TECHNOLOGY FOR BACKFILLING OF THE MINED-OUT AREAS WITH PASTE FILL APPLIED AT DUNDEE PRECIOUS METALS CHELOPECH

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ABSTRACT. This article covers the methods for backfilling of mined out areas with paste fill (PF), used at Dundee Precious Metals Chelopech. Described are the onsite Paste Plant; Paste Reticulation System, the paste fill control system, methods used for barricading the ramp accesses to the mined out areas (production stopes), as well as paste quality control methods. Presented are also the major paste fill parameters.

Keywords: paste plant, work parameters, barricades, quality control, samples, solid content, cement

ТЕХНОЛОГИЯ ЗА ЗАПЪЛВАНЕ НА ИЗЗЕТИТЕ ДОБИВНИ ПРОСТРАНСТВА С ПАСТОВО ЗАПЪЛНЕНИЕ, ПРИЛАГАНА В „ДЪНДИ ПРЕШЪС МЕТАЛС ЧЕЛОПЕЧ“ ЕАД

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РЕЗЮМЕ. В тази статия се разглеждат методите за запълване на иззетите добивни пространства с пастово запълнение (ПЗ), прилагани в „Дънди Прешъс Металс Челопеч" ЕАД. Описват се разположените на територията на предприятието Фабрика за пастов материал, Системата за мрежовидно разпределение на пастовия материал, системата за управление на пастовото запълване, използваните методи за преграждане на рамповия достъп до иззетите добивни площи (производствени крепежи), а също и методите за управление на качеството на пастовия материал. Представени са също и основните параметри при пастовото запълнение.

Ключови думи: фабрика за пастов материал, работтни параметри, преграждения, контрол на качеството, образци, съдържание на твърди частици, цимент

Introduction

Chelopech mine is an underground mine for mining of copper-gold ore. With the development of the mining works in depth, in 2005, the sublevel caving system was replaced by chamber-and-pillar system with backfilling.

Since the introduction of the chamber-and-pillar system of backfilling, the technology for backfilling of the mined-out areas has passed through the following stages:

Stage 1: Until 2008, ore mining was carried out through primary chambers where the sterile rock mass, generated by the driven mining workings in the mine, was temporarily stored.

Stage 2: In 2007, an installation for the production of cement milk that is used for the production of cemented rock fill (CRF) was put into operation. CRF is a mixture of cement milk and basic filler of sterile rock mass. The sterile rock is produced from the driven mining workings in the mine and the mined-out primary chambers temporarily filled with sterile rock mass. This type of backfilling was in operation till 2013 and afterwards its application was stopped.

Stage 3: 2008 saw the completion of the installation for the production of hydraulic hardening fill (HHF) at the north site of Chelopech mine. HHF is a mixture of cyclone flotation tailings from the processing factory, water and cement. From 2008 to the middle of 2010, the main backfilling of the mine was CRF and HHF.

Stage 4: The process for optimization of the surface installation was completed by September 2010 and the hydraulic fill was replaced by paste fill (PF). The paste fill is a mixture of compressed and filtrated flotation tailings with weight content of solid particles between 68% and 75.5% and binding substance - sulphate-resistant cement.

The introduction of PF aims at improving the quality of the backfilling, decreasing the quantity of the binding substance (cement) and increasing the utilisation of the waste product.

PF with a different percentage of cement is used during the backfilling process of the mined-out areas depending on the necessary parameters for sustainability of the artificial massif of backfilling. To reach the set parameters of the finished hardened product requires certain time for the cement to bind and for to acquire the necessary strength. Only after that is it possible to proceed with the next stage - the mining-out the adjacent chamber (Fig. 1 and Fig. 2).

