Golf Club Structure and Foundation with Slide Joint on the Undermined Territory

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Abstract: According to the Czech Mining Act, mining companies are responsible to eliminate consequences of black coal excavation on the surface. An interesting example of reclamation of a site which was affected by undermining is the design and construction of a golf course. Structures in the golf club in Lipiny have been designed to resist mining effects which are still actively occurring. Undermining effects are eliminated by sliding joints between the foundation and subsoil. The sliding joints reduce efficiently friction forces and state of stress in superstructures. All the structures have been designed to resist the load of green roofs (roofs with grass) which fit well in the reclaimed site.

Key-Words: Foundation structure, undermined areas, soil – structure interaction, slide joints, crack elimination

1. INTRODUCTION
The natural golf course was created in the Czech Republic in the Moravian-Silesian Region in the Karviná Doly excavation territory between the Olše and Stonávka Rivers. This territory was affected by underground excavation of black coal. This is a protected coal deposit site where mining is still in process and related phenomena occur actively on the surface.

Figure 1. The links with a driving range in the rear
This situation had to be taken into account when designing the architectural, structural, technical and static solution to the structure. The architectonic solution of the site was prepared by Petr Labudek. Other experts proposed the static solution.

2. LANDSCAPE RECLAMATION
According to the Mining Act, §31, Section 5 [1], each excavation company is obliged to remediate the site. This include reclamation of the site in line with special laws, incl. rehabilitation of land affected by the excavation. The excavation company is also obliged to monitor the site after end of operation. Land released during the excavation is reclaimed in line with the plan for developing, preparation and excavation of the site – see § 32 [1]. Reclamation is general adaptation of the site and territories structures, the aim being to eliminate damage to the landscape.

Construction of the golf course was required to fulfill requirements for reclamation of the landscape
in line with the Act No. 44/1988 Coll. on protection and use of raw materials (“Mining Act”) [1]. Before start of construction, it was necessary to reclaim the site in general. Originally, there had been housing development there but excavation of the coal destroyed that part of the city completely. The undermining caused the landscape to drop by several meters. Debris of demolished buildings were still on the site, and not all parts of the buildings were completely removed there. Reclamation consisted of a technical and biological parts. The technical reclamation included relaying of buried networks and supply of dump rock to form the landscape. Then, the biological reclamation was carried out: the dump rock was covered with soil and grass, bushes and trees were planted there. Rough landscaping started in 1998. Construction of the golf course started in the autumn 2009 and the whole of the golf site was completed in the summer 2011.

![Figure 3. Back facilities](image)

The construction of the golf site helped thus effectively and sensitively to reclaim the landscape in line with the Mining Act [1].

3. UNDERMINING EFFECTS

According to the binding opinion of the excavation company, OKD a.s., the construction was designed pursuant to ČSN 73 0039 [2] to fulfil class III construction parameters. The deformation parameters are as follows:
- inclination \( i_{\text{max}} = 6.5 \times 10^{-3} \) rad
- horizontal deformation \( \varepsilon_{\text{max}} = 4.0 \times 10^{-3} \)
- radius of curve \( R_{\text{min}} = 20 \) km

3.1. Method of foundation

The purpose of the load-carrying structure in terms of statics is to eliminate negative effects of the undermining. Landscape elongation, \( \varepsilon_{\text{max}} \), was eliminated considerably in the foundation structure.

![Figure 4. Composition of the sliding joint and cross-section of the foundation slab](image)

3.2. Steel structures and masonry

The steel structure is placed through joints on the foundation structure. Rectification is possible. Because the height of the structure is \( h < 10 \) m, inclination and curving of the landscape will not influence much internal forces inside the steel structure. In brick walls, minor failures may occur and additional repairs of plaster or additional leveling of floors might be necessary.

3.3. Distribution into dilatations units

Because the structure are located on the undermined territory and the site is regarded as a class III site [2], they have to be divided into dilatation units with the maximum length of 30 m. Dilatation was calculated on the basis of estimated deformation of the undermined territory, location of centre of gravity and heights of dilatation units pursuant to ČSN 73 0039 [2].

![Figure 5 – System of dilatation units](image)

4. FOUNDATIONS AND THE SLIDING JOINT

Under the sliding joint, series of rock has been consolidated. The rock consisted of gravel subbase \( E_{\text{def}} > 60 \) kPa with the required ration \( E_{\text{def2}} / E_{\text{def1}} \).
pursuant to ČSN 72 1006. For application of a rheological sliding joint, the sealing coat of concrete was cast on the gravel cushion.

