O 51. OCCUPATIONAL WORK AND WORKPLACE SAFETY PARAMETERS AT QUARRIES

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ABSTRACT: Workplaces have been locations where people work for their earnings as employees. Occupational safety rules applied for work and workplaces have gradually regulated jobs to supply healthy working conditions. Mining law and related legislations applied for occupational safety of mines have also synchronized working conditions. Rules functional for safety precautions at mining workplaces have also arranged official relationships between employers and employees. Precautions listed for occupational work & workplace safety have activated engineers to focus on the risks of accidents. In this study occupational safety conditions for quarries have been studied to understand possible risks to decide about their preventions. In order to comprehend risks appeared at quarries, whole quarry operations had been analyzed for a selected quarry near Kayseri-Turkey. Results of risk analyses are supplied here to present the importance of safety understandings and safety cultures in mine related societies.

Keywords: Mine safety, Safety in quarries, Workplace safety parameters, Safety precautions for quarries

1. INTRODUCTION

Work and workplace health and safety rules have strictly been implemented in all sectors including mining industry for 50 years. Mining workplaces include underground mines, open pits and ore dressing facilities had been known as dangerous and workers in these workplaces were accepted as honoured members of societies but they certainly had short periods of life. Before World War I, industries in countries had been forced to produce their raw materials, semi and final products without thinking too much about the workplace health and safety conditions deeply. Statistics demonstrates fatal accidents occurred in different branches of works were clearly too many for those earlier years. For example, average numbers of men killed in quarries were 182, 146 and 136 in every 5 years time periods of 1911-1915, 1916-1920 and 1921-1925 respectively. In those years average numbers of men who had worked in quarries were 103740, 80682 and 91872 for the same time intervals respectively (Adams, 1929). These numbers present the importance of safety rules forced by current governments in the world.

Work & workplace health and safety rules have been accepted as general human right subject and related legislations and rules are influenced companies' productions positively in all working sides. Health is expensive assets in modern world even with supplying related compulsory insurances. Therefore, modern societies are asked safety culture from their members in all circumstances of their life. Thus, work & workplace safety conditions for quarry operations were selected to analyze in this study to compensate mentioned safety culture especially in quarry sectors in Turkey. Quarries are essential part of raw material supply chains of construction industry. Different sizes of broken rocks, usually limestone in Turkey, have been used mainly as an aggregated material in concrete mixtures. Some parts of them have also been used as roads' foundation and asphalt road cover raw materials. These coverage presents aggregated rocks wide spread usage in Turkey. Thus there are always quarries around new road construction sides and cities. Some of the quarries have been worked for a long time but, some of them are new in business. All the men related with quarries should be in a self-control state that, they must not accepted quarries as common workplaces where you can use loaders, mine trucks and rock crushers. Quarries which have men as a patrons, engineers, foremen and workers should be ready for all types of accidents. In addition, these people are required to equip themselves in a state of safety culture in their daily life as well. Quarries in fact, have big scale excavation, hauling and crushing machines which have usually been operated with harsh conditions. Thus mining men there must obey strictly law-enforced rules. Engineering decision parameters observed in quarries which influence the work & workplace safety have been analyzed here to show accident risks. Putting extra efforts to eliminate risky factors in quarries have definitely decreased workplace accidents. Then what can be the factors which raise dangerous working conditions were researched here to perform supplied risk evaluation method.

2. ACCIDENT STATISTICS

In general, analyses performed in most of the industry demonstrate that 95 % of accidents are originated through working men. In reality, workplaces are necessary locations to produce targeted products but, commodities should be supplied into markets without any accidents. These can be handled by engineered work-plans and organisations. Main motivations of accidents are given in Figure 1. There are three types of grounds in accidents, and they are basic, direct and indirect factors. Attitudes of managers, their professional behaviours, engineers in quarries and work & workplace conditions can be considered as basic influencing factors on accidents. Supervisions on works are mostly necessary in open pit mines. Close control of pits by engineers have usually decreased the number of quarry accidents in Turkey. Accidents have occurred through serious circumstances of small scale facts. Therefore, if one of these facts has been recognised in mine, then precautions must be handled to eliminate recognised ongoing accident factors.

