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TEHNOLOGIJA UGRADNJE PRSKANOG BETONA KOD PODGRAĐIVANJA PODZEMNIH RUDARSKIH PROSTORIJA

Izvod

Ovde je obrađivana tehnologija ugradnje prskanog betona (torketiranje) u fazi podgrađivanja i osiguranja podzemnih rudarskih prostorija pri njihovoj izradi ili rekonstrukciji. Ovim se želi dati doprinos unapređenju ove tehnološke faze i pružiti informacije stručnoj javnosti o potrebi njene šire primene.

Ključne reči: *rudnik, ugalj, podgrađivanje, beton*

1. UVOD

Podgrađivanje i osiguranje podzemnih rudarskih prostorija je izuzetno složen problem u rudnicima uglja, kako sa sigurnosnog tako i ekonomskog aspekta. U osnovi pred rudarske stručnjake se postavlja problem kako racionalno podgraditi rudarsku prostoriju, kod faze izrade i održati njenu funkcionalnost za predviđeno vreme korišćenja uz minimalne troškove. U uslovima podzemnih rudnika uglja u Srbiji veoma su složeni geotehnički uslovi, i sa aspekta izgradnje i podgrađivanja prostorija prisutna je česta promena uslova radne sredine, a što iziskuje potrebu prilagođavanja tehnologije rada i primene različitih sistema podgrađivanja. Sada se u podzemnim rudnicima uglja u Srbiji izradi nešto više od 6000 m rudarskih prostorija godišnje, pri čemu su dominantni sistemi podgrađivanja sa popustljivim čeličnim lučnim okvirima i sa drvenom trapeznom podgradom. Pri ovome se samo različitim razmakom podgradnih okvira i izmenom profila prostorija nastoji održati funkcionalnost podzemnih prostorija. Prema dostupnim podacima u toku 2011. godine u jamama rudnika JP PEU izvršena je rekonstrukcija prostorija u obimu od oko 2000 m, što je veoma veliki izdatak, sa aspekta troškova materijala i radne snage, angažovanja opreme i izgubljene proizvodnje uglja iz otkopa.

Detaljnom analizom uslova radne sredine u sada aktivnim rudnicima i potrebnog obima izrade novih i održavanja postojećih rudarskih prostorija, kao i troškova za iste istaknuta je potreba da se ovom problemu da značaj koji mu u rudarskoj struci i pripada. U primeni navedene tehnologije, posebno u rudnicima metaličnih mineralnih sirovina, vodeći izvođač radova bio je RGP »Vrdnik« koji je razvio postupak od projektovanja, ugradnje, nadzora i monitoringa sa svojim kadrom.

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2. OPŠTE NAPOMENE O PODGRAĐIVANJU TEHNOLOGIJOM PRSKANOG BETONA

Podgrađivanje i osiguranje podzemnih rudarskih prostorija prskanim betonom (torketiranje) je postupak koji se sastoji u nabacivanju cementnog maltera na stenu pomoću vazduha pod pritiskom. U rudarskoj praksi podgrađivanje sa prskanim betonom je našlo primenu ili kao samostalna podgrada ili što je najčešći slučaj u kombinaciji sa nekom drugom podgradom. Kod kombinovanog podgrađivanja često se koriste kombinacije:

- prskani beton - sidra
- prskani beton - čelična mreža
- prskani beton - čelična mreža- sidra
- prskani beton - čelična mreža- čelični okviri
- prskani beton - čelična mreža- sidra - čelični okviri

Prskani beton primenjuje se samostalno u povoljnim geološkim i hidrogeološkim uslovima radne sredine i kod prostorija kod kojih su deformacije konture neznatne. Pri ovome podgrada od prskanog betona po svojoj nameni može biti zaštitna i noseća.

Zaštitna podgrada predstavlja sloj prskanog betona, debljine od nekoliko do 5 cm, nanešen po čitavoj površini iskopane konture. Ova vrsta podgrade isključivo je namenjena površinskoj zaštiti stenske mase od gubitka vlage i propadanja, kao i povezivanja manjih komada stena i sprečavanja njihovog ispadanja i osipanja. Noseća podgrada od prskanog betona ima funkciju konačne podgrade, jer je dokazano da se sa povećanjem debljine nanetog prskanog betona može postići isti efekat kao i kod ugradnje betonske podgrade. S obzirom da je kod podgrade od prskanog betona vezivanje betonske smese sa stenom 2 - 2,5 puta bolje nego kod monolitnog betona, kao i da su mehaničke karakteristike nešto bolje, to se u praksi i kod manjih debljina nanetog sloja prskanog betona (u odnosu na beton) postižu povoljniji ili isti efekti.

