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GEOTECHNICAL ASPECTS OF REVITALISATION OF POST-MINING AREAS – AN EXAMPLE OF THE ADAPTATION OF KATOWICE HARD COAL MINE FOR THE NEW SILESIA MUSEUM**GEOTECHNICZNE ASPEKTY REWITALIZACJI TERENÓW POGÓRNICZYCH – PRZYKŁAD ADAPTACJI KWK „KATOWICE” NA NOWE MUZEUM ŚLĄSKIE**

The article presents the history of the Katowice Hard Coal Mine and the concept of revitalisation taking into consideration the historical development of the mine which today is closed. The concept accepted for realisation assumes adaptation of the post-mining area with its historical infrastructure for cultural functions, and namely for the construction of the New Silesian Museum. Basing the concept on the idea of minimum interference into the existing spatial layout of the former mine has had the result that the museum areas and garages have been designed under the surface of the area adjacent to the historic facilities of the mine. In relation therewith, it was necessary to carry out the works aimed at reinforcing foundations of the historic buildings and protecting the geotechnical pit slopes. The article presents the technological solutions applied to protect the historic buildings, the lift tower, and the excavations for new facilities of the Silesian Museum. Attention was drawn to the instability of the subsoil and of the rock mass due to previous mining operations conducted in the area, the need to adapt the protection technology to the existing conditions as well as the need of constant monitoring of geotechnical works underway.

It is emphasised that the presented investment is part of an ongoing process aimed at preserving the industrial part of the material cultural heritage of Upper Silesia, for centuries connected with hard coal mining and as such it stands a chance to become a showcase not only for Katowice but for the entire region of Silesia.

Keywords: post-mining area, revitalisation, industrial heritage, geotechnical protection, New Silesian Museum

W artykule przedstawiono historię Kopalni Węgla Kamiennego „Katowice” oraz koncepcję rewitalizacji uwzględniającą historyczną zabudowę nieczynnej już dziś kopalni. Przyjęta do realizacji koncepcja zakłada przystosowanie pogórniczego terenu wraz z zabytkową infrastrukturą dla funkcji kulturowych, a mianowicie budowy Nowego Muzeum Śląskiego. Siedziba Nowego Muzeum Śląskiego lokalizowana

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jest w południowej części terenu dawnej Kopalni „Katowice”, na którym znajdują się zabytkowe obiekty przeznaczone do odrestaurowania i adaptacji dla nowych funkcji. Są to:

- budynek maszyny wyciągowej Szybu „Warszawa” (MS-8), adaptowany dla celów gastronomicznych,
- magazyn odzieżowy (MS-15), adaptowany dla celów wystawienniczych – Centrum Scenografii Polskiej,
- wieża wyciągowa Szybu „Warszawa” (MS-79), adaptowana dla funkcji widokowych.

Pozostała część terenu dawnej KWK „Katowice” wraz zabytkowymi obiektami, w miarę możliwości finansowych włączana będzie w kompleks Muzeum Śląskiego.

Oparcie koncepcji na idei minimalnej ingerencji w urbanistyczny układ zabytkowej kopalni, a jednocześnie potrzeba zapewnienia odpowiednich przestrzeni wystawienniczych, administracyjnych i miejsc postojowych znalazły odzwierciedlenie w zastosowaniu następujących rozwiązań:

- adaptacji historycznych obiektów dla funkcji wystawienniczych, gastronomicznych i widokowych;
- ulokowania nowobudowanych obiektów pod powierzchnią terenu w bezpośrednim sąsiedztwie zabytkowych obiektów.

W związku z powyższym koniecznym było wykonanie prac wzmacniających posadowienie historycznych budynków oraz geotechnicznych zabezpieczeń skarp wykopu. W artykule pokazano technologiczne rozwiązania jakie zastosowano dla zabezpieczenia zabytkowych budynków, wieży wyciągowej oraz wykopu pod nowe obiekty Muzeum Śląskiego.

Geotechniczne metody zabezpieczenia poszczególnych obiektów zaprojektowano na podstawie rozpoznania warunków geologiczno-inżynierskich oraz wykonanych analiz, co pozwoliło na zaproponowanie rozwiązań optymalnych zarówno pod względem technicznym jak i ekonomicznym. Z uwagi na skomplikowane uwarunkowania geotechniczne i wartość obiektów znajdujących się w strefie oddziaływania wykopu, przewidziano zastosowanie technologii pozwalającej uzyskać efekt maksymalnego wzmocnienia wglębnego masywu.

