. The Environmental Studio prepared the project documentation. In consequence, in November 1995 the Municipal Authority in Žaclěř issued a building permit [4].

2.1. The First Stage of Rehabilitation

In the years 1995–1997, a circumferential toe drain, including a lateral drain was constructed in accordance with the given project documentation, the seepage path of the Egidi adit was modified and earthwork especially in the area of the Heap toe (partially utilizing the material removed from the top cone) was commenced. A lack of financial means led to an interruption in all restoration and rehabilitation works in December 1997.

2.2. The Second Stage of Rehabilitation

With regard to the acute need to restore the Heap and prevent thus sliding and erosion (due to storm rainfalls, erosion furrows of considerable size were formed on the slope of the Heap), the state enterprise East-Bohemian Coal Mines (VUD), at present the state enterprise Fuel Combine Ústí (PKÚ), initiated project optimization in the year 1999. The aim of the optimization was



Fig. 1. A view of the JŠM Central Heap in March 2011 [3]
 Rys. 1. Widok centralnej hałdy JŠM w marcu 2011 [3]



Fig. 2. The geogrid-reinforced structure [3]
 Rys. 2. Struktura wzmocnionej geokraty [3]

to modify the engineering solution and the extent of works so that the required restoration and rehabilitation effects could be achieved at minimal construction costs [4].

The optimization project was again elaborated by the Environmental Studio. The fundamental change was a retreat from the original concept proposed by the company Designing of Mines Ostrava (Báňské projekty Ostrava) in the year 1992; this original concept assumed the removal of the whole top cone of the Heap of a volume of 460 000 m³ and the transfer of all material to the lower parts of the Heap – to its toe. In the optimized solution, the top cone was merely lowered and the slope re-graded. The fixed angle of slope in the lower part of the Heap was achieved not by adding the removed cone material but especially by re-grading the slope [4].

With reference to a considerable time gap between the elaboration of project documentation optimization (1999) and the commencement of rehabilitation works (2004) and with reference to the changes in the very Heap (spontaneous

sliding, etc.) in this period, the need to bring the project up to date arose. For the above-mentioned reasons, updated documentation concerning the rehabilitation of the Central Tailing Heap of the JŠM was prepared in October 2004. The mentioned documentation dealt with the entire Heap with the exception of its west part adjacent closely to the premises of the JŠM. The second stage of Heap rehabilitation lasted by the year 2010, Fig.1. The authors provided information on its course in [2].

2.3. The Third Stage of Rehabilitation

The third stage of rehabilitation followed the previous stage with the climax in the year 2009, when 11 hectares of total 18 hectares were grassed down. The aim was to complete the restoration and rehabilitation works in that part of the Central Heap, where they had not been executed yet, i.e. in the lower part of the west and south-west slopes. When establishing the grass cover, experience gained in grassing the previous part of the Heap had to be used as a basis [3].



Fig. 3. The lower part of the west Heap slope [3]
Rys. 3. Dolna część zachodniego zbocza hałdy [3]



Fig. 4. An example of ground shaping in the Central Heap – ditches and protective bunds [3]
Rys. 4. Przykład ukształtowania terenu centralnej hałdy – rowy i wały ochronne [3]

3. Completion of Central Heap Rehabilitation

Rehabilitation was planned for five years; in the first year and the second year, the construction operations were carried out and in the third, fourth and fifth years, so-called after-care leading to the creation of the state of equilibrium of the locality was provided.

3.1. Overall Description of the Engineering Solution

The west toe of the Central Tailing Heap was re-graded; as a result, the slopes are stable with safe slope conditions. Tailings, i.e. the material deposited in the Heap without treatment, were transferred and re-shaped according to the project.

In the case of geogrid-reinforced design, the material was used in compacted backfills, in the other cases, fills were not compacted.