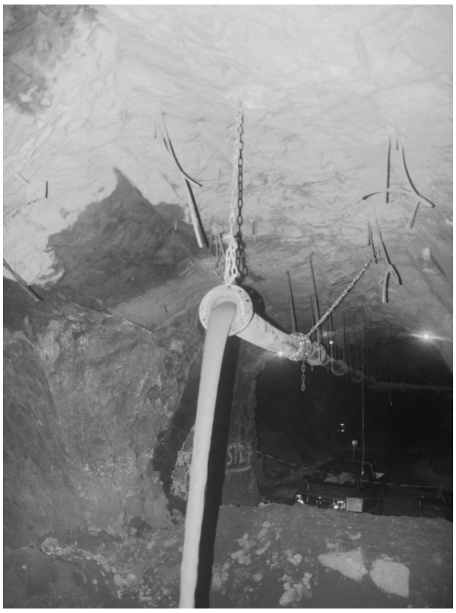


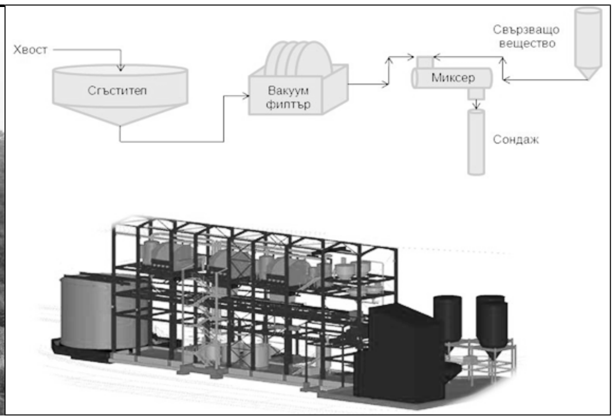
Fig.1. The process of backfilling of a chamber

Fig. 2. Surface of a chamber filled with paste fill

Installation for the production of paste fill

The after-flotation tailings from the processing factory are thickened in a cone thickener and transported via a pipeline to the installation for the production of paste fill which is situated on the north site of Chelopech mine (Fig. 3). The waste is fed into a buffer container with a volume of 1045 m^3 and has a weight content of solid particles 50%-60%.

a) Surface filling complex



b) Principle scheme of the installation for paste fill (PF)

Fig.3. Installation for the production of paste fill

Through a pipeline, the material is transported to two Bokela disc vacuum filters (Fig. 4) which de-water the mixture to about 80% content of the hard substance. Flocculant water solution is added to the tub of each vacuum filter in order to better catch the particles of the waste, to clear the waste waters, and to increase the productivity of the filters.

The dried waste is supplied by a belt conveyor (Fig. 5) to the mixer for continuous mixing (Fig. 6). The cement and the unfiltered waste are added in the mixer together with the dried waste.

The dry binding substance (in this case sulphate resistant cement, strength class 42.5) is transported to the mixer via a pipeline with compressed air. The unfiltered waste is added from the buffer container to dilute the waste to the planned content of solid particles.

Productivity and production parameters

1. ***Productivity***:
   - Daily productivity of the paste fill (m^3/day): ~2 500 m^3/day
   - Monthly productivity of the paste fill (m^3/h): ~52 500 m^3/month
   - Annual productivity of the paste fill (m^3/h): ~680 000 m^3/year
   - Mean quantity of the sulphate resistant cement (t/year): ~40 000 t/year
   - Total flotation tailings generated by the factory (t): ~1 900 000 t
   - Total flotation tailings used for backfilling (t): ~800 000 t/year, which is 40% from the overall waste.

Fig. 4. Disc vacuum filter

Fig. 5. Belt conveyor for supplying the filtered waste

Fig. 6. Mixer for mixing the filtered waste, dry cement, and unfiltered waste

2. ***Production parameters:***

The parameters for backfilling of each chamber are described in the detailed design on the basis of tested recipes, ensuring the necessary strength parameters of the hardened filling material, and respectively, the non-problematic and safe future mining-out of the adjacent secondary stalls.

- Targeted pack compression of the ready product – maximum 240 mm;
- Level of the material in the borehole/boreholes: 230 – 250 m;
- Content of the solid particles in the borehole (%):
  - Minimum: ≥ 68%;
  - Targeted: 75.5%
- Content of the cement (%): *2% ÷ 8%.* [1]

[1] The cement content in the paste fill is different for each chamber and is determined on the basis of the width, length and height of the uncovered surface of the fill from the adjacent secondary stall.