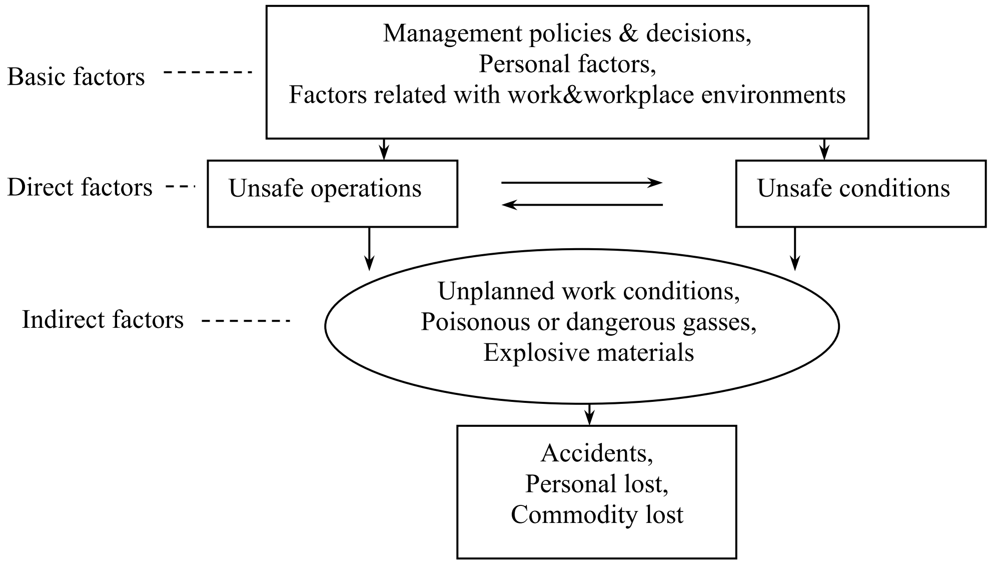

Figure 1. Main reasons of workplace accidents (Altay, 2015)

Physical, chemical, mechanical, dynamical etc. aspects influence quarry working conditions and sometimes create good, favourable, conditions for mine related accidents. In order to evaluate accidents, it is not enough to report the total number of accidents (accident statistics) at certain types of industry. That values can be used to understand level of accident occurances, but number of working men in the selected industries are also considered to realize their impacts. Table 1 includes numbers of occupational accidents in mining, metal and construction industries together with the numbers of working men in these sectors. This table shows that, number of occupational accidents in mining sector was smallest (10336 accidents) among these 3 sectors (for 2015) but, when accident numbers were compared with the numbers of sectors' working men, related ratio for mining industry was found highest.

Table 1. Accident statistics of Turkey including three different industry sectors for year 2015, (Bayraktar etal., 2018)

Industry sectors	Occupational accidents	Number of working men	Accident ratio (for every 100 men)
Mining	10336	128741	8.05
Metal	51327	1070162	4.80
Construction	33361	1980630	1.68

Sometimes researchers have supplied accident evaluations with respect to the size of the companies, (Table 2). In general size of the organisation is related with their proffessionality. Big mining companies in Turkey for example are governed by state owned organisations and big private cooperations (holdings). They have numereous employees, specialists and expert mine engineers together with shift mining engineers to produce their ore. Soma mine accident (Soma disaster) in Turkey (2014) showed that, scale of companies and number of foremen and engineers sometimes are not enough to prevent accidents if organisations and related controlling mechanisms are not pay their full attentions including all scientific and engineering rules.