Bazična filozofija podgrađivanja prskanim betonom zasnovana je na konceptu da stena koja okružuje iskopni deo prostorije postaje deo nosive konstrukcije kroz aktiviranje nosivog prstena.Statički se rudarska prostorija razmatra kao cev koja se sastoji od nosećeg prstena u stenskoj masi i podgrade.

Stenska masa je glavni nosivi element rudarske prostorije, i kao takvu, nastoji se održati njena čvrstoća koju je imala pre iskopa. Ugrađivanje podgrade treba uraditi pravrovremeno, ni previše rano ni previše kasno, i ne sme biti ni previše kruta ni previše fleksibilna. Kruta i rano ugrađena podgrada izaziva visoka naprezanja, a previše fleksibilna ili kasno ugrađena podgrada prouzrokuje kretanje stenske mase što za posledicu ima visoka naprezanja na podgradu. U kvalitetnoj i dobro držećoj stenskoj masi iskop može ostati duže nepodgrađen, a u stenskoj masi lošijeg kvaliteta treba se što pre izvršiti podgrađivanje.

Primarna (zaštitna) podgrada od prskanog betona treba da stabilizuje masiv, a sekundarna - noseća podgrada treba da povećava sigurnost. Probleme stabilnosti iskopa treba rešavati pojačavanjem primarne podgrade (armaturne mreže, sidra....) a ne njenim podebljanjem. Sekundarna obloga prostorije takođe ne treba biti debela i nije poželjno da se sile između primarne i sekundarne podgrade prenose trenjem. Takođe, pri podgrađivanju važi pravilo da profil rudarske prostorije treba biti zaobljen kako bi se izbegla koncentracija naprezanja koja bi mogla izazvati slom stenske mase u široj okolini.

3. UGRADNJA PRSKANOG BETONA

Prskani beton ne zahteva nikakvu posebnu pripremu, kao što je priprema oplate, montaža i demontaža iste. Ravnomerno se nanosi na obrađen profil i na taj način obrazuje oblogu koja već nakon 2-3 sata posle nanošenja dostiže čvrstoću 0,8 N/cm^2, što omogućava rad na podgrađivanju čeličnom podgradom. Čvrstoća prskanog betona dostiže i do 60 N/cm^2, otpornost na zatezanje iznosi 5-15 N/cm^2.

Postoje dve metode ugrađivanja prskanog betona, u literaturi poznate kao:

- suvi postupak
- vlažan postupak

Kod suvog postupka mešavina agregata i cementa sa dodatkom brzovezujućeg sredstva transportuje se pneumatskim putem, kroz cevovod kao suva mešavina sa vodom pod pritiskom. Maksimalna veličina zrna je do 30 mm. Mešavina se transportuje i ugrađuje pod pritiskom 3-5 atm, a u zavisti od veličine zrna.

Suva smeša materijala potiskuje se komprimiranim vazduhom kroz cev mlaznice, gde se vlaži vodom dovedenom pomoću drugog creva. Navlažena smesa izlazi iz mlaznice brzinom od 135-170 m/s i nabacuje se na površinu.

Kvalitet nabačenog sloja prskanog betona zavisi kako od izbora materijala koji će se nabacivati, od načina rada mašinom kojom se nabacuje prskani beton, zatim od rukovanja mlaznicom i od izbora brzovezujućeg sredstva. U toku nabacivanja sloja prskanog betona vodi se računa o sledećem:

- formiranje sloja prskanog betona,
- postupak nabacivanja prskanog betona,
- nagib površina koje se prskaju,
- odstojanje mlaznice od površine,
- ugao pod kojim se vrši prskanje,
- regulisanje dotoka vode u mlaznicu,
- maksimalnoj i minimalnoj debljinu slojeva,
- proveri debljine nabačenog sloja i kvalitet nabacivanja,
- temperaturi vazduha pri nabacivanja.

