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Using Intermediate Buffer Temporary Warehouses Inside the Working Area of the Open Pit Mining

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Abstract: *The use of cyclical-flow technology with a multi-link transport system requires rhythmic operation of the quarry, which excludes unproductive downtime of conveyor complexes. However, the use of cars in the system of loading and transport complex, as shown by the experience of both the Krivbass and Muruntau quarries, determines a significant variation in the parameters of cargo flows. This leads to uneven cargo flow entering continuous transport, and, as a result, to a significant decrease in the design performance of complexes with a corresponding deterioration in technical and economic performance indicators. Analysis of the study of dynamic characteristics of cargo flow shows that this process is generally carried out in two modes: stationary and transient (the beginning and end of the shift and the lunch break), which indicates a significant unevenness of cargo flow during the shift. The role of rock engineering in the design and operation of deep mines is discussed in detail. Critical issues are the rock fracturing around mining excavations, the support and control of the fractured rock, and the rock mechanics design of mine infrastructure and extraction (stoping) systems. Mining-induced landslide is a man-made geohazard that has drawn increasing public attention. Studies have shown that these landslides are generally triggered by a confluence of factors including underground mining, topographical and geological conditions. Progress of the science of rock mechanics in the areas related to these issues is highlighted and critically examined. Specific areas are the prediction and assessment of the mechanical properties of rock mass, the mechanics of controlling fractured rock around deep mining excavations and the resulting demands on support systems. Rock engineering aspects of stoping systems and the regional stress changes resulting from the extraction of large mineral bodies are discussed in detail.*

Keywords: quarry, buffer, open pit mining, blasting, parallel-close charges, rock.

I. INTRODUCTION

The roof above the coal seam is allowed to collapse freely into the goaf upon extractions of the coal. This consequently results in an alteration to the stress state of the slope body, a sagging and bending of the overlying rock strata, a formation of tension cracks, and a subsidence of the ground surface. The value of energy-based design concepts for very deep mines exploiting tabular mineral deposits is shown. The tools are available. What is needed is the development of robust design criteria for mine infrastructure, excavations and support systems for dynamic and changing stress environments. The second critical issue is the lack of highly qualified rock engineering personnel on the mines [1]. This has been recognized by the European mining industry through supporting a continued education programme in rock engineering for deep mines. This raises the question whether there is a need for a special issue on mining rock mechanics and rock engineering and if so what are the differences to rock mechanics and rock engineering in civil underground construction. A further point that needs clarification is increased emphasis on rock engineering compared to rock mechanics. Rock engineering is seen as the application of rock mechanics principles in the design, construction and support of underground structures. Within the context of this contribution, the discussion will be confined to the design and support of extraction (stoping) and service excavations in mines. Rock excavation by means of drilling and blasting and mechanical means will not be covered with the exception of caving of rock, i.e. rock breakage due to the effects of gravity.

Thus, with the mathematical expectation of hourly equity participation of 0.124, the real values range from 0.057 to 0.166.at the same time, the average intensity of cargo traffic in stationary mode is 1.5-2 times higher than the value of this parameter in the transition period [2].

In addition, the complexity of the face grades also determines fluctuations in cargo flow [3]. At the same time, the probabilistic distribution of the cargo flow of overburden by shifts is characterized by a coefficient of variation of ± 18-19 %.

Thus, with a certain mathematical expectation of the average hourly value of cargo flow, which determines the throughput of the transshipment point, ensuring full loading of the conveyor complex, the actual receipt of dump trucks for transshipment in hourly intervals significantly changes. Variation in the parameters of existing cargo flows at the quarry can lead to underloading of conveyor equipment during its negative values, or to the inability to receive a part of dump trucks during peak periods (positive values of variation), which ultimately leads to a mismatch of the parameters of the entire system, and, consequently, the expected volume of work of the conveyor complex [4].