Earthworks were divided by character and location as follows:

- west toe of the Heap
- lower part of the west slope of the Heap
- ditches and bunds.

a) West toe of the Heap

The west toe of the Heap was stabilized within the whole length to the height of 5.40 m and within the width of 3 m by means of a geogrid-reinforced structure with a side slope of 1:1, see Fig. 2.

b) Lower part of the west slope of the Heap

Works in the lower part of the Heap represented the suitable grading of the area between the crest of the geogrid-reinforced toe in the west and the transport berm. In the area of interest, the tailings were locally removed from the Heap, loaded on trucks and transferred and deposited into uncompacted fills so that the designed shape could be obtained. Subsequently, the new graded surface was levelled by a bulldozer, Fig. 3.

c) Ditches and bunds

In the framework of ground shaping, ditches following the ditches constructed in the previous phase of construction works were dug. The material excavated from the ditches was used in pro-



Fig. 5. An example of ground shaping in the Central Heap – ditches [3]

Rys. 5. Przykład ukształtowania terenu centralnej hałdy – rowy [3]



Fig. 6. The geogrid-reinforced structure with a retaining grid and shrub planting [3]

Rys. 6. Struktura wzmocnionej geokraty wraz z zaprojektowaną siatką i sadzeniem krzewów [3]

tective bunds; the excess material was used for the completion of shaping the Heap, Fig. 4, 5.

In connection with the earthworks, a drainage system was completed and the whole area of interest was grassed.

4. Substantiation of the Engineering Solution

4.1. Shape Solution

To the west and east-west toe of the Heap, the premises of the JČM, where many operations are carried out, are adjacent. The adjacent slopes of the Heap were very steep and falling rocks threatened the safety and health of people.

With reference to the cramped space conditions that, in the west toe of the Heap, did not allow the realization of a corresponding protective area ended with an earth bund as in the case of the north part of the Heap, and with reference to the efforts to minimize the transfer of materials, at the toe of the slope a geogrid-reinforced structure, supplemented in its crest by a retaining grid with bush planting, was designed, Fig. 6, 7. The slope above

the toe thus stabilized was subsequently shaped by local material removal and addition. The upper part of the long south-west slope was removed and by adding at the toe, the slope gradient was changed to 1:3 without interruption by stabilizing berms.

4.2. Drainage

Drainage is carried out by a system of ditches connected to sections already constructed in the previous stage of construction work. In the places where the route of the ditch was in contact with transport operations and in sections with a steep incline, and thus the risk of destruction by erosion, the laying of pipes was designed, Fig. 8. With regard to mechanical-physical properties, plastic corrugated pipes were selected; they can withstand heavy loads even without additional concrete encasement, Fig. 9. The ditches themselves are reinforced with stones (up to 80 kg/pc). This solution makes them able to resist torrential rains, fully complies with local conditions and has



Fig. 7. The geogrid-reinforced structure with a retaining grid and shrub planting [3]

Rys. 7. Struktura wzmocnionej geokraty wraz z zaprojektowaną siatką i sadzeniem krzewów [3]



Fig. 8. Ditches are reinforced with stones [3]

Rys. 8. Rowy wzmocnione kamieniami [3]

been successfully implemented on the slopes in the north part of the Heap.

4.3. Revegetation

The way of establishing grasses on the reshaped surface of the Heap was designed based on obtained experience of revegetation of the previous part of the Heap, where, owing to unfavourable climatic conditions and especially pedological conditions, any optimal state had not been reached at the first attempt. For this reason, grassing was carried out by hydroseeding or by manual sowing with raking the seed in; the required amount of nutrients was added to the barren tailings by means of suitable fertilization, Fig. 10. An increased attention was paid to adequate irrigation.

5. Construction Work Sequence

The construction work itself together with “after-care” to integrate the newly shaped Heap into the surrounding environment was planned for 5 years so that natural phenomena (settlement of

fills) could be utilized and simultaneously, the costs of the structure could be minimized. The structure was commenced in the year 2011.

5.1. The First Year 2011

In the first year, a geogrid-reinforced construction was installed in the west toe and shortly after that, the remaining slope was graded. By implementing this measure, the basic stabilization of the Heap was performed to eliminate spontaneous landslides. The fact that uncompacted fills were constructed manifested itself favourably in the total investment costs of the structure; on the other hand, it was necessary to consider the subsequent spontaneous reshaping and, for this reason, no other work was performed in the first year.