Zaprojektowane technologie zabezpieczenia mają na celu:

- wzmocnienie posadowienia zabytkowych obiektów i przeniesienie obciążeń na grunt poniżej dna wykopu;
- umożliwienie wykonania wewnętrznego poziomu -1 poprzez pogłębienie części budynku maszynowni (MS-8) o jeden poziom;
- zabezpieczenie geotechniczne ścian wykopu w rejonie historycznych budynków,
- zapewnienie bezpieczeństwa pracy przez okres realizacji podziemnych części Nowego Muzeum Śląskiego jak również funkcjonowania obiektu po zakończeniu procesu rewitalizacji – konstrukcje oporowe przy budynku magazynu odzieży MS-15 i wieży wyciągowej MS-79 będą pełniły rolę docelowych ścian segmentów podziemnych.

W artykule zwrócono uwagę na zróżnicowaną budowę geologiczną w rejonie inwestycji, różne obciążenie naziomu, a przede wszystkim na niepewność podłoża i masywu ze względu na wcześniej prowadzone roboty górnicze. Prowadzona przez 176 lat podziemna eksploatacja złóż węgla kamiennego spowodowała osłabienie masywu poprzez m.in. występowanie wkladek węgla kamiennego i stref uskokowych oraz prawdopodobnie starych zrobów.

W zależności od rodzaju obiektu będącego przedmiotem zabezpieczenia, jak również konieczności dostosowania technologii zabezpieczenia do zastanych warunków zastosowano kilka rodzajów konstrukcji takich jak palisady czy też bariery mikropalowe stabilizowane kotwiami lub gwoździami.

Z uwagi na charakter prac zabezpieczających, dokładność rozpoznania geologiczno-inżynierskiego oraz skalę zadania, projekt zabezpieczeń geotechnicznych miał charakter aktywny. Oznacza to, że rozwiązanie projektowe dostosowywano na bieżąco do faktycznie napotkanych warunków geologicznych. Ponadto podczas realizacji wszystkich prac zabezpieczających wykonywany był monitoring geotechniczny. Ze względu na zabytkowy charakter obiektów sąsiadujących z wykopem konieczny był również monitoring ich konstrukcji.

Przedsięwzięcie realizowane jest przy wsparciu Europejskiego Funduszu Rozwoju Regionalnego w ramach Regionalnego Programu Operacyjnego Województwa Śląskiego na lata 2007-2013 oraz środków Ministra Kultury i Dziedzictwa Narodowego. Zakończenie realizacji planuje się na 2013 r.

Wartością dodaną opisanego przedsięwzięcia jest fakt ulokowania nowej siedziby Muzeum Śląskiego na terenie dawnej Kopalni „Katowice”. Zabytkowa zabudowa dawnej Kopalni sama w sobie tworzy „żywe muzeum” górnictwa węglowego. Poza ekspozycjami związanymi z malarstwem, rzeźbą itp., w muzeum planuje się prezentować również przemysłowe dziedzictwo kulturowe Górnego Śląska. Rozpoczęto już gromadzenie eksponatów. Dlatego w artykule podkreślono, że opisana inwestycja wpisuje się w działania na rzecz zachowania przemysłowej części materialnego dziedzictwa kulturowego Górnego Śląska, od wieków związanego górnictwem węgla kamiennego i ma szansę stać się wizytówką nie tylko Katowic, ale i regionu śląskiego.

Słowa kluczowe: teren pogórnicy, rewitalizacja, dziedzictwo przemysłowe, geotechniczne zabezpieczenia, Nowe Muzeum Śląskie

1. Introduction

The first big scale attempts to reclaim and revitalise post-industrial areas in Upper Silesia consisted in setting up city parks on the areas recovered after dismantling the industrial infrastructure. One such example is Südpark City Park (presently Kościuszko Park), set up on the area of Beata Mine which closed down at the end of the 19th century and which today constitutes the biggest and the most valuable composed green area in Katowice (c. 51 ha). The only relic from the times of the mine's operation is a pond, located in the northern part of the park, created on the site of the former mine reservoir (*Local revitalisation programme...*, 2010). Another example comes from the Wojewódzki Park Kultury i Wypoczynku [Provincial Park of Culture and Leisure] established in the 1950s and 1960s to cover post-mining and post-industrial areas of three cities: Katowice, Chorzów, and Siemianowice Śląskie (630 ha) which perfectly combines sport, leisure, and educational functions with an abundance of natural and composed verdure. This initiative was hailed a sensation on the European scale and it is the only one of its kind in Poland so far.

