Implementation of Risk Assessment Techniques to Coal Mines in Turkey

Celal Karpuz
Middle East Technical University (METU)
Dept. of Mining Engineering, Ankara, 06531 Turkey
karpuz@metu.edu.tr

Ayº e Sevtap Selçuk
METU, Dept. of Statistics, Ankara, 06531 Turkey
sselcuk@metu.edu.tr

Mehmet Sarý
METU, Dept. of Mining Engineering, Ankara, 06531 Turkey
mesari@metu.edu.tr

Taylan Bozdað
METU, Dept. of Mining Engineering, Ankara, 06531 Turkey
taylan@metu.edu.tr

1. **Introduction:** Turkey is one of the countries experiencing mine accidents most frequently. Mining activities include material, equipment, human resources and environment where the potential risk of catastrophic losses is very high. Accidents in coal mines are can not be diminished easily but can be controlled by several techniques. The assessment of risks and the determination of proper risk control methods for mining applications become a requirement for decreasing the unpredicted costs and increasing the job safety. These techniques require the careful evaluation of the systems, their components, the factors affecting the functioning of these components and the role of these components in the whole system. Risk management technique is an approach to identify all potential hazards with respect to cause-effect manner and to emphasize the most appropriate technique to handle these risks (Kýzýl and Joy, (2000)).

The aim of this paper is to develop a statistical model for the risk assessment of the coal mines in Turkey in order to develop a strategy for reducing their undesirable results. Historical data for two major lignite coal mines in Turkey, Tunçbilek (GLI) and Soma (ELI) Coal Mines, are taken into account. A recent study has been done by Selçuk et al. (2000) to analyze accident data for GLI occurred last 6 years has shown that categorization of risk will enable investor to minimize the loss and develop strategies for maximizing the profit as well as making the working environment safe for the employees.

2. Statistical Modeling: The number of accidents (frequency) and the days lost (severity) are taken as the basic variables. Statistical distributions of frequency and severity are derived and found to follow Poisson and lognormal distributions, respectively, for the proposed coal mines. The significancy of these distributions have been tested and approved by a Chi-square goodness of fit test and by Q-Q plots. Based on this, for GLI coal mine, frequency has an average rate of 0.44 accident/day. The probability of mine's accident free operation for a day is 64%, for a week is %5 which is quite small. That is, the probabilities of having an accident for any day and for any week are equal to 0.36 and 0.95, respectively. Also, expected time between two consecutive accidents is around 2.27 days. Severity has a mean rate of 10.8 days with σ^2=10.8 days, that is, the days off for any employee working in the mine because of an accident is 10.8 days on average. ELI data for years 1996-1999 yields the frequency of accident having an average rate of 0.72 accidents/day. With %48 and probability the mine will experience no accident in a day and with 35% probability occurrence of exactly one accident per day is expected to appear. The distribution of days lost is the

same as GLÝ with mean value of 8.27 days and σ^2=9.26. It can be concluded that average rate of days off from work resulting from an accident in ELI is smaller than what was found for GLI.

The data set for two mines are also analyzed by the risk classification schemes to identify which factors are dominant in accidents. The method proposed by Davies (1997) applied to accident/injury type, accident/injury location, job title and body part (Selcuk et al., 2000). These factors contains considerable large amount of occurrences allowing satisfactory statistical analysis. Risk screening of selected factors has shown that the risky factors for both mines agree on the same factors causing the accidents. For the injury types falls of ground, struck by or falling object and handling material, for the injury location face area, roadways, for the job title the coal winners and for the body parts hand, foot and the main body are found to be the high risk factors.These two coal mines do not indicate big differences in principle. However, ELI prones more number of accidents than GLI but, severity on average is smaller than GLI.

For deriving the linear the relation among the random variables, regression model has been fitted to the following random variables: the number of labor (X_1), coal production (X_2), the number of woking days (X_3) and the number of accidents (X_4). The linear relationships are as follows:

$$\text{Days Lost} = -54.37+0.14X_1+0.001X_2-0.0071X_3+15.39X_4 \quad (1)$$

$$\text{No. of Accidents} = -21.56+0.018X_1+0.000074X_2+0.00025X_3$$

The linear models are significant statistically and yields a reasonable predicted values for the dependent variables.

This ongoing study proposes analysing the random occurrences in terms of statistical models. Risk assessment approaches in statistical modelling, stochastic evaluation of the random occurrences and decision tree-approach for the evaluation of conditional probability distributions will be examined as future study.

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RESUME: Cette étude propose une étude comparative pour concevoir un modèle de risque pour les mines de charbon souterraines dans la Turquie. Les incertitudes dans les apparences de pertes sont identifiées et sont modelées en utilisant des methodes stochastiques et des techniques d'évaluation de risque sont exécutées en utilisant des techniques de risques classiques. Deux hautes mines de charbon de capacité, Tunçbilek (GLI) et Soma (ELI) sont choisis comme pilote des systèmes. En utilisant les données d'accidents de six dernieres années, l'information apriori est utilisée pour dériver les modèles proposés.