System for transportation of the fill to the mined out areas

The system for transportation of the fill consists of two inclined boreholes driven from the surface to level 448 underground, a pipeline installation along the main haulage tunnels and preparatory cuts, and short boreholes between the separate sublevels.

The wellheads on the surface are situated immediately next to the surface installation for the preparation of the filling material and have a length of 300 m and a diameter of 300 mm. They are cased with metal and polyurethane pipes. The polyurethane pipes are with an external diameter of 225 mm and an internal diameter of 134.8 mm.

The pipeline installation along the main mining workings is implemented via 8” metal pipes, mounted on the ceiling of the workings (Fig. 7). The pipeline installation along the preparatory cuts to the chambers is via 10” polyurethane pipes for high pressure.

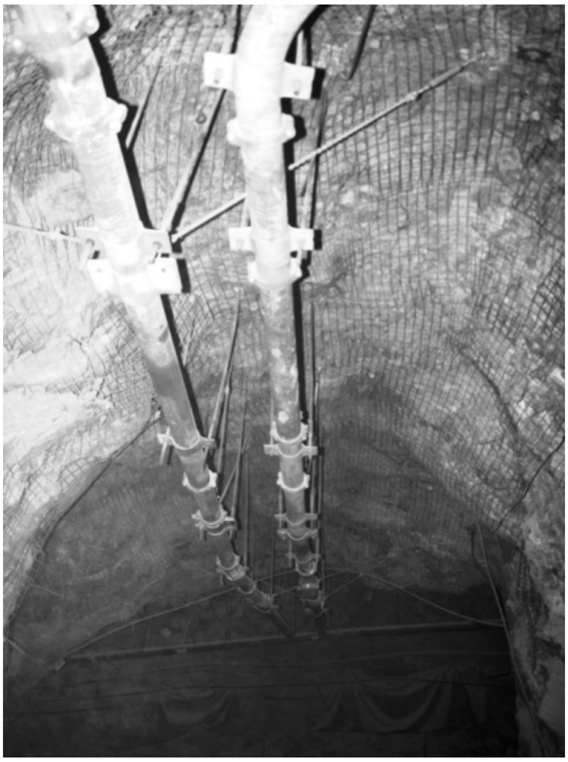


Fig.7. Metal pipeline for the supply of paste fill

Control and management system of the filling process

All available tools and functions for the management of the paste fill are ensured by the SCADA software system for process management. The operator monitors, controls and manages the filling process of the pit chambers from the control room.

SCADA provides for:

- Remote start and stop, as well as for emergency stopping.
- Visualisation of the paste fill cycle on a display;
- Visualisation of the planned and real parameters of the filling;
- Monitoring of the state of the electrical engines, including the indications for failures;
- Archiving the data for the backfilling.

Barricades

The barricades are used for closing the ramp accesses to the empty space in the mined-out areas in order to prevent spilling of the paste fill on the underground infrastructure of the pit. The barricades are built from reinforced net and shotcrete with a width of 300mm ÷ 500mm and strengthened with fibers.

The barricades (Fig. 9) are constructed in each entry that has been cut off for access to the chamber and that has to be filled in; they are situated on the lower and intermediate horizons. The detailed design for filling of each chamber with paste fill contains information about the type, parameters, and location of the barricades.