Table 2. Company sizes in mining industry of Turkey in 2015, (Bayraktar etal., 2018)

Size of workplaces, companies	Share in all industry sectors, (%)	Share in mining sector, (%)
Big-scale	0.27	0.88
Middle-scale	1.80	5.25
Small-scale	12.52	31.03
Micro-scale	85.41	62.84

Arslanhan & Cunedioglu (2010) wrote that due to several influencing parameters (paying less attentions on work & workplace health and safety details, cost of experts in mining, cost of experieced workers etc.), mining sector has become more dangereous sectors. Table 2 presented that micro-scale mining companies (workplaces) are widespread and they constitute more than half of the sector (62.84 %). When we think micro-scale and small-scale companies in mining sectors they form 93.87 % of workplaces together in Turkey. This value is very important during mine accident evaluations. Mining engineers who work for micro or small scale companies should then be more carefull on causes of accidents and they have to decide carefully about their precautional works. Quarries in general mining operations can be considered as micro or small scale mining workplaces according to the size of the quarry operations. One of the researchers who evaluated quarry operations and related accidents was from Kenya. Wanjiku (2015) worked on occupational health and safety hazards associated with quarrying activities at a quarry in Kenya. Wanjiku reported that; the European Agency for Safety and Health at Work (EASHW, 2008) had stated; "*the quarry workers are twice as likely to be killed in an accident at work as construction workers, and 13 times more likely to die at work as those in manufacturing industries*". Wanjiku noted also; "*In France about 44% of all fatal accidents in 2002 were related to quarrying while in Germany, between 1999 and 2003, 48% of all accidents reported were from the quarrying sector, (ILO, 2005)*".
What can be the causes of accidents in quarries. These parameters are main research considerations in related studies. Alejano etal. (2008) supplied their reasonings for fatal accidents occurred for open pit aggregate mining in Spain (Fig.2). According to their paper, ANEFA (Spanish Association of Aggregate Producers) supplied data that they pointed 9 main accident causes for Spanish quarries. These data presented that most effective causes in fatal quarry accidents in Spain (for 1987-1995 time period) were; "rock fall", "toppling or falling of machines", and "falling from equipment or facilities". The other causes were; "trapping in equipment or facilities", "running overs", "falling of objects over persons", "falling of workers through slopes", "electricity" and "others".

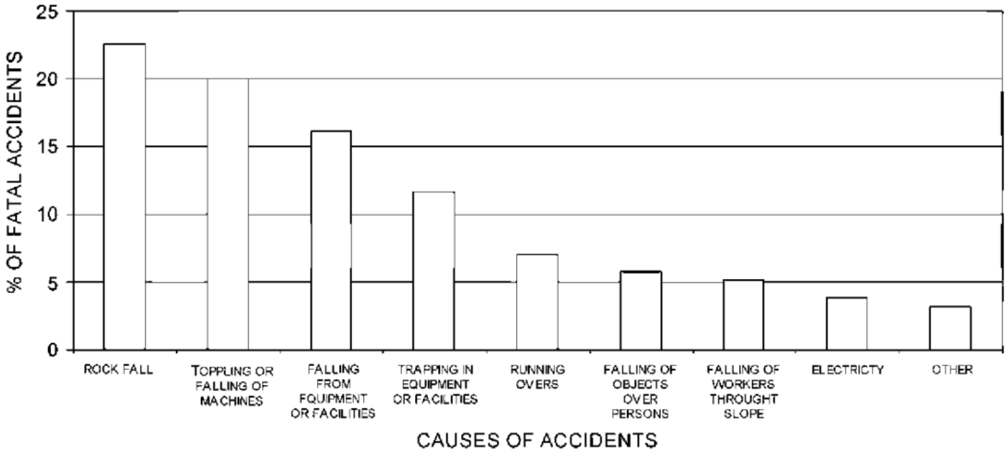

Figure 2. Causes of fatal accidents in open pit aggregate mining in Spain (for 1987-1995 time periods, data reported by Spanish Association of Aggregate Producers), (Alejano etal., 2008)