Formiranje sloja prskanog betona se vrši stalnim vrlo značajnim udarcima zrnaca agregata. Ovo se nabijanje vrši ravnomerno od sloja do sloja, a u tome i jeste preimućstvo nabijanja pomoću mehaničkog nabacivanja. Tanki cementni sloj uslovljava solidan spoj prskanog betona sa površinom na koju se nabacuje i povećava vodonepropusnost prskanog betona. Pri nabacivanju nekoliko slojeva jedan na druge stvara se također dobar spoj a vodopropusnost betona se znatno povećava.

Pri nabacivanju prskanog betona koristi se dizna sa priključkom za vodu. Regulisanjem dotoka vode reguliše se vodocementni faktor. Prskani beton se nabacuje na površine koje po položaju mogu biti horizontalne i vertikalne.

- **Nabacivanje na vertikalne površine:**

Nabacivanje počinje od temelja vertikalne površine sa pokretanjem dizne levo i desno i sa malim potiskivanjem krugova. Po dovoljno nabačenom sloju, postepeno se dizna podiže naviše, kada se opet pokretom levo desno nabacuje dalja površina. Pri ovom postupku potrebno je da se izlazaći mlaz materijala uperi upravno na površinu stene ili zida, sa nešto više podignutim vrhom dizne. Ovakvim načinom držanja dizne postiže se ravnomernije nabacivanje materijala i ne dolazi do curenja materijala naniže.

Ako se nabacivanje prskanog betona vrši u više slojeva potrebno je da se prvi sloj stvrdne, pa tek onda nanositi drugi sloj. Neispravno je da se slojevi nanose na još nestvrdnuti sloj, jer tu dolazi do vibriranja čitave nabačene mase prvog sloja i postoji opasnost da se taj prvi sloj

odvoji od stene. Obično se drugi sloj nanosi posle 12 časova, a to vreme zavisi od toga koliko ima cementa i vezivnog sredstva u mešavini.

- **Nabacivanje na horizontalne površine:**

Pri nabacivanju prskanog betona na horizontalne površine, treba voditi računa da se ne stvori odvajanje većih zrna od mase betona ispred i u pravcu kretanja i da isti bude podjednako nabacivan na površinu. Stoga treba i ovde prvo unapred nabaciti tanji sloj, a zatim ga pokriti završnim slojem. Diznu treba držati nešto više uperenu prema već nabačenom materijalu, pa se time otklanja izbacivanje većih zrna ispred sloja na površini.

- **Postupak nabacivanja na čeličnu mrežu ili armaturu**

Pri nabacivanju slojeva prskanog betona gde se upotrebljava čelična mreža ili armatura, postupak je isti kao i bez armature, ali je potrebno da se nabacivanje na zid ili stenu vrši jednim slojem pre postavljanja armature. Ovo se zahteva zato što armatura stvara izvesnu prepreku prskanom materijalu, da ista pravilno prione na zid ili stenu. Prskani materijal u većoj meri jednostano curi iza armature i stvara se neispravan spoj između zida ili stena sa armaturom. Zbog udara zrna za vreme prskanja dolazi do vibriranja čitave postavljene armature. Ona se usled toga ne spaja potpuno sa materijalom koji je već u fazi vezivanja. Da bi se svi navedeni nedostaci izbegli i da bi se postigao što bolji kvalitet, čvrstoća i dobra zaptivenost, potrebno je da se nakon prvog nabačenog sloja odmah postavi i armatura utisne u taj sloj. Nakon 10-12 časova posle vezivanja, ovako nabačenog sloja i postavljene armature, prska se drugi sloj, te ako je potrebno i više slojeva, ali sa vremenskim razmacima radi stvrdnjavanja.

Kod svih položaja stena i zidova dizna se drži upravno na površinu, jer kod kosog držanja dizne postotak odskoka je veći. Diznu treba uvek voditi sa premeštanjem položaja stanja, levo-desno, a nikako je ne pokretati iz centra stajanja.

Smatra se da se na svakom nanesenom sloju nakon njegovog stvrdnjavanja pojavljuju pukotine i to kod debljih slojeva u većoj meri, te ako se prskanje izvodi u više slojeva pukotine se pokrivaju drugim nanesenim slojem i zaptivenost je bolja. Ugao pod kojim se vrši nabacivanje prskanog betona treba da je uvek približno upravan na površinu na koju se nanosi prskani beton. Rastojanje mlaznice treba prilagoditi zavisno od krupnoće zrna, tako da odskok bude najmanji.