Quality control of the paste fill

1. Stability of the rock mass from hardening paste fill when mining out adjacent chamber/s

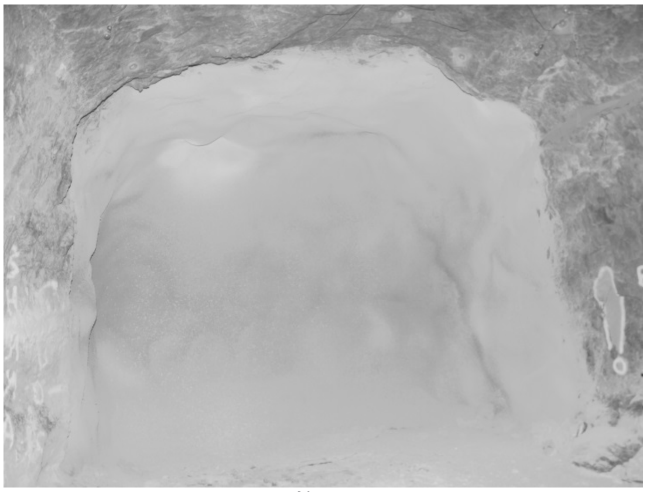
The artificial monolith mass of hardening paste fill should guarantee the overall stability in order to be able to withstand sufficient loads and to remain stable in the presence of free open space during the further mining-out of the adjacent stalls (Stefanov, Dr., 1993).

The necessary targeted strength of the paste fill is defined through computer modelling done by Revel Resources PTY LTD which is reflected in the technical report Chelopech Mining Paste Fill Exposure Stability Analysis (2011).

Preliminary assessment of the necessary stability of the artificial mass according to its open area is prepared for each chamber to be filled in (Fig. 10). This assessment takes into consideration:

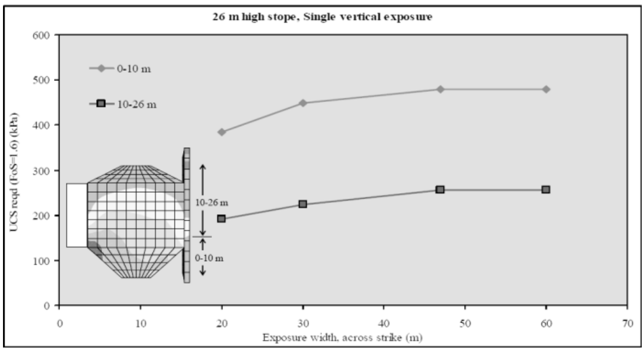
- The height of the open area of the artificial mass of filling.
- The width of the open area of the artificial mass of filling.
- The length of the open area of the artificial mass of filling.

a)



b)

Fig.9: a) Barricade in the process of sprinkling with shotcrete; b) Completed barricade



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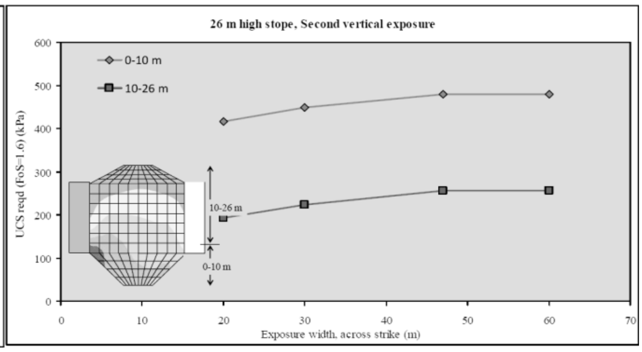

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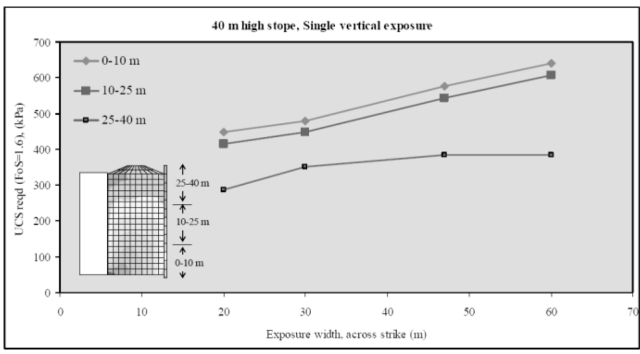