In order to understand work & workplace accidents, comparisons among quarries and other industry sectors, report supplied by Queenland (Australia) Government migth also be helpful. Mining sector influence *(as a production capacity and number of men worked in the sector)* has gradually decreased in European countries for 40 years. Therefore, data from Australia, China and US have more recent working conditions for mines. Figure 3 showed that there is no distinct relation between size of the industry and the frequency rate of fatalities (in accidents). According to QMQSP, (2017), *"increases in fatalities have occurred during periods of industry growth, as well as construction*". Queensland Government (Australia) supplied numbers of accidents (Fig. 4) in mining sector for 2014-2017 time period.

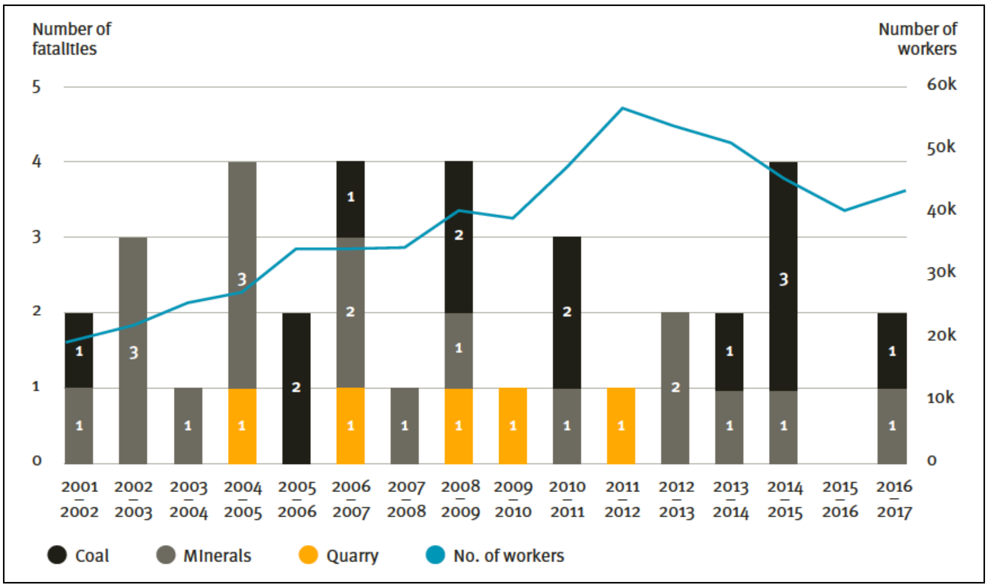

Figure 3. Numbers of fatalities in mining sector together with numbers of workers in Queensland (Australia) for 2001-2017 time periods, (QMQSP, 2017)