The listed examples of revitalisation reflected the needs of the population of Upper Silesia – a region with a high concentration of industry, mainly mining and steel industry. Demolition of former industrial plants was first and foremost caused by the desire to eliminate sources of pollution which had contributed to the region's negative image whereas the creation of parks was meant as a compensation for green areas devoured by encroachment of industry and accompanying urbanisation processes. Despite the fact that such an approach must be deemed correct while the sheer scale of the ventures commands nothing short of recognition, it nonetheless remains a fact that they have contributed to the impoverishment of the part of Silesia's history inseparably connected with heavy industry.

However, a different approach to historical industrial resources has been observed for many years. It is manifested in the increasing number of projects involving the adaptation of the industrial heritage. Municipal and regional authorities are aware that protection and adaptation of former industrial sites is decisive for their identity and competitive advantage. Industrial areas building their future on the basis of their industrial heritage, such as the German Ruhr Area or England's Cornwall and West Devon provide models to be followed. This is also happening in Upper Silesia as more and more interesting projects making use of post-industrial infrastructure begin to appear in the region. The Silesian Industrial Monuments Route is the region's showcase in this respect. The Route features 36 post-industrial and engineering facilities of exceptional historical, artistic, and tourist value.

Revitalisation of the area of the former Katowice Hard Coal Mine with the view to its adaptation for cultural functions, and namely the seat of the New Silesian Museum, fits into the trend of similar projects. The venture is difficult and complex. Not only does it assume the adaptation of historic objects for new public functions, but also the construction of new facilities in their immediate vicinity and underground. This entails the necessity to carry out numerous studies and analyses aimed at:

- Assessing the historic value of listed buildings with a focus on the possibilities of their adaptation for public use,
- Identifying the floor on the post-mining areas in order to assess the possibility of constructing foundations for new objects,
- Developing appropriate technologies for securing both the structure of the historic buildings as well as the floor or slopes of excavations for new buildings under construction, thereby guaranteeing safety of work and later operation of the facilities.

The mentioned aspects related to the adaptation and securing of the historic elements of the mine infrastructure constitute the subject and the content of the present article.

2. The history of Katowice Hard Coal Mine and the present status of the post-mining area

2.1. Location

The area of the former Katowice Hard Coal Mine is located in the central part of the City of Katowice, at Kopalniana Street in close proximity to the Rynek [Market Square] (fig. 1). It is well connected to the surrounding areas thanks to both existing and planned communication routes and enjoys the advantages of being located next to the city's main communication artery – Walentego Rożdzieńskiego Ave.



Fig. 1. Location of the former Katowice Hard Coal Mine (based on: maps.google.pl, Wikipedia)

2.2. History of Katowice Hard Coal Mine

Katowice Hard Coal Mine was established in Bogucice in 1823 by a grant of the Higher Mining Office in Brzeg, later approved by the higher mining authorities in Berlin. Extraction operations were launched the same year. Initially, to the mine employed specialists and professionals recruited from Wałbrzych Basin, Westphalia, Olkusz, and Wieliczka.

Until 1936, the Mine bore the name of Ferdynand after its initiator and one of its first owners, Ignacy Ferdinand Beym. During the 176 years of the Mine's history, both the ownership and the name of the mine underwent changes. In 1839, the last owner of the estate of Mysłowice, Aleksander Mieroszewski, sold the Mine to Maria Wincklerowa. In 1889, Katowicka Spółka Akcyjna dla Górnictwa i Hutnictwa [Katowice Joint-Stock Company for Mining and Steelworks] was established which owned the Mine until the end of World War I. Since 1922, the Polish name of Ferdynand was used while in 1936 the Mine was renamed as the Katowice Hard Coal Mine and became part of the Wspólnota Interesów Górniczo-Hutniczych [Community of Mining and Metallurgy Interests], an enterprise with majority Polish stock a year later. During the Nazi occupation, it was incorporated into the Herman Göring Concern under its original name of Ferdinand. During this time the underground Komitet Ochrony Kopalni [Mine Protection Committee] operated in the plant while its director saved the mine from being blown up by retreating German forces. After the war, the Mine was nationalised, and was again named the Katowice Hard Coal Mine, which was the case right up until the end of the Mine's operation with the exception of the period from 1953 until 1956 when it was named Stalinogród, just like the city where it was located.

