Completion of Restoration and Rehabilitation of the Central Tailing Heap of Jan Šverma Mine in Žacléř

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In the year 2010, the authors made the reader familiar with the successful implementation of rehabilitation of the Utilization of result of trial seeding experimental plots in the course of rehabilitation of the central tailing heap of Jan Šverma Mine in Žacléř by means of the article Rehabilitation of Central Tailing Heap of Jan Šverma Mine in Žacléř, [3,5,6,7]. They described briefly the locality of the Jan Šverma Mine and made the reader acquainted with the joint-stock company GEMEC – UNION carrying out the rehabilitation. The authors generally described the restoration and rehabilitation methods [8,9,11] and subsequently the procedure and execution of rehabilitation work on the Central Tailing Heap, namely grassing using the Hydroseeding method. The contribution included the results of trial seeding with the application of various fertilisers and soil conditioners.

In this contribution, the authors will focus on the continuation of restoration and rehabilitation works in the west part of the Central Heap. They will be concerned with the evaluation of both overall completion of rehabilitation and subsequent use of the very Heap.

Key words: *Jan Šverma Mine (JŠM), restoration, rehabilitation, west part of the Central Heap, utilisation of the Central Heap*

1. Introduction

The construction of the Central Heap of the Jan Šverma Mine (henceforth referred to as JŠM) in Žacléř dates back to the year 1930 when the tailings began to be transported to the Heap in manually pushed cars. Since this historical date, owing to the need for the rehabilitation and restoration of the Heap, techniques and procedures have moved a significant step forward. In the previous article, we made the reader acquainted with the realisation of rehabilitation on the premises of the JŠM and rehabilitation of the Central Heap.

In the submitted article, we shall focus on the completion of rehabilitation works on the Central Heap, including the evaluation and subsequent use of rehabilitated land.

2. The Central Heap

In March 1995, the Municipal Authority in Žacléř, 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, the Municipal Authority in Žacléř issued a building permit in November 1995 [2].

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 was commenced, especially in the area of the Heap toe (partially utilising the material removed from the top cone). A lack of financial means led to an interruption in all restoration and rehabilitation works in December 1997.

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Fig. 1. A view of the JŠM Central Heap in March 2011 [1].

2.2. The Second Stage of Rehabilitation

With regard to the acute need to restore the Heap and thus prevent 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 optimisation was 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 [2,10].

The optimisation 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 m^3 and the transfer of all material to the lower parts of the Heap – to its toe. In the optimised 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 [2,13,14,15].

Concerning a considerable time gap between the elaboration of project documentation optimisation (1999) and the commencement of rehabilitation works (2004) and concerning the changes in the very Heap (spontaneous sliding, etc.) in this period, the need to bring the project up to date arose. For the reasons mentioned above, 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 except its west part closely adjacent to the premises of the JŠM. The second stage of Heap rehabilitation lasted by the year 2010. The authors provided information on its course in [3].

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 the 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 [1,12].

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
- the 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 stabilised 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, Fig. 2.

Fig. 2. The geogrid-reinforced structure [1].

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. The lower part of the west Heap slope [1].

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 protective bunds; the excess material was used for the completion of shaping the Heap.

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

Fig. 4. An example of ground shaping in the Central Heap – ditches and protective bunds [1].

Fig. 5. An example of ground shaping in the Central Heap – ditches [1].

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 realisation of a corresponding protective area ended with an earth bund as in the case of the north part of the Heap. Concerning the efforts to minimise the transfer of materials, a geogrid-reinforced structure, supplemented in its crest by a retaining grid with bush planting, was designed at the toe of the slope. The stabilised slope above the toe 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 stabilising berms.

Fig. 6. The geogrid-reinforced structure with a retaining grid and shrub planting [1].

Fig. 7. The geogrid-reinforced structure with a retaining grid and shrub planting [1].

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. With regard to mechanical-physical properties, corrugated plastic pipes were selected; they can withstand heavy loads even without additional concrete encasement. 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 been successfully implemented on the slopes in the north part of the Heap.

Fig. 8. Ditches are reinforced with stones [1].

Fig. 9. Corrugated plastic pipes [1].

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 using suitable fertilisation. Increased attention was paid to adequate irrigation.

Fig. 10. An example of revegetation of the Central Heap of JŠM [1].

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 five years, so that natural phenomena (settlement of fills) could be utilised and simultaneously, the costs of the structure could be minimised. The structure was commenced in the year 2011.

5.1. The First Year 2011

During 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 stabilisation 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 excessive local subsidence of 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 m^3, of which: 4 860 m^3 – the west geogrid-reinforced toe of the Heap, 17 060 m^3 – the lower part of the west slope of the Heap, 3 890 m^3 – 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 m^2, of which the grassing area of slopes was 22 000 m^2, that of the crest of the geogrid-reinforced toe was 905 m, and that of the front of the geogrid-reinforced toe 3 105 m^2.
- 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: the minimum short-term tensile strength of 60 KN/m, ultimate deformation of 12 %, resistance to UV radiation.
- 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:

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

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

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 in the seed. Concerning the quality of the local material (barren tailings), the addition of nutrients was necessary. Based on experience in the revegetation of the 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/m^2),
- 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 m^3/ha/day). For the total grassed area of the graded surface of the Heap of about 23 000 m^2, the required irrigation amount was about 115 m^3/day.

8. Conclusion

8. 1 Utilisation of the Rehabilitated Central Tailing Heap of the Jan Šverma Mine in Žacléř

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. A view of the Bikepark HALDA from the JŠM hoist tower [4].

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. The bike festival "Marosana End of the Season" – an example of the trail on the Central Heap [4].

Fig. 13. The bike festival "Marosana End of the Season" – an example of the trail on the Central Heap [4].

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 just being constructed, several significant events have already been held there. The most important 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 "Žacléřská 70" led along the cross-country trail and in September 2013, the first race of cross-country mountain bikes "Žacléřská HALDA" as the unofficial Czech Republic's Championship of workers in the extractive industries took place there.

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