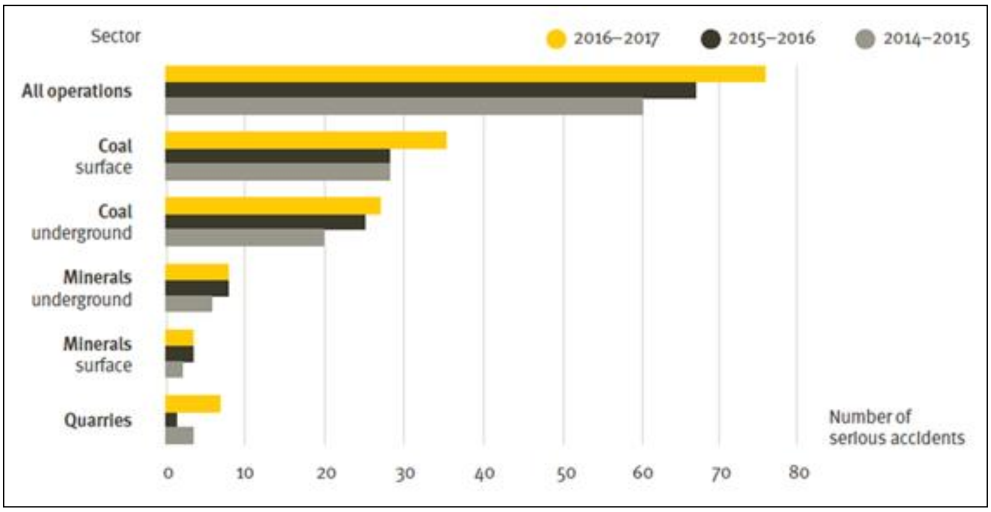

Figure 4. Numbers of "serious mine accidents" (in different operations) in Queensland (Australia) for 2014-2017 time period, (QMQSP, 2017)

According to their classification "serious accident" refers insidents where working men who involved in accidents are "requiring admission to hospital as an patient and exclude fatalities", (QMQSP, 2017). This figure (Fig. 4) illustrated that number of serious accidents in quarries of Queensland were higher than mineral ore open pit mining operations for 2016-2017 time period. In Queensland (Australia), there were; 1464 workers, 992 employees, 472 contractors, 216 quarries in production, 43 quarries in care & maintenance, 49 quarries in infrequent operations. These quarries have no fatal accident in 2016-2017 time period but, 6 "serious accidents" and 64 "high potential incidents" were occurred. Figure 5 summarized "high potential incidence" according to hazard types. Due to vehicle, excavator and mine truck usage for overburden and rock mass moving in quarries, their collision insidents were in high level with respect to other accident types.

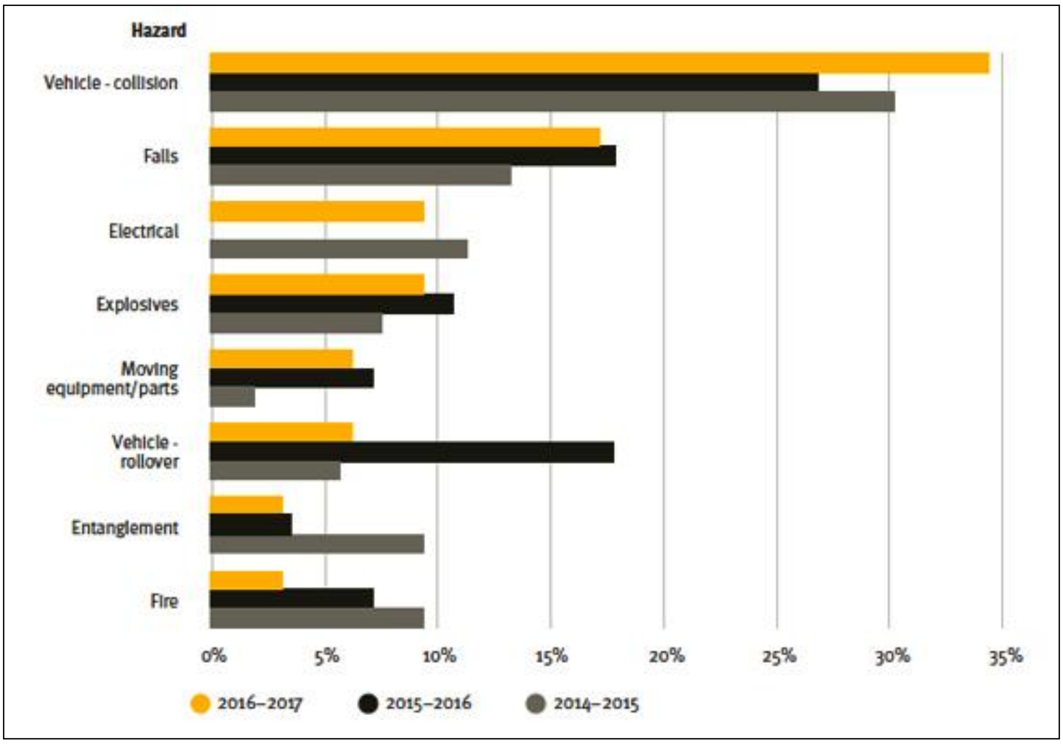

Figure 5. High potential incidents by hazard type in quarries in between 2014-2017. In these graph only the top 8 occuring catergories have been included by (QMQSP, 2017)