In 1875, the mine was flooded while the extraction operations were launched again a year later after substantial modernisation works. Since the 1890s, the surface development of the Mine was rendered in the the 19th century Neo-Gothic and Art Nouveau style; earlier facilities were not preserved. The mine expanded on a continuous basis, incorporating adjacent coalfields; unfortunately, however, the process which entailed extending the surface infrastructure did not always adopt the architectural form of the original facilities. In 1993, Katowice Hard Coal Mine was incorporated into the Katowicki Holding Węglowy S.A. In 1996, Katowice Hard Coal Mine merged with Kleofas Hard Coal Mine, a part of which was converted into the Silesia City Center shopping and entertainment centre.

In its 176 years of operation, Katowice Mine extracted a total of 120 million tonnes of coal. The mine was officially closed down in 1999¹.

2.3. Present status of the post-mining area

The failure to secure the post-mining area in the first years after the closure of Katowice Mine resulted in the devastation of the facilities, first and foremost on account of theft of steel and cast iron elements. In 2001, 86 surface facilities were demolished. Despite the devastation and additions which distorted the original architectonic form of certain facilities, the existing mine buildings are of high historical and architectonic value. This fact was instrumental in preserving the mine and extending legal protection over, which was confirmed by appropriate amendments to the local land use plan as well as the entry of the following facilities into the register of historic monuments (*National Heritage Board...*, 2011 a,b):

¹ Information from Silesian Museum, 2012.

- Bartosz Shaft complex (fig. 2) with the lift machinery room (1881-1883) with a steel construction lift tower (1900); the engine house (1893-1895) with preserved steam engine (1892); and a power station building with the compressor hall (1893-1895) – register of historic monuments (A/16/99 and B/6/99),
- supervision and Gwarek bath,
- mechanical, electricians', borers' and joiners' workshops,
- smithy and water tower,
- leatherworker's house and clothing warehouse,
- Warszawa Shaft lift tower and engine house.

Three of the mentioned facilities, i.e. the clothing warehouse, the lift tower, and the Warszawa Shaft engine house will be adapted to house the Silesian Museum. The remaining facilities need to be temporarily secured and undergo thorough restoration and renovation in the future.

Detailed geotechnical documentation of the ground is critical for the correct foundation of post-mining facilities as well as new buildings erected for the purpose of adapting the immediate



Fig. 2. Bartosz Shaft Development Complex with the lift tower (Photo by: A. Ostreġa)

surroundings to new uses. Ground condition tests for this area indicated favourable groundwater conditions. However, made soils complicate construction works since they are not suitable for subsoil of structures foundation on account of their varied composition, including the presence of culm which is poses an ignition threat in addition to its changeable bearing capacity and undefined compressibility. Another considerable threat could come from old goafs and openings remaining after mining operations, which can lead to the formation of non-continuous deformations on the surface, are another considerable threat which needs to be thoroughly analysed.

The geotechnical assessment of the floor provided the basis for the formulation of the guidelines for implementation of the construction design and protection works as well as for the determination of the degree of risk for the planned investment in connection with the mining operations. The southern part of the area of the former Katowice Mine was indicated as best-suited for the construction of new facilities.

As a result of a 2004 settlement between the Silesia Province, Katowicki Holding Węglowy S.A., Spółka Restrukturyzacji Kopalń S.A. [Mine Restructuring Company JSC] in Katowice, and the Silesian Museum, the area of the former Katowice Hard Coal Mine was entrusted to the Silesian Museum and a year later it was allocated for the construction of the new site. This decision was of substantial significance in the context of protecting and maintaining historic objects since entrusting this area to a museum will be the best guarantee of its protection and preservation.

3. The construction concept of the New Silesian Museum on the area of former Katowice Hard Coal Mine

The site of the New Silesian Museum is presently under construction in the southern part of the previously described post-mining area in which historical objects designated for restoration and adaptation to new functions are located. They are²:

- Warszawa Shaft lift engine house (MS-8), to be adapted for catering purposes,
- Clothing warehouse (MS-15), to be adapted for exhibition purposes – Centrum Scenografii Polskiej [Polish Stage Design Centre],
- Warszawa Shaft lift tower (MS-79), to be adapted for panoramic purposes.

The remaining part of the area of the former Katowice Hard Coal Mine will be included within the Silesian Museum complex, subject to availability of funds.