II. MATERIAL AND METHODS

In the case of mining, the purpose of creating underground excavations is to extract the minerals needed by society. In the case of civil subsurface structures, the purpose is to provide the infrastructure required by modern industrial society. Other important differences which have an influence on the rock engineering approach are the areas of ownership and financing. Since most mining companies are private sector enterprises, their financial success depends on the cost of operation and the revenue received from the sale of minerals. In the development stage of a new mine, the costly infrastructure required to prepare the mineral deposit for extraction has to be established. At the stage of mine development, no income from mineral sales is available to finance the infrastructure work. For this reason, the exploration of the geological situation is often confined to the mineral deposit and very little if any geotechnical information is collected to assist the mine planer [5]. This results in a high design risk which to some extent can be counteracted by flexible mine design. Since the design and development of the underground infrastructure is usually carried out by the mining company changes can be implemented readily and there are no legal and contractual implications. In the case of civil subsurface construction work, the situation is quite different as there are a number of different organizations involved, namely the owner, the engineering consulting company and the contracting company. Any change in plan has financial and legal implications. For this reason, the degree of site and geological exploration tends to be much greater than is the case of mining. This is facilitated by the public funding situation. Another important difference is that civil underground structures are often used by and open to the public, whereas mining excavations are not open to the public. This has implications on design safety and excavation support design. The main objective of mining is to provide society with the mineral raw materials required by the building industry, the energy industry, the manufacturing and chemical industry, the agricultural sector and the transport and communication sector [6]. The source of mineral raw materials is the mineral deposit. Mineral deposits are anomalies in the earth crust where physical, chemical, hydrological and biological processes have resulted in a concentration of valuable mineral matter. Mineral deposits are limited in size and number, and constitute a valuable and in most instances non-renewable resource. The locality, size, shape and mineral concentration of a deposit and its geological and geotechnical environment is determined by nature and is outside human control. This severely constrains the degree of freedom of the rock engineering design of mines.

To stabilize the flow of rock mass to conveyor complexes, to ensure the specified productivity, along with organizational measures, it is necessary to choose rational technological parameters of transport and transshipment complexes, as well as to make special technological decisions [4].

These include, first of all,:

1) rational organization of preparatory work - changing drivers, maintenance, refueling, which allows virtually eliminating zero runs of dump trucks, which will speed up their exit to the line;

2) choosing a rational number and type of transfer points from dump trucks to the conveyor, which are the main link in the relationship of combined modes of transport;

3) a device near the transshipment point (or on the surface) of a buffer intermediate warehouse, the parameters of which are determined based on the characteristics of the cargo flow of vehicles.

III. RESULTS

The same applies to the effect of depth of mining on the thermal environment in deep mines which depends on the thermal properties of the rock mass. To illustrate these points, the effects of depth on mining conditions in “deep” coal and gold mines are compared. At a depth of 1000 m below surface, the vertical in situ rock stresses are very similar in the two mining situations, namely about 25 MPa in the case of the coal mines and 27 MPa in the case of the gold mines [7]. However, due to the very much weaker rock formations found in coal mines, the rock pressure-related problems in the coal mines tend to be much more severe than those experienced by gold mines at the same mining depths. The thermal problems in the two mining industries are also very different because of the different thermal properties of the rock formations. In the case of the geologically much younger coal deposits, the temperature increase with depth is about, whereas in the case of the 3.500-million-year-old gold mining deposits in Southern Africa the rock temperature increase per 90 m depth is only about 1 °C. At the same mining depths, the virgin rock temperatures in the coal mines are, therefore, three times higher than those found in gold mines. These examples illustrate and explain the difficulties encountered in defining deep mining. In the case of the heat problems in deep mines, the depth at which the virgin rock temperature exceeds 30 °C would appear to be bench mark value as at such rock temperatures measures would have to be taken to cool the ventilating air to prevent heat stress problems. The uncertainty concerning magnitude of the pre-mining horizontal stresses constitutes a serious problem in the rock mechanics planning of new mines [8]. It is hard to imagine architecture and construction without large-span shells of various applications and taking into consideration the requests of architects, the new achievements in numeral modeling of the surfaces and introduction of new groups of tailored surfaces, the appearance of new forms and types of thin-walled shell structures of this kind is inevitable. The bionic method of solving these tasks pushes the boundaries of these opportunities.

IV. DISCUSSIONS

What is lacking to some extent is the application of the newly gained knowledge and understanding of mine design and mine operation. There are two main reasons for this. The first is a lack of practical rock engineering hand books for mine operators and rock mechanics personnel working on mines. The second reason is the lack of rock engineering courses at universities. In most instances, the emphasis of the courses is on rock mechanics and fundamental rock mechanics issues [9]. As a result, university graduates are ill prepared as far as finding solutions to the most pressing rock engineering problems encountered by the mines are concerned. The training of mining personnel in the area of applied rock engineering has been identified by the European mining industry as one of the most urgent needs. Once the width of remnant has reached a dimension of about 30 m, it may be opportune to change the direction of mining in such a way that the active mining face advances perpendicular to the strike direction of the mining-induced shear fractures thereby minimizing the potential of triggering sudden shear movement over large areas of the mining-induced rock fractures.