High level of work&workplace alerts in government offices, general cultural background for workplace safety, health insurance costs in Queensland may force companies to record almost all minor & major insidents occured in quarries. Actually, statistics supplied through different goverment offices have some degree of biases about workplace accidents. Countries which have separated private companies for; workplace safety controls; workplace preliminary inspections; workplace insurances; workplace health caring services etc. might be more effective about work&workplace accident recordings. Employees usually are members of lobour sendicates and these sendicates record carefully all incidents and accidents for the behalf of their members. Fatal accident statistics supplied for 3 different industry sectors of Turkey (for 2015) is given in Table 3. It shows fatality ratios for every 100000 working men in each sector. These industry sectors in Turkey have been selected due to their high fatal accidents and high fatality ratios. According to supplied data; highest number of fatality ratio was determined for mining sectors and it was 61.4 accidents/(100000 working men). This value was 23.9 for construction industry and 8.8 for metal industry in Turkey.

Table 3. Fatal accident ratio per 100000 working men in three main industry sectors of Turkey (for a calendar year; 2015), (Bayraktar etal., 2018)

Industry sectors	Occupational accidents	Number of working men	Accident ratio (for every 100000 men)
Mining	79	128741	61.4
Construction	473	1980630	23.9
Metal	94	1070162	8.8

3. MATERIALS AND METHODS

Accident risk factors evaluated in literatures have been analyzed in this study to rate quarries in Turkey. At the beginning of such a work, responsibilities of all employees are analyzed by considering applicable current legislative rules in Turkey. As a researcher, factors influencing the quarry products (aggregated and sized rock materials) have been observed in a test quarry to understand actual conditions. In addition, critical approach for every operation in selected quarry resulted in decision parameters qualifications. Creative thinking about quarry operations results in different possibilities of accidental cases. According to these cases, quarry administration & engineers can develop their own accident precautions. Factors that may influence the *"causes of expected (but unwanted) accidents"* should be established for more detail analyses of their appearances. Are they human depended factors? Do they include any machine or procedural features? These and similar questions should be considered to catch "the causes of expected accidents in quarries". These parameters can also be analysed by using fish-skeleton type (Fig. 6) presentation charts. This chart helps engineers to think deeply about the accident cases together with their causes and related decision parameters.