- **Regulisanje vode u mlaznici**

U toku rada treba stalno regulisati doticaj vode u mlaznicu. Kad se masa nabacuje na stenu, ona ima karakterističan mastan sjaj, ako je propisno nakvašena. Nedostatak vode ogleda se u vidu suvih mrlja, a kod viška vode prskani beton curi. Posebno treba voditi računa da je čvrstoća prskanog betona zavisna od vodocementnog faktora, te je potrebno dodavati što manje vode, odnosno samo onoliko koliko je neophodno da prskani beton dobro prilegne na površinu koju pokriva.

- **Izbor materijala i kontrola kvaliteta betona**

Da bi prskani beton zadovoljio zahteve nužno je izvršiti predhodna ispitivanja sastavnog materijala: agregata, cementa, vode i brzovezujućeg dodatka.

AGREGAT: Pesak treba da bude oštrouglast, čist od štetnih sastojaka, kao npr. zemlje, uglja, gline, soli i kiselina. Pored toga, treba da je otporan na mraz. S druge strane, materijal ne sme da bude suviše mokar, maksimalno 5% vlage da bi se sprečilo vezivanje cementa unutar mašine koje može da prouzrokuje smetnje.

CEMENT: Za vezivna sredstva upotrebljavaju se svi normalni cementi, kao i specijalni cementi. Koji cement treba izabrati zavisi od traženih čvrstoća.

Načelno treba upotrebljavati uvek svež cement. U svemu ovome najbolje su se pokazali portland cementi. Odnos mešavine u težini leži po pravilu između 1:3 i 1:6.

VODA: Značaj vode za spravljanje prskanog betona se obično pocenjuje. Čvrstoća vode je od velike važnosti, jer se u suprotnom ugrožava čvrstoća betona, ili čak sprečava pravilno vezivanje. Upotrebljavaju se vode iz vodovoda i sve prirodne koje nisu zagađene. Ako postoji sumnja na čistoću, vodu treba dati na ispitivanje, jer i kod bistrih voda može postojati nečistoća koja beton hemijski oštećuje.

DODACI ZA UBRZAVANJE VEZIVANJA: Kod podzemnih radova je neophodno potrebno da se prskani beton posle nabacivanja trenutno stegne i da počne vezivanje. Već nakon nekoliko časova mora veći deo da postigne krajnju čvrstoću, da se ne bi za drugim nabacivanjem čekalo danima. To se postiže dodavanjem specijalnih dodataka koji pospešuju brzo vezivanje prskanog betona. Ova sredstva, dodaci, moraju predhodno biti ispitana, kako ne bi nepovoljno uticali na cement koji se upotrebljava. Doziranje tih sredstava potrebno je predhodno utvrditi. Važno je da se brzovezujuće sredstvo dodaje prskanom betonu neposredno pred samo nabacivanje prskanog betona.

- **Određivanje recepture za prskani beton**

Za spravljanje projektovane marke prskanog betona MB-30 upotrebljavaju se sledeće količine materijala:

1. CEMENT PC 450 (350)
   400,00 kg/m^3
2. AGREGAT
   - I frakcija agregata
   60% x 1800 kg/m^3 = 1296,00 kg/m^3
   - II frakcija agregata
   40% x 1800 kg/m^3 = 864,00 kg/m^3

$\frac{W}{C} = 0{,}20$, prema tome, maksimalna količina vode za spravljanje 1,00 m^3 betona iznosi 200 ℓ / m^3.

Ukoliko se beton nanosi u dva sloja, a koje je potrebno nanositi brzo jedan za drugim, potrebno je upotrebljavati i dodatak za brzo vezivanje prskanog betona. Doziranje brzovezujućeg dodatka vrši se u skladu sa preporukom proizvođača. Suva smeša treba da sadrži cca 5% vlage (agregat ne sme biti sasvim suv.)

Za izvođenje radova prskanim betonom u jami koristi se najčešće sledeća oprema:

1. Pumpa za prskani beton
2. Priključak za cevovod komprimiranog vazduha
3. Vagoni za transport suve mešavine
4. Lokomotiva za transport vagona sa potrebnim materijalom
5. Mešalica za beton

4. ZAKLJUČAK

Sistem osiguranja i podgrađivanja rudarskih prostorija u podzemnim rudnicima Srbije iziskuje potrebu unapređenja i uvođenja novih rešenja, kako bi se uticalo na sigurnost i sniženje troškova izrade i održavanja. Sadašnji sistemi podgrađivanja sa čeličnim okvirima, odnosno drvenom podgradom su dosta skupi i odlikuje se visokim učešćem radova rekonstrukcije.