The concept adopted for realisation refers to the industrial history of Silesia and the primary function of the area, and involves minimum interference with the existing urban layout of the former mine. In relation thereto, the new facilities under construction have been located in the vicinity of historical facilities whereby the majority of the levels is located underground, with only the glazed body of the administrative, communication and technical utility buildings visible outside. The new objects under construction have been designed to house³:

- The new Main Building of the Silesian Museum consisting of an exhibition and auxiliary part and a conference and office section;
- The Main Hall of the Museum Quarter consisting of an exhibition and auxiliary area;
- Underground car park with 232 parking spaces and a supplies delivery zone.

The surrounding area will be made into a city park open to the general public and connected with the area of the Bogucicki Park located on the eastern side of the Museum area⁴. The concept is presented in Figures 3 and 4.

The fact of locating the new site of the Silesian Museum on the area of the former Katowice Mine represents the added value of the described venture. The historic development of the former Mine itself creates “a living museum” of coal mining. Apart from exhibitions related to painting,

² Information from Riegler Riewe Architekten ZT-Ges.m.b.H, 2012.

³ As above.

⁴ As above.



Fig. 3. The architectonic concept of the new location of the Silesian Museum – cross-section
(Source: Riegler Riewe Architekten ZT-Ges.m.b.H)

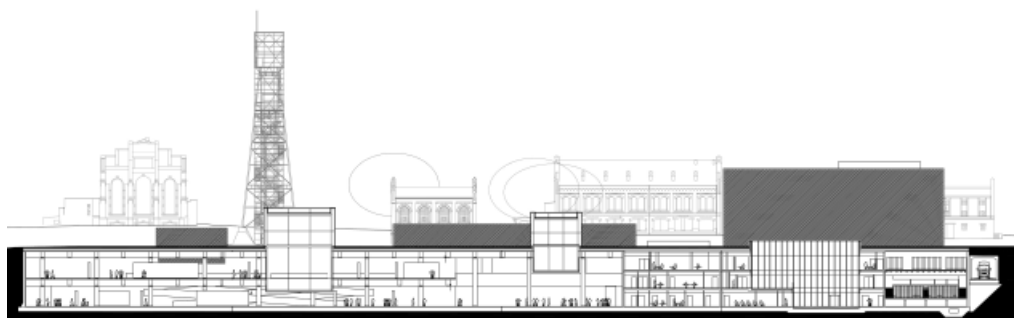


Fig. 4. The architectonic concept of the new site of the Silesian Museum – cross-section
(Source: Riegler Riewe Architekten ZT-Ges.m.b.H)

sculpture, etc. the museum plans to present the industrial and cultural heritage of Upper Silesia. The process of building the collection is already underway.

The value of the entire project exceeds PLN 324 million. The project found its way onto the list of projects of regional significance to be completed with the support of EU funds within the framework of the Regional Operational Programme for the years 2007-2013 and it obtained subsidies in the amount exceeding PLN 225 million. The project also obtained a subsidy to cover its own contribution from the funds of the Minister of Culture and National Heritage in the amount of PLN 2.3 million. The completion of the project is planned for the year 2013⁵.

⁵ Information from Silesian Museum, 2012

4. Technologies for securing the historic buildings of the mine and excavations in connection with the construction of the underground section of the Silesian Museum

The idea of minimum interference in the urban layout of the historic mine contained in the concept and at the same time the need to guarantee adequate exhibition and administrative areas as well as parking sites are reflected in the application of the following solutions (fig. 5):

- Adaptation of historic objects for exhibition, catering, and panoramic functions;
- Location of the objects to be constructed under the surface of the area directly adjacent to the historic objects.



Fig. 5. The excavation and historic facilities of the former Katowice Hard Coal Mine, from the left: the lift tower and engine house of the Warszawa Shaft, bath, clothing warehouse – only the safety installation is visible here – the status as in June 2012 (Photo by: A. Ostreġa)

The adopted solutions entail the necessity to design appropriate safety installations for the historic buildings as well as those aimed at ensuring the stability of the walls of the excavation for the museum buildings under construction. Two-dimensional and sometimes three-dimensional slope stability analyses might be necessary in such cases (Cała, 2007). The geotechnical methods for securing individual facilities have been designed based on the identification of the geological and engineering conditions and conducted analyses which have made it possible to

offer optimum solutions both in technological and economic terms. Because of the complicated geotechnical conditions and the value of the historical buildings located in the excavation impact zone, technology which ensures a maximum deep reinforcement of the rock mass is applied.