The rheological sliding joint consists of a two layers of heavy modified asphalt belt (“NAIP”). The rheological sliding joint was covered with a cement finish in order to prevent the rheological sliding joint from being damaged by binding of the concrete reinforcement. The foundation structure was made from concrete, class C25/30 pursuant to EN 206-1 and reinforcing iron R10505 (S500), see Figure 6. The foundation was cast continuously, without creating undesirable working joints.

In order to design the sliding joint and to set internal forces in the structure correctly, it is essential to know the shear resistance of the asphalt belt for a specific rate of deformation [16]. The shear resistance for the specific rate of horizontal deformation of landscape was specified by experiments in laboratories of the Faculty of Civil Engineering in VŠB - Technical University of Ostrava. Measurement results were used in calculation of internal forced in reinforced concrete foundation. The software was based on a finite element method [13] až [18].

This method expresses the parameters of the contact functions within the static analysis, if FEM is used. If it is assumed that the friction parameters $C_{1x}$ and $C_{1y}$ are constant for the foundation structure, the distribution of the normal forces is not similar as if the method pursuant to ČSN 73 0039 [2], [18] is used. For simple cases, however, this method is sufficient because the maximum values of the normal forces are not exceeded.

5. LOAD-CARRYING STRUCTURES

External walls and internal load-carrying structures are made of standard brick blocks placed on lime-cement mortar. A reinforced concrete ring beam was cast in site on the brick structure. The ring beam reinforces the brick structure of the building. Above windows, the ring beam is replaced with cast-in-situ head pieces. The head pieces transfer the load from trusses in the load-carrying steel structure of the roof.

In places without load-carrying walls, steel columns are used instead of the brick construction. The load-carrying steel structures are anchored into concrete by means chemical anchors which are applied into predrilled holes. Base plates and top plates are placed in cement mortar and anchored with bolts. Thanks to bolt connection between the steel
elements, dilation and rectification is possible – this compensates excessive uneven subsidence of landscape by undermining [2].

In places with dilatation joints, there are oval holes in steel elements and trapezoid sheets. The steel structure was made from steel S235, JR G2 (dead-melted steel) pursuant to EN 10025-2, „B“ class pursuant to ČSN 73 2601.

In order to reduce the state of stress caused by the undermining, the sliding joints from meltable insulate belts were used in the construction of facilities within the gold course. They include [12], [13], [14], [16], [32]. The design, static solution and assessment of the state of stress of the structures were based on requirements of the standards [2] to [5], derived numerical methods [6] to [12], [18] to [21] and results of laboratory tests of materials used in the sliding joints conducted by the Department of Structures in the Faculty of Civil Engineering in VSB – Technical University of Ostrava [13] to [17].

There were several reasons for choosing the green roof. The undermining results in movements of the dilatation units. If fragile materials – such as ceramic or concrete tiles – were used, damage to the roof cladding might occur. Thanks to the green roof, the structure possesses very good acoustic and thermal properties. Last but not least, it is attractive, considering the purpose and nature of the golf course. The proposed green roof improves general reclamation of the territory which had suffered from mining subsistence as it is clear from the attached photos. The construction of the Golf Club Lipiny was awarded the Special Environment Prize in the competition for the best construction in the Moravian-Silesian Region in 2011.

6. CONSTRUCTION OF A GREEN ROOF

For attractive appearance of the construction and sensitive harmony with the reclaimed landscape, it was decided to use a green roof. Steel frame girders are installed on the reinforced concrete ring beam and steel skeleton. The frame girder carry the load of the roof. The green roof cladding consists of a moisture stop, heat insulation, a waterproof foil, an inclined layer, a drainage layer and a humus layer with grass turfs.

7. CONCLUSION

Construction of a golf course is among solutions which improve attractiveness of the reclaimed territory which has suffered from extreme impacts of undermining [1], [22], [23], [24], [29], [30]. The reclaimed landscape meets now requirements set forth for reclaimed territory in the Mining Act No. 44/1988 Coll., on protection and use of raw materials [1]. The territory which would not be otherwise used, is now utilised as a sports centre for sports and leisure times activities for people living in this region.

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References:

[1] Zákon č. 44/1988 Sb., o ochraně a využití nerostných bohatství (horní zákon), v platném znění, Parlament České republiky, 2012 (Act No. 44/1988 Coll. on protection and use of raw materials, the Mining Act, as amended)