Analizom uslova radne sredine u aktivnim rudnicima i sagledavanjem tehnologije ugradnje prskanog betona došlo se do saznanja da se ova tehnologija može uspešno primeniti u određenim slučajevima.

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TECHNOLOGY OF SPRAYED CONCRETE LINING IN SUPPORT OF UNDERGROUND MINING FACILITIES

Abstract

This work gives a technology of sprayed concrete lining (guniting) at the stage of supporting and securing the underground mining facilities during their construction or reconstruction. This is a contribution to the improvement of this technological stage and providing the information to the professional community about the need for its wider use.

Keywords: *mine, coal, support, concrete*

INTRODUCTION

Supporting and securing the underground mining facilities is an extremely complex problem in the coal mines, both from the security and economic aspects. Basically, the mining experts have the problem how to support rationally a mining room in a development stage and to maintain its functionality for the estimated time of use with minimum costs. Under the conditions of underground coal mines in Serbia, the geotechnical conditions are very complex, and in terms of construction and supporting the facilities, the change of working environment is very frequent, which initiates a need to adapt the operation technology and use different system of supporting. Now, in the underground coal mines in Serbia, more than 6000 m of mining facilities annually are developed, with the dominant support systems with semi steel arch frames with wooden trapezoid support. Hence, only different spacing support frames and change the profile of facilities has been seeking to maintain the functionality of underground rooms. According to the available data in 2011, in the mine pits of JP PEU, the rooms were reconstructed to the extent of about 2000 m, which is very high expense, in terms of material costs and labor, hiring of equipment and lost coal production from the stope.

A detailed analysis of the working conditions in the existing active mines and an adequate amount of new development and maintenance the existing mining facilities, as well as costs for the same, needs to address the importance to this

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issue that belongs to it in mining profession. In the use of this technology, particularly in the mines of metallic mineral resources, the leading contractor was RGP "Vrdnik" that developed the procedure from design, installation, supervision and monitoring with its staff.

2. GENERAL NOTES ON SUPPORT USING THE TECHNOLOGY OF SPRAYED CONCRETE

Supporting and securing the underground mining facilities using sprayed concrete (guniting) is a procedure which consists in lining the cement mortar on a rock using the compressed air. In mining practice, supporting with sprayed concrete has found its use or as an independent support or, what is the most common case, in a combination with some other support. The following combinations are often used in combined support:

- Sprayed concrete - anchors
- Sprayed concrete - steel mesh
- Sprayed concrete - steel mesh - anchors
- Sprayed concrete - steel mesh- steel frames
- Sprayed concrete - steel mesh - anchors - steel frames

Sprayed concrete is applied independently in favorable geological and hydrogeological conditions of the working environment and facilities where contour deformations are slight. In this, the support of sprayed concrete may be protective and supporting.

The protective support is a layer of sprayed concrete, thickness from a few to 5 cm, applied over the entire surface of the excavated contour. This type of support is only intended to the surface protection of rock mass from moisture loss and decay, and connection of smaller pieces of rocks and prevention their falling and dropping. Supporting reinforcement of sprayed concrete is a function of the final support, because it was approved that with increasing thickness of sprayed concrete, the same effect can be achieved as with installation of concrete support. Since bonding of sprayed concrete support with concrete mixture with rock is 2 to 2.5 times better than that of monolithic concrete, and mechanical properties are slightly better, in practice, with smaller thicknesses of sprayed concrete layer (with respect the concrete), the same or better effects are attained.

The basic philosophy of supporting by sprayed concrete is based on a concept that the rock surrounding the excavation part of the room becomes a part of the supporting structure by activating the bearing ring. Statically, the mining room is considered as a tube that consists of a bearing ring in the rock mass and support.

Rock mass is the main bearing element of the mining room, and as such, it seeks to maintain its strength that it had prior to excavation. Fitting the roof support has to be done on time, neither too early nor too late, and neither too rigid nor too flexible. Rigid and early built support causes high stress, and too flexible or too late built support causes the rock mass movement which results in high stresses on support. In the quality and well stable rock mass, the excavation can stay longer unsupported, and in the poor quality rock mass, supporting should be made as soon as possible.