The safety technologies developed are designed to (Rysiewicz et al., 2011 a-d):

- Reinforce the foundations of the historic buildings and transfer the load to the soil below the excavation floor;
- Render possible the construction of the internal level –1 by deepening a part of the engine house building (MS-8) by one level;
- Ensure geotechnical safety of the excavation walls in the area of the historic buildings,
- Ensure occupational safety over the period of realisation of the underground sections of the New Silesian Museum as well as the building's operational safety after the completion of the revitalisation works – retaining structures at the MS-15 clothing warehouse building and the MS-79 tower lift will play the role of target walls of the underground segments.

4.1. Technology for securing the excavation walls and historical buildings

In order to secure the walls of the excavation adjacent to the MS-8 engine house a steel reinforced anchored palisade was applied (fig. 6). Additionally, inside the MS-8 building, due to its deepening, the second palisade made with grouting micropile allowing for the construction of the elevator shaft and tunnel to a new underground segment in the excavation, at the same acting as the stay-in-place formwork for its walls, was made. In order to ensure the safety of the building's construction and to relieve the excavation walls adjacent directly to the walls of the building, the walls were reinforced with the use of grouting micropiles. Cavilling the foundations with micropiles also ensured the safety of the historic MS-8 building during the deepening works (Rysiewicz et al., 2011 a).

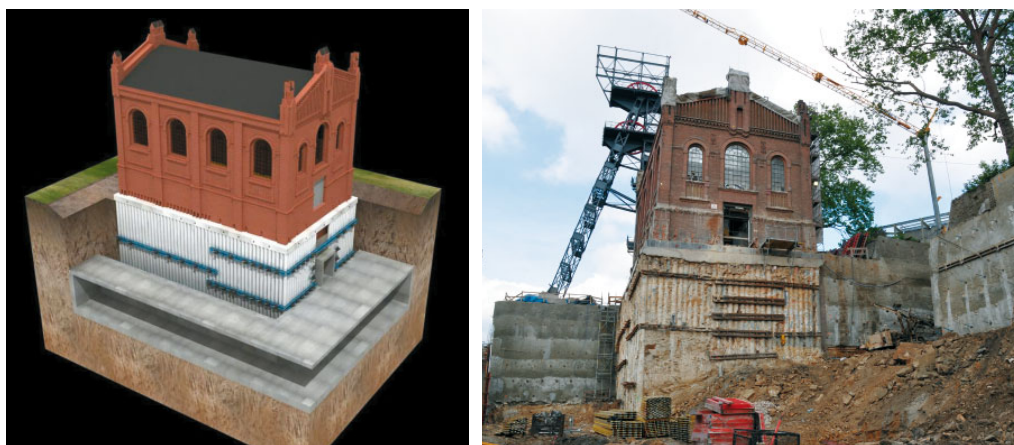


Fig. 6. Securing of the MS-8 engine house of the Warszawa Shaft, left – visualisation (Source: TITAN POLSKA Ltd), right – status as of June 2012 (Photo by: A. Ostreġa)

A similar construction was used in the case of the MS-15 clothing warehouse, the western wall of which was reinforced with grouting micropiles while an anchored palisade was used to secure the excavation (fig. 7). To the south, due to the complicated layout of geotechnical strata, a crossing fault zone, and probability of occurrence of old goafs, an anchored micropile barrier was used (Rysiewicz et al., 2011 b).

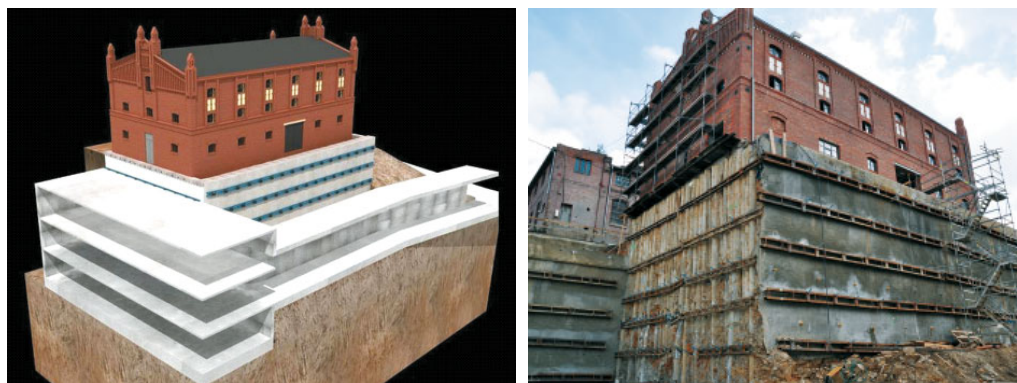


Fig. 7. Securing of the MS-15 clothing warehouse, left – visualisation (Source: TITAN POLSKA Ltd), right – status as of June 2012 (Photo by: A. Ostreġa)