5.2. The Second Year 2012

Work on sheeted excavations for pipes was done. The excavated material was used for additional shaping the surface of the Heap especially in places of local excessive subsidence of



Fig. 9. Plastic corrugated pipes [3]

Rys. 9. Plastikowe rury faliste [3]



Fig. 10. An example of revegetation of the Central Heap of JŠM [3]

Rys. 10. Przykład wegetacji na centralnej hałdzie JŠM [3]

uncompacted fills. After that, consolidated surfaces were completed and the whole area was greened.

5.3. The Third to Fifth Years

In the third year, the grass cover, created in the second year, was not closed perfectly yet. The partial washing of fine particles from slopes away occurred, erosion furrows were formed, trenches were silted and particles settled in the sedimentation structure in front of the inlet into the pipes. In this period, the following activities have been or will be executed:

- Subsequent drainage maintenance
- Subsequent maintenance of seeded areas
- Subsequent maintenance of planting
- Irrigation

6. Technical Data

- The total volume of earthwork was 25 810 m³, of which: 4 860 m³ – the west geogrid-reinforced toe of the Heap, 17 060 m³ – the lower part

of the west slope of the Heap, 3 890 m³ – excavation of trenches and drainage.

- The total length of drainage was 1 748 m, of which the length of trenches was 1 537 m and that of pipes 211 m.

- The total grassing area was 26 110 m², of which the grassing area of slopes was 22 000 m², that of crest of geogrid-reinforced toe was 905 m, and that of the front of geogrid-reinforced toe 3 105 m².

- Stones weighing less than 80 kg each – it is a case of quarry stone used in the wedge-shaped hand placed rockfill for reinforcement of drainage trenches. The supplier had to prove the suitability of stone for the given purpose (absorption, frost susceptibility, compressive strength).

- The geogrid used for reinforcing the rock fill ground structure in the west toe of the slope had to satisfy the following criteria: minimum short-term tensile strength of 60 KN/m, ultimate deformation of 12%, resistance to UV radiation.

Tab. 1. Costs of completion of Central Heap rehabilitation works [3]

Tab. 1. Koszt ukończenia prac rekultywacyjnych na centralnej hałdzie [3]

Year	Item	Costs in CZK without VAT
1 st year	Geogrid-reinforced structure, slope grading, backfills	4 726 696
2 nd year	Consolidated surfaces + rehabilitation	6 649 326
3 rd year	After-care	1 031 366
4 th year	After-care	904 869
5 th year	After-care	711 743
Total price in CZK without VAT		14 024 000



Fig. 11. A view of the Bikepark HALDA from the JŠM hoist tower [5]

Rys. 11. Widok parku rowerowego HALDA z wieży wyciągowej JŠM [5]

- The grass mat – grass seed containing geotextile of the type RALTEXT GRASS 700 g/m² Mitop a.s. was used.

- Plastic corrugated pipes – pipes BOCR Polycor DN 100/851/8 were used for the structure.

Costs associated with the completion of rehabilitation works in the Central Heap in individual years is shown in Table 1.

7. Method of Grass Sowing on the Central Heap

The surface of the Heap in the area of interest was grassed over mostly in a classic way, i.e. by manual sowing with slight raking the seed in. With regard to the quality of the local material (barren tailings), the addition of nutrients was necessary. Based on experience in the revegetation of previous part of the Heap, a grass mixture and specific growth stimulators were used.

7.1. Grass Mixture

In the grass mixture for the revegetation of the Heap, grass species, such as meadow fescue, red fescue, sheep fescue – 64%, Italian rye-grass, English ryegrass – 25%, clover, crown-vetch, button clover – 11% were used.

7.2. Growth Stimulators

- Floranid Permanent (30 g/m²)
- 20 ml Bi-Algeen S – 90

7.3. Irrigation

The need for supplementary irrigation changes with time and depends on climatic conditions. The water demand is the most significant in the summer months when the theoretical irrigation amount is taken as 5 mm water column daily (i.e. 50 m³/ha/day). For the total grassed area of the graded surface of the Heap of about 23 000 m², the required irrigation amount was about 115 m³/day.