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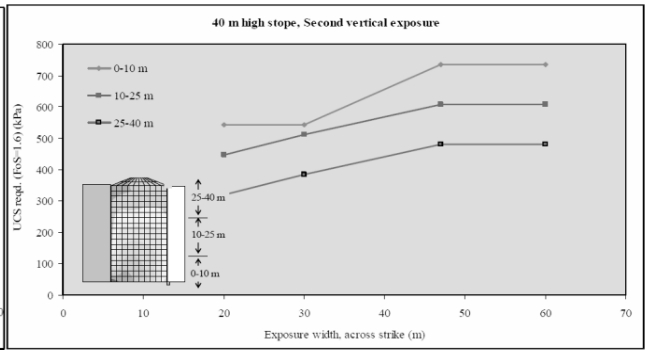

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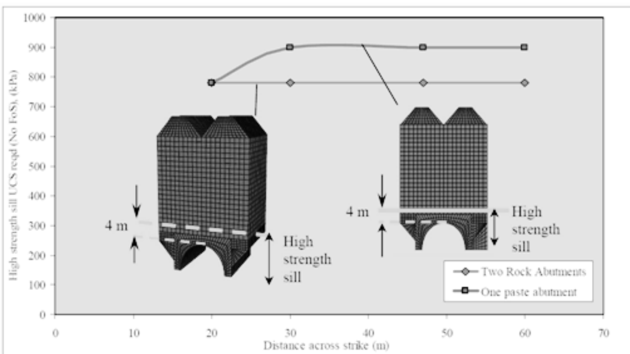

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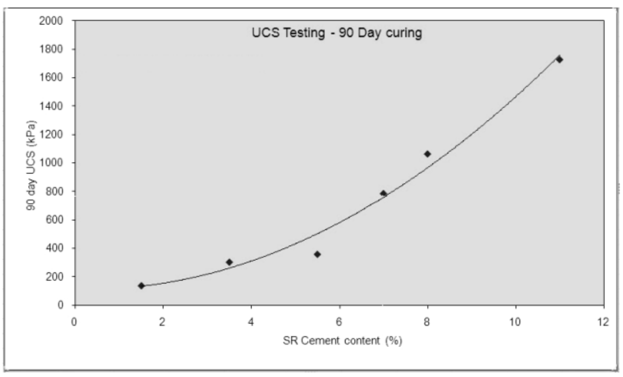

f)

Fig.10: a), c) – Targeted strength of the fill in case of one vertical open area; b), d) - Targeted strength of the fill in case of two vertical open areas; e) Targeted strength of uniaxial pressure (UP) of the PF with an open area at the base of the chamber; f) Graph for defining the percentage of the cement content

2. Sampling of the fill and strength tests

A local database has been collected on the behavior of the artificial pillars from hardening fill for the specific conditions.

In order to define the quality of the fill, samples are taken in plastic cylindrical containers with dimensions width/length – 100/200mm. The samples are taken from the installation for paste fill at the point of backfilling immediately after the mixer. The samples mature in special containers which maintain constant temperature and humidity to maximally resemble the conditions in the pit. The samples are left to gather strength for 7, 28, 56, 90 or 360 days respectively and after that are tested for uniaxial pressure (Fig.11).

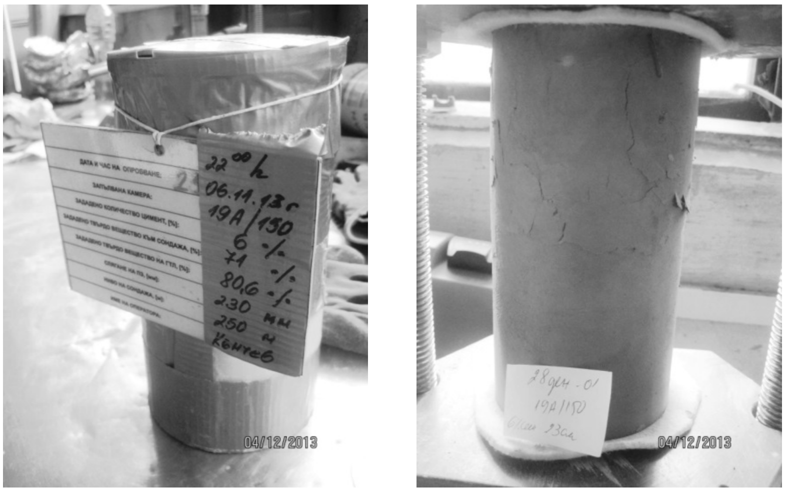

Fig.11. Sample from paste fill tested for uniaxial strength in laboratory conditions

