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ADVANCED LIFE SUPPORT REQUIREMENTS FOR UNDERGROUND WORKPLACE ACCIDENTS

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ABSTRACT: Mining sector is important business and industrial activity in some countries. When ore explorations are gradually turned into mine operations, more people will gradually be employed in the mining industry. Even with today's mining capacity, work and work place occupational safety are main concern for related workbodies. Minor scale mine accidents are not publically announced due to their individual characteristics. But some others happened in big scale which becomes national dilemma. After the event, each of them is followed by mine rescue operations, media broadcastings from the sites, families waiting for their relatives in indescribable hopes, angers, disappointing physiology. Rescue teams in these occasions have responsibilities to reach and safe the trapped/injured miners. The question arose here is what the level of "first-aid" or "life-support" training for some of the members of rescue teams should be. Some of the rescue team members should deal with excavations, ventilations, mine supports etc. but some of them should definitely deal with trapped, injured, collapsed workers without loosing their own life and physiologic wellness. In this study, importance and requirements of Advanced Life Support (ALS) services in mine accidents are evaluated according to experiences to have more realistic and valuable rescue operations.
Keywords: Mines, Mine accidents, First-aid, Advanced life support, Mine rescue.

Yeraltındaki İşyeri Kazaları İçin İhtiyaç Duyulan İleri Seviye Hayat Destek Servisi

ÖZ: Madencilik birçok ülke ekonomisi için önemli bir iş ve sanayi koludur. Maden arama faaliyetleri sonuçlandıkça bu faaliyetlere bağlı olarak çalışmaya başlayan maden ocaklarında çalışan insanların sayısı gün geçtikçe artmaktadır. Bugünün çalışma şartlarında, gelişen teknolojiye rağmen, iş ve işyeri güvenliği maden ocakları için hala üzerinde dikkatle durulması gereken konular arasındadır. Bazı maden işyeri kazaları medya aracılığıyla herkese duyurulmasada, büyük çaplı maden ocağı kazaları ülke çapında üzüntüye neden olabilmektedir. Önemli maden kazaları sonucunda görmeye alıştığımız manzara ve olaylar; organize edilen kurtarma çabaları, medyanın yayınları, maden ocağı çevresinde umut, kızgınlık, hayal kırıklığı psikolojisi içinde bekleyen kazazede yakınları ve ülke genelinde duyulan üzüntü şeklinde sıralanabilir. Kurtarma ekiplerinin maden kazalarındaki sorumluluğu kaza yerine ulaşıp orada mahsur kalan ve/veya yaralanan kazazedeleri kurtarmaktır. Bu aşamada sorulması gereken sorulardan birisi; kurtarma ekibi içinde yeralacak görevlilerin hangi düzeyde "ilk yardım" ve/veya "hayat destek" sağlık bilgileriyle eğitilmeleri gerektiğidir. Maden ocaklarında kurtarma ekibi faaliyetleri sürerken, bazı ekip üyeleri, galeri kazısı, göçük kaldırma, havalandırma ve galeri tahkimatı işleriyle uğraşırken, bazı ekip üyeleri de kaza yerinde sıkışan, göçük altında kalan, yaralanan kazazedeleri kurtarma işleriyle uğraşacaklardır. Bu işlemleri yaparken kurtarma ekibi üyeleri kendi hayatlarını tehlikeye sokmamalı ve kendi psikolojik durumlarını bozmadan kurtarma işlemini sürdürebilmelidirler. Burada, maden kazaları ele alındığında, uzman doktorların kurtarma ekip üyesi olarak, kaza mahallinde verebileceği hayat destek servisinin önemi ve ihtiyaç durumu, maden kazalarında edinilen kurtarma deneyimlerine göre değerlendirilmiştir.
Anahtar Kelimeler: Madencilik, Maden kazaları, İlk yardım, İleri seviye hayat desteği, Maden kurtarma.

INTRODUCTION

Natural and engineered underground openings have their own conditions. Natural ones cover caves, cave systems, sinkholes, underground water passageways in macro scale, and discontinuity apertures in micro scales. Engineered underground openings on the other hand are underground mine facilities, road and rail tunnels, metro openings, machine chambers of energy plants, underground repositories, underground cities, underground spaces used for hotels, restaurants, cafes and sport&life activity centers etc.

Underground openings can be analyzed for their stability conditions in two main phases; excavation and usage phases. Excavation sometimes is the aim of the operation, like in mining. Excavated ores and coals are main product to get earnings. In other cases, openings obtained after excavations are the required targets to use as tunnels, storage volumes and living spaces. In both cases, occupational workforce employed for these openings either for their excavation or their usage should work in planned and safe workplaces. Underground mines, especially coal mines have very strict rules to maintain work and workplace safety (ILO, 1986; WVOMHST, 2008). These rules have been upgraded gradually after getting experiences through mine accidents. Other underground openings have also their own workplace safety procedures to follow (Hooker & Shalit, 2000). Coal mines probably have more seam gases which can be poisonous, suffocating or explosive. Other underground openings might have (or not) country rock related gases also. Therefore they have to be controlled to get safe workplaces with paying attention to their ventilation, water discharge and openings' stability.