4.2. Technology for securing the lift tower

Another facility located on the area of the Silesian Museum which needs to be secured is the Warszawa Shaft lift tower designed as a panoramic platform. The failure-free operation of the lift tower both during the construction and the operational stage is guaranteed by a system of grouting micropiles selected in such a manner as to ensure stability of the support-micropiles system and to minimise and compensate for potential subsidence resulting from the weight put on the tower. To ensure the stability of the excavation wall adjusted to the lift tower and to secure the facing, a threaded construction is used which will simultaneously act as an external wall of the Museum building under construction (Rysiewicz et al., 2011c).

To effectively secure against the effects of surface stability loss and considering the geotechnical conditions within individual zones, increased overburden load, and the permanent nature of the slope stabilisation in the lift tower zone, stiff facing with shotcrete was used for the designed nailing construction (Rysiewicz et al., 2011c) (fig. 8).

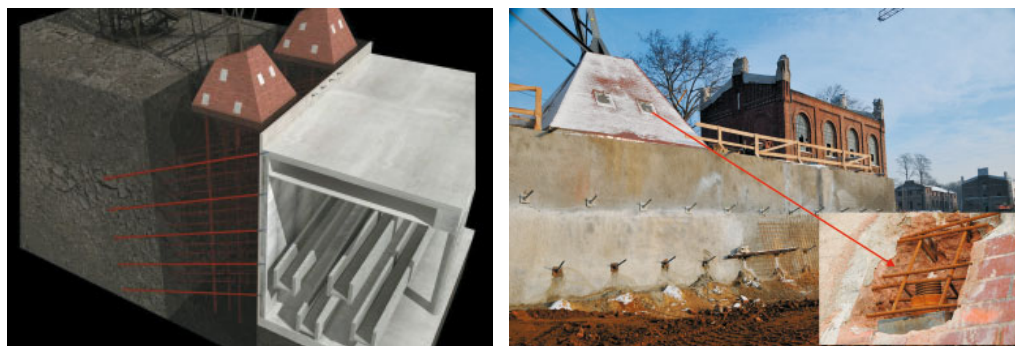


Fig. 8. Securing of the MS-79 Warszawa Shaft lift tower, left – visualisation
 (Source: TITAN POLSKA Ltd), right – status as of December 2011 (Photos by: TITAN POLSKA Ltd)

4.3. Technology for securing the land mass in the area of historic buildings

The underground levels of the new site of the Silesian Museum were executed in the traditional technology of an underground excavation whereby the maximum depth of the excavation was 16.70 m. In relation therewith, it was necessary to design comprehensive geotechnical securing of the excavation walls. The technology for securing the excavation must guarantee the stability of temporary escarpments, protection of the existing buildings, occupational safety throughout the entire period during the construction of the underground sections, and operational safety of the construction (by minimising the earth pressure) during exploitation. Owing to the varied geological structure in the investment area, varied overburden load, and the fact that the investment is carried out where hard coal was once extracted, which in turn means that the rock mass is weakened by occurrence of hard coal inserts and fault zones and probably old goafs, several types of constructions were used.

Threading technology was adopted as the basic approach for securing the walls of the excavation. The technology involves the execution of a deep reinforcement in the form of self-drilling soil nails with the length and bearing capacity selected on the basis of calculations. The nail layout cooperates with the surface casing system adjusted to the type and condition of the land mass of which the escarpment consists (steel mesh or shotcrete).

In the zones of particularly unfavourable geological and engineering conditions, where potential excessive land mass shifts would result in specific risks for the already existing buildings, a system of anchored micropile barriers was introduced. These barriers were executed along the buildings of the baths, MS15 clothing warehouse, and the joiners' workshop. Their task is to reinforce the deep ground reinforcement, tighten rock strata with varied strength parameters, fill in potential post-exploitation voids, stop destruction processes and, in consequence, ensure the stability of the excavation walls and safety of the existing buildings.