Rational organization of preparatory work for vehicles will speed up the saturation of the traffic flow at the beginning of the shift, but can not exclude the irregular operation of vehicles during the shift [10].

The analysis of the obtained data shows that the choice of a rational number and type of transshipment point also cannot fully solve this problem, since the volume of the hopper in most cases is equal to 2-4 capacity of dump trucks.

V. CONCLUSIONS

Under the auspices of the European Raw Materials Initiative, a continued education programme in rock engineering for deep mines was recently established to address this need. Open issues that will have to be addressed are the more extensive use of geophysical tools and methods to predict and monitor rock conditions in mines and the development of practical and reliable criteria and tools for designing rock structures and assessing support needs. From an operational point of view, there is a need to give rock engineering the right place in the mining hierarchy to ensure the safe and economic operation of deep mines [11]. These have to be well supported and of adequate cross section to enable access to the remnant even in the event of severe rock pressure damage. Extraction of the remnant should start from the inside and progress towards the periphery of the remnant. Experience in extracting high stress-remnant areas in tabular mining situations shows that extensive steeply dipping shear fractures can develop along the advancing stope face. These mining-induced fractures are preferred discontinuities for the occurrence of rock bursts. To completely eliminate the influence of variation of the intensity of quarry cargo flows to work the conveyor line, stabilize the load, as shown by studies on simulation models, as well as the practice of career Muruntau", possibly by creating an intermediate buffer store about transhipment point, which not only compensates for the effect of variations in traffic, but will also serve as a storage container when unforeseen downtime of the conveyor complex [12].

For the development of technological schemes of buffer temporary warehouses at the quarry at the CPT, justification of their design and technological parameters, a classification of such warehouses has been developed (table 3.1).

The systematization is based on the principle of satisfying the technological conditions for the completeness of loading of the conveyor complex of the CPT during non-rhythmic operation of cyclical road transport [13].

Let's consider technological schemes, design parameters and economic efficiency of the least expensive buffer warehouse when storing on a ledge inside the working zone of the Muruntau quarry. Loading of such warehouses is carried out by road in case of accidental unexpected stops of conveyor complexes, overflow of cargo traffic going to the transshipment points of the Central processing center, as well as planned, preventive repair works (each complex is 7 days monthly).

Roller-free conveyor), such conveyors can transport ordinary rock mass without the usual pre-preparation of rock mass on the CL. -300 mm. In addition, due to a certain temporary shipment of rock mass from the warehouse, it is advisable to use mobile loaders as loading equipment in such warehouses, rather than excavators of the EKG type. Reloading points at the site of ledges require a certain area for storage of the rock mass. In this case, when they are formed in the working area of the quarry for these sites, either the acceleration of the quarry Board or temporary zatselichivanie is required [14]. The latter is accepted in the practice of the Muruntau quarry.

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Based on these schedules, it is established that the maximum accumulation of the warehouse is 391 thousand m^3 (2013). In this case, the occurrence of this random event in a year is equal to two, or the probability of occurrence is 0.167.

The same does not exceed VC.CP. =+222 thousand m^3 when appearing 10 times a year, the probability is 0.833. When random events occur, δvc. =164 thousand m^3 (without Δvc. max) is equal to 5, the probability is 0.6.

Therefore, based on the analysis of receipt of the rock mass in the warehouse, its shipping taking into account the remaining capacity of the warehouse determined that the maximum storage capacity at a probability not equal to the overflow of 0.88 is 220 thousandthis value is the determining factor for determining the site for the buffer warehouse with the capacity of the conveyor complex of 4000 m3 / hour.

Consider the accumulation of a buffer warehouse during 2014. Similarly to the previous year, the occurrence of the event Δvs. max=+390 thousand m^3 is equal to one or the probability is 0.112. The same does not exceed Δvsr. =224 thousand m^3 when appearing 8 times (per year), the probability is 0.888.

Thus, based on the analysis of the receipt of rock mass in the buffer warehouse during the practice of the quarry during 2013-2014. it is established that such a warehouse should have a maximum volume of receiving capacity equal to 220 thousand.m^3. At 15-30 m height of the ledge when forming a warehouse to provide such a volume of buffer warehouse, the required warehouse area must correspond to 14.6-7.3 thousand m^2.

The use of compensating buffer warehouses at the quarry allowed to increase the productivity of conveyor transport and dump complexes by 30-39%.

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