The primary (safety) support of sprayed concrete should have to stabilize the massive, and the secondary - bearing support should have to increase security. Excavation stability problem should be solved by increasing the primary support (mesh, anchors, etc.) and not by its bolding. The secondary lining of the room should not be too thick and it is not desirable that the forces between the primary and secondary roof supports are transferred by friction. Also, during supporting, there is a rule that the profile of mining room should be rounded to avoid stress

concentration that could cause a collapse of rock mass in the vicinity.

3. SPRAYED CONCRETE LINING

Sprayed concrete does not require any special preparation, such as the preparation of formwork, assembly and disassembly thereof. Uniformly applied to the processed profile and thus forms a lining that after 2-3 hours after application reaches strength of 0.8 N/cm^2, allowing the supporting of the steel support. The strength of sprayed concrete reaches up to 60 N/cm^2, and tensile strength is 5-15 N/cm^2,

There are two methods of placing the sprayed concrete, as known in the literature:

- dry process
- wet process

In dry process, the mixture of aggregate and cement with the addition of quickly binding agent is transported by pneumatically, through the pipeline as a dry mixture with water under pressure. Maximum grain size is 30 mm. The mixture is transported and sprayed under pressure of 3-5 atm, and depending on a grain size.

Dry mixture of materials is pushed by compressed air through a pipe of nozzle, where it is wetted by water supplied by another water hose. Wet mixture exits from the nozzle at rate of 135-170 m/s and sprayed on a surface.

Quality of lined layer of sprayed concrete depends on a material selection that will be sprayed, the way of machine operation which threw the sprayed concrete, then the handling with nozzle and selection of quicly binding agent. During throwing a layer of sprayed concrete, the following shall be paid:

- Forming the layer of sprayed concrete,
- Process of sprayed concrete throwing,
- Slope of sprayed surfaces,
- Distance of nozzle from surface,
- Angle of spraying,
- Regulation of water flow in the nozzle,
- Maximum and minimum thickness of layers,
- Checking the thrown layer thickness and quality of throwing,
- Air temperature at throwing

Formation of sprayed concrete layer is done by constant very important blows of aggregate grains. This compaction is carried out uniformly from layer to layer, and that is the advantage of mechanical compaction by throwing. A thin layer of cement causes a solid binding of sprayed concrete to the surface of throwing and increases the water non-permeability of sprayed concrete. In throwing a few layers on each other, also a good bonding is created, and water permeability of concrete increases significantly.

A nozzle with water connection is used in throwing the sprayed concrete. Water flow is regulated by water-cement factor. Sprayed concrete is thrown on the surfaces of horizontal or vertical positions.

- Throwing on vertical surfaces:

Throwing starts from the foundation of vertical surface with nozzle movement left and right and small pushing of circles. After enough thrown layer, the nozzle gradually raises upward when further area is thrown by the left and right movements. In this method, it is necessary to spray the jet of spraying material perpendicular to the surface of rock or wall, with a slightly more elevated nozzle tip. This type of nozzle posture is achieved by more uniformly spraying of material and without leakage of material down.

If throwing of sprayed concrete is done in many layers, it is required that the first layer is hardened and then applies the second layer. Incorrectly that the layers are applied onto unhardened layer, because that leads to vibration of the whole

sprayed mass of the first layer and there is a danger is that this first layer is separated from the rocks. Usually, the second layer is applied after 12 hours and this time depends on how much cement and binding agent are in the mixture.

- Throwing on horizontal surfaces:

In throwing of sprayed concrete on horizontal surfaces, the care should be taken not to create a separation of large grains from concrete mass in front and in a direction of movement and that the same is equally thrown on the surface. Therefore, the first pre-thin layer has to be thrown here and then cover it by final layer. Nozzle needs to keep a little more directed towards already sprayed material, and it removes the ejection of larger grains in front of the layer on the surface.

- Procedure of throwing on a steel mesh or reinforcement

In throwing the sprayed concrete layers where steel mesh or reinforcement is used, the procedure is the same as without reinforcement, but it is necessary to throw on a wall or rock in one layer before placement the reinforcement. This is required because the reinforcement creates the certain barrier to the sprayed material and proper adhering of the same on the wall or rock. Sprayed material to a greater extent simply leaks behind the reinforcement and a faulty contact is created between the wall or rocks with reinforcement. Due to the impact of grain during the spraying occurs, the entire set reinforcement vibrates. Due to this, it does not connect fully with the material already in the binding phase. To avoid all these disadvantages and to achieve better quality, strength and a good seal, it is necessary, after the first sprayed layer, to set up immediately reinforcement and to fit the reinforcement into this layer. After 10-12 hours after binding, such thrown layer and set reinforcements, the second layer is sprayed, and if multiple layers are required, but with the intervals for hardening.