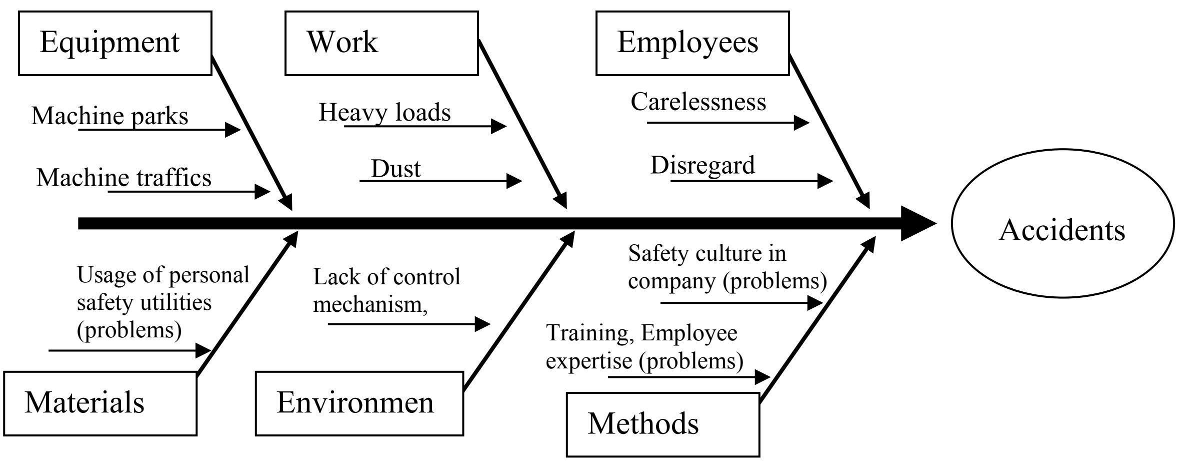

Figure 6. Fish-skeleton type reasoning for expected (synthetic) quarry accidents

In order to evaluate causes of expected quarry accidents, selected quarry's 3D location plan were checked and strugle points in terms of; *elevations, vehicle-vehicle cros-passages, vehicle-pedestrian cross-passages, rock slopes, types of rock failures concluded according to rock discontinuities, dangereous locations where the slope failure are excected etc.* should be determined. In order to rate safety considerations that may arise in selected quarry, "L-type risk evaluation and decision matrix" was used in this study, (Table 4). For the selected test quarry, (basalt quarry near Kayseri-Turkey); machines, vehicles, offices, natural plants&creatures, water bodies, environmental facts, related legislations etc. have been evaluated for the quarry's safety conditions. Table 5 illustrates accident probability cases and their classifications in terms of probabilistic level of occurances. These classes are usually decided by expert engineers who have enough information and knowledge about quarries working conditions. After analysing all presumptional cases including accident precautions and actual facts related with works&working conditions of analysed quarry; If the conclusion points inevitable "accident"; what will be the results then.

Table 4. L-type risk evaluation matrix, (Ceylan & Bashelvaci, 2011).

Level of harmness → Probability of occurance ↓	**Very low (1)**	**Low (2)**	**Middle (3)**	**High (4)**	**Very high (5)**
Very low (1)	Too low, Tolerable (1)	Too low, Tolerable (2)	Low (3)	Low (4)	Low (5)
Low (2)	Too low, Tolerable (2)	Low (4)	Low (6)	Middle (8)	Middle (10)
Middle (3)	Low (3)	Low (6)	Middle (9)	Middle (12)	High (15)
High (4)	Low (4)	Middle (8)	Middle (12)	High (16)	High (20)
Very high (5)	Low (5)	Middle (10)	High (15)	High (20)	**Very high Untolerable (25)**

Table 5.Probability designation for expected accidents. If accident is inevitable, the resultant facts can be classified in 5 categories (Ceylan & Bashelvaci, 2011)

Probability	Accident probability	**Results**	Classification
Very low (1)	Never	**Very low (1)**	No lost of working days; Emergency health care
Low (2)	Very a few (once a year) abnormal case	**Low (2)**	No lost of working days; No permanent effects; Care without hospitalization
Middle (3)	Low (a few cases per year)	**Middle (3)**	Minor wounding; Hospitalization necessary
High (4)	Frequently (once a month)	**High (4)**	Serious wounding; Hospitalization; Long-term treatment
Very high (5)	Very frequently (once a week, in every day, in normal working days)	**Very high (5)**	Fatal accident; or workers permanently out of jobs

Table 5 shows "result classifications" for expected accidents. These results should be predicted early enough to handle required precautions. The results presented in Table 5 *(which no one would like to experience)* are in fact, the reality of the accidents and their results on employees. For the case of selected quarry, expected accident cases have been evaluated to understand risky parameters for the tested basalt quarry. The evaluations are as follows;

i. In this quarry, different machines, vehicles and employees (pedestrians) move in the same pit for different purposes. Machines for this quarry were planned and handled for heavy excavation, loading and hauling steps. Therefore size of the rock blocks, rubbles, sometimes can be big enough to harm employees. Rolling over might be one important accident cause. [Probability of accident occurrence: Low (2), Expected results: High (4) or Very high (5)].