Engineers worked for rock engineering studies and rock engineering design procedures have realized long before that (Bieniawski, 1992), risk originated by rock masses can not be totally eliminated. There are always some degrees of risk of accidents due to uncertainties of data obtained from rock formations (Stacey etal, 2007). Engineers know that without accepting the risk in mining and usage of other underground openings, nothing could be obtained from earth crust (Erdogan, 2016). Beside this handicap, engineers supply underground design options for different operations. Design engineers handled the uncertain data features by increasing engineering safety factors. Expecting concealed factors causing accidents is another fact originating basically through these natural uncertainties. Thus each underground opening has options to follow in case of accidents. Besides fire danger, underground openings might be affected by discharge of gases and water through the country rocks; deterioration of rock strengths; roof, floor and sidewall failures etc. Therefore employees in underground openings can be involved in an accident not related with human and machine related factors (Patterson, 2009), but also factors related with the mentioned parameters above (Hall&Snelling, 1907; Saleh&Cummings, 2011).

Mine design engineers have been educated in mining sectors to supply mine plans which end up with no or minimum casualties in case of mine accidents (Gokay&Shahriari, 2016, 2017). This target may possibly be obtained supplying alternative galleries, passageways and heavily supported chambers, emergency shelters, etc. (Fernando etal, 2007). These types of organized mines have also well trained rescue teams including first-aid members and physicians (Muezzinoglu, 2015). Therefore, underground openings design stage is starting point to get safer underground spaces for different businesses. Thus, different types of engineers should be employed in this stage to reach most applicable and most meaningful underground design options by good manner (direction) of cooperation. Thus, each company requires these design procedures after getting full brainstorming, factorizing, analyzing, evaluation, planning, checking and verification steps in their design duties. One of the questions which should firstly be thought, while performing underground design activities; (that is), how the employees can be rescued in different cases of underground workplace accidents? Mining law of each country has detail procedures to organize rescue teams in mines (HSE, 2001; USDL, 2008; NSW, 2010; Capstone, 2015; Lehnen, 2016; Catakci, 2016). Similar procedures should be followed for each engineered underground operations. Underground rescue duties can not professionally be handled by other teams which have not been trained for accidents occurred at underground openings.

UNDERGROUND OPENINGS AND RELATED RESCUE OPERATIONS

Accidents can be occurred in all workplaces including underground operations. Minor scale accidents which cover small localization together with very few employees can be handled professionally as the major scale underground disasters like coal mine explosions. Main aims are saving and securing the employees lifes first. Especially mining safety rules describe the procedure to be followed in any case of accidents. For each type of underground openings, (mines, tunnels, storage places, living places, hotels, cafes etc) there should be pre-described steps which employees have been trained to follow in case of accidents. In case of underground workplace accidents, followings are the main aims of emergency actions (NMA, 2015) described by National Mining Association, NMA, of USA; *i)"Minimize the effect of emergencies on company personnel and on the surrounding communities, and on the public.", ii) "Minimize: injury; damage to environment; property damage; damage to equipment; and losses to process that result from emergencies".* Employees who noticed underground accident should follow certain pre-described steps like given by NMA, (NMA, 2015);

> *"a) Notify the supervisor of the emergency situation. b) Report the emergency as described on the "Emergency response plan". c) Provide help until the appropriate response team(s) arrives. Never place yourself or others in danger, especially during fires, or chemical emergencies. d) If an alarm is sounded or you are instructed to do so, evacuate the area to designated assembly points and stay there until you are instructed to leave. e) If an evacuation takes place, follow the directions. Make sure you and any visitors you are responsible for are accounted for by your supervisor. f) If you are responsible to perform shutdown procedures, know your responsibilities and perform them accordingly. g) If responders are already at the scene of an emergency, do not go to the scene to watch or offer assistance unless you are personally called to the scene. "*

As it is described here appropriate response team(s), accident rescue team(s), have important role to save injured workers and set the accident situation in order, as soon as possible. There are certain procedures to follow about "health of rescue team members and their experiences in underground activities" by regulations. It is obvious that these workers and engineers aiming to save injured workers and mine equipments and properties have enough skills, experiences, education and trainings (HSE, 1993; Conti etal, 1998; TTK, 2000; Mischo etal, 2014; NIOSH, 2015). Underground rescue operations include, entering underground facilities which had minor or severe scale accidents (or explosions) before. These action covers advancing through unsecure galleries and working places.