With all positions of rocks and walls, the held nozzle is held perpendicular to the surface because with the sloping holding, a percentage of jumps is higher. Nozzle should always be led with the position movement of conditions left-right, and does not run it from the center of condition.

It is considered that at each applied layer after its hardening, the cracks occur, and also at thick layers to a greater extent, and if the spraying is performed in multiple layers, the cracks are covered with the second sprayed layer and the sealing is better. Angle of concrete spraying should always be approximately perpendicular to the surface to which the sprayed concrete is applied. Distance between nozzles should be adjusted depending on the grain size, so the jumps are minimal.

- Regulation of water in the nozzle

During the work, the water flow into nozzle has to be constantly regulated. When the concrete is thrown on the rock, it has a characteristic greasy luster, if it is properly wetted. Lack of water is reflected in the form of dry spots, and with the excess of water, the sprayed concrete leaks. It should take into account the strength of sprayed concrete depending on the water cement ratio, and the need to add less water, or only to the extent necessary to well lining of sprayed concrete on the surface that it covers.

- Selection of materials and quality control of concrete

It is necessary to carry out the previous testing of constitutive material: aggregate, cement, water and quickly bonding additive, as the sprayed concrete could satisfy the requirements.

AGGREGATE: Sand should be sharply angular, free of harmful ingredients, such as soil, coal, clay, salts and acid. In addition, it should be resistant to frost. On the other hand, the material must not be too wet, maximum 5% of moisture to prevent the binding of cement inside the machine that can cause interference.

CEMENT: All normal cements and special cements are used as binders. A type of cement that should be chooses depends on the required strengths. In principle, the fresh cement has to be always used. In all of this, the Portland cement has proved as the best. Mixing ratio by weight is generally between 1:3 and 1:6.

WATER: The importance of water for making the prayed concrete is usually underestimated. Hardness of water is of great importance, because otherwise it jeopardizes the strength of concrete, or even prevents proper bonding. Tap water and all natural non-polluted water are used. If there is doubt on the purity, the water should be analyzed, because the clear water could have the impurities that can chemically damage the concrete.

ADDITIVES FOR QUICKLY BONDING: In the ground works, it is necessary that the sprayed concrete after throwing is instantly hardened and starts with bonding. After a few hours, the most of concrete has to reach the ultimate strength, not to wait for days to the other spraying. waited for days. This is achieved by adding the special additives that promote quickly bonding of sprayed concrete. These additives must be pre-tested, so as not to have adverse effect to the used cement. Dosage of these additives must be previously determined. It is important that quickly bonding additive is added to the sprayed concrete immediately before throwing of sprayed concrete.

- **Determination of a recipe for sprayed concrete**

For making the designed brand of sprayed concrete MB-30, the following amounts of materials are used:

1. CEMENT PC 450 (350)
   400.00 kg/m^3
2. AGGREGATE
- I fraction of aggregate
  60% x 1800 kg/m^3= 1296.00 kg/m^3
- II fraction of aggregate
  40% x 1800 kg/m^3= 864.00 kg/m^3

$\frac{W}{C} = 0.20$, therefore, maximum quantity of water to make 1.00 m^3 of concrete is 200 ℓ / m^3.

If concrete is applied in two layers, which need to be applied quickly one after the other, it is necessary to use an additive for quickly bonding of sprayed concrete. Dosage of quickly binding additive shall be in accordance with the manufacturer recommendation. Dry mixture should contain about 5% moisture (aggregate must not be completely dry).

For implementation the works with sprayed concrete in the mine, the following equipment is mostly used:

1. Pump for sprayed concrete
2. Connection for compressed air piping
3. Wagons for transport of dry mixture
4. Locomotive for transport of wagons with necessary material
5. Concrete mixer

CONCLUSION

System of insurance and supporting the mining facilities in the underground mines of Serbia requires the need to improve and introduce the new solutions in order to affect the safety and reduction of manufacturing and maintenance costs. The current systems of supporting with steel frames and wooden roof supports are quite expensive and characterized by high percentage of reconstruction works.

Analyzing the working conditions in the active mines and considering the technology of lining the sprayed concrete have resulted into knowledge that this technology can be successfully applied in certain cases.

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