8. Conclusion



Fig. 12. The bike festival “Marosana End of the Season” – an example of the trail on the Central Heap [5]

Rys. 12. Festiwal rowerowy "Marosana End of the Season" – przykład szlaku na centralnej hałdzie[5]

8.1 Utilization of the Rehabilitated Central Tailing Heap of the Jan Šverma Mine in Žaclěř

After the completion of rehabilitation by hydroseeding, manual sowing and after the rest period, when the grass cover was sufficiently established, the Central Heap was used for the building of a bike park (Bikepark HALDA), Fig. 11.

The bike park began to be constructed with the material and financial support from the joint-stock company GEMEC-UNION a.s. in part of the Central Heap and its near surroundings in the summer of 2012. On the slopes of the Heap, a cross-country mountain bike trail and a dual slalom track were constructed. Fig. 12.

At present, the cross-country trail is about 3 km long. Part of the trail runs along unsurfaced roads and part along newly built single-track paths. For the sake of variety, two stony sections, several jumps, crossing over trenches and banked curves were constructed. The dual-slalom trail consists of two parallel identical tracks. It includes banked curves and two jumps.

Although the bike park is only being constructed, several significant events have already been held there. The most significant events of them are the 14th and the 15th legendary bike festival “Marosana End of the Season”. Already twice, the route of MTB three-member patrol race “Žaclěřská 70” led along the cross-country trail and in September 2013, the first race of cross-country mountain bikes “Žaclěřská HALDA” as the unofficial Czech Republic’s Championship of workers in the extractive industries took place there.

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Literatura – References

1. HUDEČEK, V., ČERNÁ, K., ADAMEC, Z. “Rehabilitation of Central Tailing Heap of Jan Šverma Mine in Žacléř.” *Inżynieria Mineralna* 1/29(2012): 41–53.
2. HUDEČEK, V., ČERNÁ, K., ADAMEC, Z. “Utilization of result of trial seeding experimental plots in the course of rehabilitation of central tailing heap of Ján Šverma Mine in Žacléř.” *Acta Montanistica Slovaca* 17/2(2012): 119–125.
3. Materials provided by the company GEMEC – UNION, JSC.
4. Ing. Cyril Mikyška – ATELIER ŽIVOTNÍHO PROSTŘEDÍ, supplement to the project “Dokončení sanačních a rekultivačních prací na Centrálním odvale hlušín DJŠ Žacléř” (Completion of Restoration and Rehabilitation Works in the Central Tailing Heap of JŠM in Žacléř).
5. Photographs from the bike festival Marosana End of the Season.

Zbieranie i utylizacja zrekultywowanych odpadów z kopalni Jan Šverma in Žacléř

W artykule autorzy skoncentrowali się na kontynuacji i ukończeniu rekultywacji terenów w zachodniej części centralnej hałdy w połączeniu z oceną przyszłego wykorzystania zrekultywowanego terenu. W [1] i [2] przedstawiono wyniki pierwszego etapu rekultywacji centralnej hałdy kopalni Jan Šverma Mine w Žacléř w czasie kryzysu z roku 2009 kiedy 11 hektarów z ogółu 18 hektarów zostało pokrytych trawą.

Część wstępna była następnie kontynuowana na drodze kolejnych prac rekultywacyjnych mających na celu przekształcenie hałdy w celu utworzenia stabilnych, bezpiecznych zboczy. Prace ziemne zostały opisane. W połączeniu z nimi ukończono również system drenażu a cały obszar został pokryty trawą. Kładziono nacisk na odpowiednie nawadnianie. Na koniec opisano zastosowanie zrekultywowanej centralnej hałdy po ukończeniu prac.

Słowa klucze: pokrywanie hałdy trawą, kontrola obszaru zasiewu, drenaż centralnej hałdy, zastosowanie hałdy, koszty ukończenia prac rekultywacyjnych