If the accident is related with methane or coal dust explosions, situation at underground disaster site (exploited galleries, working places etc) is most probably unreachable due to collapse of galleries. If the accidents in underground is just related with roof failure, working places are most probably filled by collapsed country rocks which should be cleared away to reach injured victims (employees). Other underground accident types have their own especial cases (water in flushes, underground mine fires, etc) which rescue teams had been trained accordingly to deal with the problems they might come across during rescue operations. Rescue team has always a leader, experienced person to handle situations in harsh underground environments. The other members of the team should be ready (healthy, fit enough and trained) to perform any required excavations, (drill, blast, load & carry jobs to clear away the debris and country rocks) to advance toward the accident victims in underground. Distances from the mine entrance to accident locations are generally long enough (a few kilometers) which require really healthy rescue members to walk through in harsh, polluted, dangerous and dark environments. Some team members have duty to records the situations rescue team come across and report (communicate) them to main rescue head office (usually at the surface) for evaluation. Some team members have duties related with *"First-Aid"* applications. These workers have enough education and training certificate to supply required first-aid helps for injured victims, workers, in underground accident chambers.

ADVANCED LIFE SUPPORT (ALS) REQUIREMENTS FOR INJURED UNDERGROUND EMPLOYEES

In last years new concerns have been pointed for the mine accident victims who need more treatment than first-aid level. Advanced life support (ALS) services were advised to be more effective in more complex health procedures come across in mine accident cases (Enright etal, 2016). Experiences obtained from several mine rescue works attended by Calkaya (2018) in Turkey have also caused to reach a decision that, mine rescue operations in Turkey need to be re-arranged to include more effective life saving operations including advanced life support (ALS) services. In mining engineering departments, there are several lectures that students have been supplied with information and knowledge for safe mine operations. In these lectures, several procedures have been given to students to prevent mine accidents either minor scale or major scale (mine disasters). In some universities there are experimental mines to train underground rescue teams (organized for students or trainees). Beside of these training activities given by universities, private companies, governmental mine safety offices and societies of mine engineers; accidents in underground have still been observed. Countries which have underground workplaces have supplied their statistical evaluations to understand reasons of the mine accidents to enforce new upgrades in required sectors. That means, "underground rescue team" activities have seriously been considered for all underground activities. Related law enforcements have been supplied for any type of underground activities. There should be "engineered plan" to rescue employees and other people trapped in underground in any case of accidents at; underground heritage museums, historical underground cities, metro tunnels and stations, rail and highway tunnels, underground hotels and cafes, underground storages for commercial purposes, underground repositories for radwaste or other waste materials, underground passages for shopping centers, underground sport and parking places, underground mines etc. Mine employees and people using underground spaces should definitely be informed about emergency stages. Required rescue operations must be planned for these underground openings in engineering way. Since there is no way to eliminate underground accidents totally, then organizations and companies responsible from underground activities should be ready for their unexpected accidents as prepared as possible. Despite precautions if an underground workplace accident was happened, there are certain procedures to follow by workers, engineers, local police, local people and governing bodies (NMA, 2015; Calkaya&Gokay, 2016). These steps have been documented for "first moment accident reporting" and mine accident rescue operations in literature (Kowalski etal, 2010).

When an accident related with underground openings was reported, national based "Underground accident governing authority" should immediately be called on duty (organized according to legislations) and this rescue center is charged to handle the accidents. Accident site security, communication with media and families, calling the underground (mine) rescue teams in duty, and other related duties are controlled under their responsibilities. Positive experiences together with deficiencies of this authority directly influence life of victims trapped in underground.

When the rescue teams enter the mine by obeying all necessary precautions they trained before, they have to clear the debris away from the galleries or they have to excavate passage galleries to reach accident chambers, openings. During these duties, when they come across the victims of underground (mine) accidents, they have to decide quickly to move the victims from their dangerous location and transport them to safer first-aid locations in underground. Moving victims from their original locations have many health related parameters in addition to factors related with underground openings stabilities and gasses. Experiences reported by Calkaya (2018) presented that "Advanced life support", (ALS), members are required in some case to handle the accident victims' health conditions as Enright, etal., (Enright etal, 2016) reported also. For example, one of the experienced military doctor's rescue service in an underground coal mine which had terrible accidents has still been remembered by local people and miners at Springhill, Nova Scotia, Canada, (CH, 2018). Some accidents related with underground openings (especially methane explosions at coal mines) have exploded workplace sceneries similar to bombed grounds of war fields. Therefore mine rescue members should also be trained physiological manner as well to bear the situations they might see around the accident locations in underground.