Due to the nature of the protection works, precision of the geological-engineering site characterization, and the scale of the task, the geotechnical protection project has a flexible character. This means that the design solutions were adjusted whenever geological conditions required



Fig. 9. Land mass and bath protection system – as of June 2012 (Photo by: A. Ostreġa)

it. Moreover the process of carrying out of all the securing works was subject to geotechnical monitoring. Due to the historic character of the objects adjacent to the excavation, their structure ought to be monitored as well.

5. Conclusions

The revitalisation of the former Katowice Hard Coal Mine for the purposes of a museum follows in the footsteps of other projects which have adopted a novel approach to preserving the industrial heritage of Katowice and Upper Silesia for future generations. The venture is centered on the adaptation of historic facilities (the engine room, warehouse, and lift tower) for utility functions and construction of new exhibition areas and underground so as to preserve the appearance of the historic industrial complex. Such an approach has many advantages in the context of protecting the industrial heritage. Securing and adapting historic buildings is in and of itself a form of protection. The preserved industrial infrastructure will form a living museum of mining which shall constitute an additional attraction for art connoisseurs and is certain to attract fans of industrial tourism.

The construction of the new site of the Silesian Museum carries multiple challenges as well. The complex character of the venture follows from the fact that it is to be located in a post-mining area and because of that the area is uncertain in terms of the geotechnical characteristics of the floor and land mass. It is therefore vital that a precise investigation and identification of the

mining area takes place which will allow to determine optimum securing technologies but also to adequately react to unpredicted phenomena which may occur during the works.

The technologies for securing historic infrastructure presented in the article prove that new functions of post-mining areas need not be limited to city parks; thanks to the adaptation of the existing infrastructure and addition of new, skilfully composed infrastructure, the range of possibilities is significantly wider.

The project to construct the New Silesian Museum on a post-mining area shows that despite the complex character and unpredictability of the terrain transformed by mining operations there are solutions making it possible to realise interesting projects while at the same time protecting valuable resources of the industrial culture and identity of mining cities.

Acknowledgements

The article was written within the frames of National Science Center research project no. 18.18.100.595

References

- Cała M. 2007. *Convex and concave slope stability analysis with numerical methods*. Arch. Min. Sci., Vol. 52, No 1, p. 75-89.
- Local revitalisation program for Katowice for 2007-2013*. Annex to Resolution No. LXII/1260/10 of Katowice City Council on July 26, 2010, as amended by Resolution No. LXIII/1285/10 of Katowice City Council on August 30, 2010 (in Polish: Lokalny program rewitalizacji miasta Katowice na lata 2007-2013, Załącznik do Uchwały nr LXII/1260/10 Rady Miasta Katowice z dnia 26 lipca 2010 r. zmienionej uchwałą nr LXIII/1285/10 Rady Miasta Katowice z dnia 30 sierpnia 2010 r.).
- National Heritage Board of Poland*, 2011. The list of historic buildings entered in the register of monuments, as of December 31, 2011. The list of movable monuments entered in the register of monuments, as of December 31, 2011. (in Polish: Wykaz zabytków nieruchomych wpisanych do rejestru zabytków - stan na 31 grudnia 2011 r.; Wykaz zabytków ruchomych wpisanych do rejestru zabytków – stan na 31 grudnia 2011 r.).
- Rysiewicz M., Kowalski M., Maca N., Rzezińska B., 2011a. *Technological project for protecting the MS-8 building and the adjacent excavation*. (in Polish: Projekt technologiczny zabezpieczenia budynku MS-8 i sąsiadującego wykopu). Krakow, SOLEY Ltd. Not published.
- Rysiewicz M., Kowalski M., Maca N., Rzezińska B., 2011b. *Technological project for protecting the MS-15 building and the adjacent slopes of the excavation*. (in Polish: Projekt technologiczny zabezpieczenia budynku MS-15 i sąsiadującego wykopu). Krakow, SOLEY Ltd. Not published.
- Rysiewicz M., Kowalski M., Maca N., Rzezińska B., 2011c. *Technological project for protecting the MS-79 facility protection and the adjacent slopes of the excavation*. (in Polish: Projekt technologiczny zabezpieczenia obiektu MS-79 i skarp sąsiadującego wykopu). Krakow, SOLEY Ltd. Not published.
- Rysiewicz M., Kowalski M., Maca N., Rzezińska B., 2011d. *Technological project for protecting the rock mass in the area of the MS-15 building and joinery*. (in Polish: Projekt technologiczny zabezpieczenia górotworu w rejonie budynku MS-15 i stolarni). Krakow, SOLEY Ltd. Not published.

Received: 17 December 2012