ii. Personal safety utilities which employees have to use at workplaces of quarry should be reinforced. For example any men in the pit should wear helmet other than the office rooms. Helmets protect employees from any falling and flying (small) rock pieces or materials. [Probability of accident occurrence: Low (2), Expected results: High (4)].

iii. Dusts originated due to quarry excavations and truck movements (on pit roads) may create hazardous circumstances for employees' health. Dusts sometimes eliminate clear view which is important for drivers and excavator operators. Water spraying is one practical solution for dusts. [Probability of illness and accident occurrence: Low (2), Expected results: Low (2)].

iv. If there is any accident case in this quarry, quick responded rescue team should always be ready to handle the situation. This team includes first-aid health service should be trained regularly to update their knowledge and readiness. [Probability of accident occurrence: Low (2), Rescue team readiness: Ready].

v. Experts should controls all facilities in quarry "service-sides" including all the machines and vehicles park sides, offices, stores, for fire control facilities, electrical water appliances. They should not create any causes for accidents. These control actions should be organised and performed in regular bases. [Probability of accident occurrence: Low (2), Expected results: High (4)].

vi. Quarry slopes should be controlled daily bases for their stabilities. In any case of instability, dangerous locations, preliminary support or controlled excavation procedures should be applied to eliminate danger of rock falls or slope failure cases. [Probability of accident occurrence: Low (2), Expected results: High (4)].

vii. In quarries, excavation machines are big machines so their park areas and small control vehicles' park sides should be different. At excavation sides in the quarry, any service vehicle should definitely be parked away from those machines. [Probability of accident occurrence: Low (2), Expected results: High (4)].

viii. Safety related announcements, signboards and banners should be big enough and firmly attached to their locations. They should be clearly seen. Safety signboards should be written in basic-understandable language. Employees have to be trained for the seriousness of these signs. [Probability of accident occurrence: Low (2), Expected results: Middle (3)].

4. CONCLUSIONS

Quarries are operated to supply aggregated material for construction industry. Therefore, aggregated materials should be economical enough to be used in concrete mixtures for instance. Some aggregates are used as railroad ballast and some of then used for road foundations. Most of the quarries are open pit mines and they are not so deep, that means they have limited slope benches. When the depth of quarry pits is getting deeper, the costs of operations are getting higher as well. So companies have surely checked other rock mass reserves for suitable and economical new quarry locations. In general accidents in quarry operations are originated due to machine usage, rock falls and falling from slopes. Commonly they are caused due to lack of attentions. Vehicles, mine trucks and excavators used in quarry operations are technologically high in standard. If their maintenances and services are also made in required time periods, they produce very limited opportunities which cause inevitable accidents. Most of the accidents in quarries which include humans, machines, excavators and vehicles interactions are related with human factors. Therefore employees in quarries should be trained in a way that they must measure their attitudes and attentions during workdays. They should be in level of professionalism that, they may decide themselves to stop working immediately in case of any lost of carefulness. It was also revealed that training of the employees for their safety is not enough to protect them from accidents. They should have eager to obey safety rules. Employees and any other men who do not carry personal safety utilities should not be allowed to enter quarry operation sides. Employers, employees and even daily-visitors of a quarry companies should understand importance of the safety rules. Basic health and safety requirements which companies have to implement at their quarry operations need extra spending of money, (increase the cost). Thus, costs of quarry operations may increase due to engineered operations and actions *(including: water spraying at rock crushers, water spraying of pit roads, slope stability precautions, efficient blast requirements, personal safety utilities, training for first-aids, training for rescue operations, traffic control in pits, putting signboards and banners in necessary locations, safe electric and water appliances, safe office buildings at safe locations, training of engineers and foremen, asking safety or stability reports from referenced professionals etc.).* However, in long time periods, these actions have positively influenced the safety of the quarries.

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