Engineers have to pre-organize their rescue operations for different accident scenarios. These operations include different cases of rescue plans and rescue team member selection. Rescue teams have then trained and performed drills to get experiences in trapped-workers search and rescue procedures. In addition, they have guided in controlling keyfigure machinaries which perform critical functions in mine ventilation, mine water pumping etc. One or two members of the underground rescue teams are capable to supply first-aid procedures. The question should be asked here, how the rescue team members evaluate health conditions of victims trapped due to underground accidents. These decisions include their own responsibility levels. When the rescue teams clear their way and reach to accident locations in an underground mine which had already mine accidents, there may be wounded workers around. Following options (hypotetical evaluation) should be considered to evaluate complexity of the situations; i) victims' wounds are first-aid types, or ii) these wounds or traumas are complex. In dark underground environment, first-aid members of underground (mine) rescue team should decide quickly to help these victims. What is the level of correctness of their decision under extraordinary circumstances? If they reach faulty decisions what happens to the victims. Another question arose also that; what will be the moral situation of that rescue members in the following years. These kinds of decisions have negative effects on physiology of the team members. There may be legislative responsibilities as well. The question again should be asked here; Do you want to be a member of underground rescue team them? As a member of team, your life is under danger, because you are entering underground accident area; you may come across accident sceneries you may not forgot them in all your life. You may save mine accidents' victims that may be good for you, but you may not save some of them. As a member of team, are you sociologically and physiologically ready for that? Experienced gained by earlier practices pointed also that; these conditions and questions should deeply be considered during mine rescue team arrangements, (Yilmaz, 2006). The team members have to be supported during and after rescue operations. These facts should necessarily be included in underground rescue team legislations. Companies and organizations should be informed for their legislative support responsibilities during and after the rescue operations on these team members. In this paper, following hypotetical underground rescue situations are put forwarded for further considerations and evaluations by related mine and health realated professionals;

i) In victim searching phases of underground accident, what will be the responsibilities, if the victims can not be found around?

ii) If there are obstructs to reach victims site and that obstructs can not be eliminated, what will be the resultant decisions?

iii) If there are several obstructs to reach victims and eliminating that features are going to damage some of the victims body parts (or may cause deadly results for some of the victims), what will be the resultant decisions?

v) If there are obstructs to reach some body parts of victims, who is going to decide that body parts are totally damaged, so it is better to cut. To save the victims, if the decision was already given for similar situations, who is going to perform the operations without causing complications for victim's health situations? What will be the legislative responsibilities about similar situations?

vi) Underground accident sites include victims who have different traumas and they might be in shocked stage, if there is no ALS doctor-medic to handle the situation, who is going to save the victims?

These and many other factors (possibilities) should be considered and described in details at related rescue legislations for any kind of underground openings. Underground openings need particular design procedure. Design engineers should take all precautions for any type of underground accidents. For difficult circumstances in case of accident cases; underground openings may need extra first-aid access galleries and shafts in addition to especially designed sheltered rooms (sheltered room supply for underground coal mines in some countries are required by law enforcement). These features have gradually supplied for some coal mines but, what about the other underground activities, including metal mines, metro systems, businesses related with underground; passageways, storages, hotels, repositories etc. People might be tramped there for different causes should have opportunities similar to planned coal mines which have extra first-aid access galleries, shafts etc. and safer sheltered rooms.

CONCLUSIONS

Underground openings have their own working conditions. Mine gasses and stresses acting on them have been evaluated in rock mechanics together with mine design considerations. Besides precautions, enforced mining safety laws/legislations, there may be workplace accidents in underground mines. Moreover, underground spaces have been used for different purposes and responsible people acting for the managements of these occupations have not seemed to understand perfectly the difficulties of underground workplaces and its safety precautions in detail like mine engineers. Tunnels, depots, machine openings, caves, passageways, hotels, cities etc. are the ones where people have started to work in underground openings. Any accidents happened in these workplaces require "mine rescue team" like operations. Companies responsible from those workplaces should ask themselves if they are ready for accidents, as big as underground mine disasters. Victims injured terribly in underground accidents have mostly been handled by rescue teams which have only first-aid health experiences. If there is long distance to go out of underground, these victims might lose their life due to time required to transfer (carry) them to surface health facilities. In this paper, advance life support (ALS) service required in most of the underground accidents is put forward for evaluation. Special medical practitioners, medical doctors who have expertise on underground accidents might be the answers to save more life at underground accidents. They should be trained and equipped to act in underground, especially at underground accident sites. If there are gaps in legislation and in their work definitions, for the requirements of ALS, these facts should be evaluated in detail to regulate. Ethical responsibilities are belongs to underground design engineers for taking all possible precautions to save workers life in case of underground accidents. However, legislative people (*by applying joint works with mine & underground-space designer*) should also complete all possible (thinkable) rules/legislations for underground openings and involve possible mine accident cases including ALS applications for rescue operations.

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