- Each sample is taken out of its container (in laboratory conditions) and checks for disruptions are made. The state of each sample prior to the test is described.
- The height and width of each sample is measured prior to the test.
- An even load of 0.5 mm / min is applied throughout the test.
- The type of disturbance is recorded for each sample.
- The humid weight of the disturbed sample is measured after the end of the test.
- The disturbed sample is dried in a furnace for at least 24 hours at a temperature of 100°C and the dry weight it measured.
- A comparison is made between the dry and moist sample in order to define the unit weight.

The information from the samples is important and provides preliminary information about the behavior of the artificial mass at its exposed surface.

3. Defining the pack compression of the ready product

The test for defining the pack compression is an important parameter in the control programme and gives information about the quality and mobility of the fill which is supplied underground. The targeted pack compression of the ready product is between 200 mm and 240 mm and is defined in the detailed designs for the filling of the individual chambers. The Abrams cone is used for testing the paste fill for subsidence (fig.12).

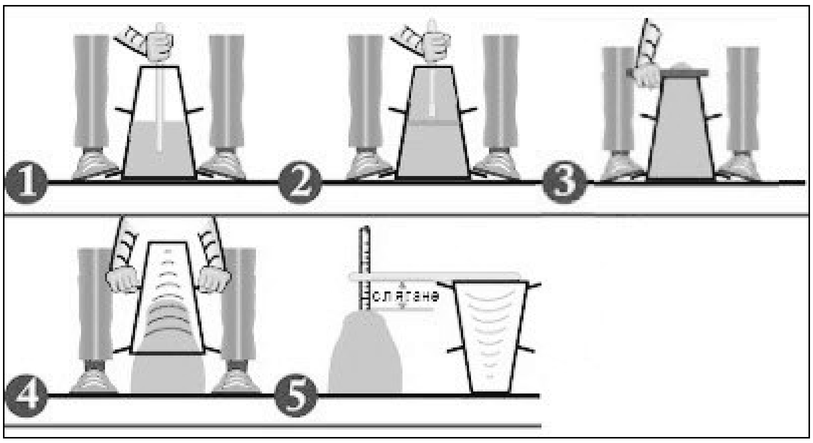

Fig.12. Defining the pack compression of the ready product using the Abrams cone

Conclusion

Backfilling is an important element for the development of the Chelopech mine and for the effective sustaining of the 2 200 000 t annual ore output. Concurrently with the backfilling of the mined-out areas in the pit, the PF should guarantee stability with regard to the various dimensions of the subsequently exposed walls of the artificial pillar formed after its hardening.

The advantages of the paste fill in comparison to the hydraulic fill are as follows:

1. Reduced quantity of the binding substance for obtaining the necessary strength of the hardened fill;
2. Lower speed of the transportation of the fill to the mined-out areas in the stalls which leads to a considerable decrease in the wearing-out of the pipeline system;
3. Shorter time for achieving early strength;
4. Smaller quantities of water generated in the water drainage system of the pit;
5. Simpler design of the barricades of the ramp accesses to the mined-out chambers;
6. Better utilisation of the waste product from the mineral processing.

Under the conditions of continuous development of the mining works in depth at the planned output of the pit, the filling of mined-out areas is a dynamic system that undergoes changes; therefore, optimisation solutions and formulations are sought that lead to safer work, continuity, stability, efficiency, economy, and flexibility of both the process and the mining technology as a whole.

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Designs, presentations and work procedures at Dundee Precious Metals Inc.

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