A STUDY ON THE CORRELATION BETWEEN GROUND SUBSIDENCE AREA NEAR ABANDONED UNDERGROUND COAL MINE AND GEOPHYSICAL PROSPECTING DATA USING GIS

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ABSTRACT:

To estimate presumptive local ground subsidence area near Abandoned Under ground Coal Mine(AUCM) at Samcheok city in Korea, the geological properties of existing ground subsidence area and the geophysical prospecting data were analyzed using GIS. The electrical resistivity survey and seismic reflection survey database were constructed from investigation reports and factors which are related with ground subsidence such as geological map, topological map, land use map, lineament map, groundwater level, RMR (Rock Mass Rating), mining tunnel map and slope database were constructed also to make a comparative study of each parameters. As a result of the spatial analysis of existing ground subsidence area, 9 major factors causing ground subsidence were extracted and a connection between the structure of underground and the ground subsidence was determined from the analysis of geophysical prospecting data. The estimation of presumptive ground subsidence area was performed using the correlation between the result from neural network analysis of 9 factors and the scrutiny of geophysical prospecting data.

KEY WORDS: ground subsidence, abandoned underground coal mine, geophysical prospecting data, GIS

1. INTRODUCTION

Since 1989, almost all of underground coal mines were abandoned and few are remaining, and the occurrence of ground subsidence around abandoned coal mine area has become a serious social problem in Korea recently. However, quantitative assessment of predicted ground subsidence area is difficult especially in coal mining area where structure of geology is very complicated. To predict the probability of ground subsidence empirically with (1)intact strength of the rock, (2)stress field, (3)geological structure of the rock, (4)depth of the mining horizon, (5)areal extent of mining, and (6)volume extracted per unit area of mining was suggested within surprisingly narrow limits considering the form of the input data (Goel, 1982). The National Coal Board published a basic technique to find out estimated area of influence by ground subsidence with height of cavity, width of mined panel and inclined angle of coal seam (National Coal Board, 1975).

The prediction method for subsidence area is very dependent on a structure of local geology and coal mining method, but above empirical methods were developed under condition of horizontal coal seam and longwall working dominant in Europe. In Korea, due to the mixed structure of geology there are various widths of coal seam, irregular inclined angle of coal seam and strata and slant-chute block caving method has been using. As a result, a sink-hole type subsidence is general therefore, another estimation method of regional ground subsidence is necessary.

Initial quantitative assessment of ground subsidence near abandoned underground coal mine at Samcheok city in Korea using GIS and Neural network analysis was conducted to predict the ground subsidence area (Kim, 2005). The purpose of this study is to perform a comparative analysis between the predicted ground subsidence area and the scrutiny of electrical resistivity and seismic reflection survey data of existing subsidence area adjacent to the predicted area using GIS at Samcheok city.

2. GEOLOGICAL SETTING

The coal resource of South Korea almost consists of anthracite and 85% of them had been deposited during the upper Paleozoic era and the lower Mesozoic era in the Jangseong Formation of the Pyeongan Supergroup (Geological Society of Korea, 1999). The study area is located around the Nampoong gallery on the Jangseong Formation. Along the study area the Oship fault, the Oship creeks, Youngdong rail road, and no. 38 local road pass by (CIPB : Coal Industry Promotion Board , 1999).

The location map and electrical resistivity survey and seismic reflection survey lines of this study appear in Figure 1.

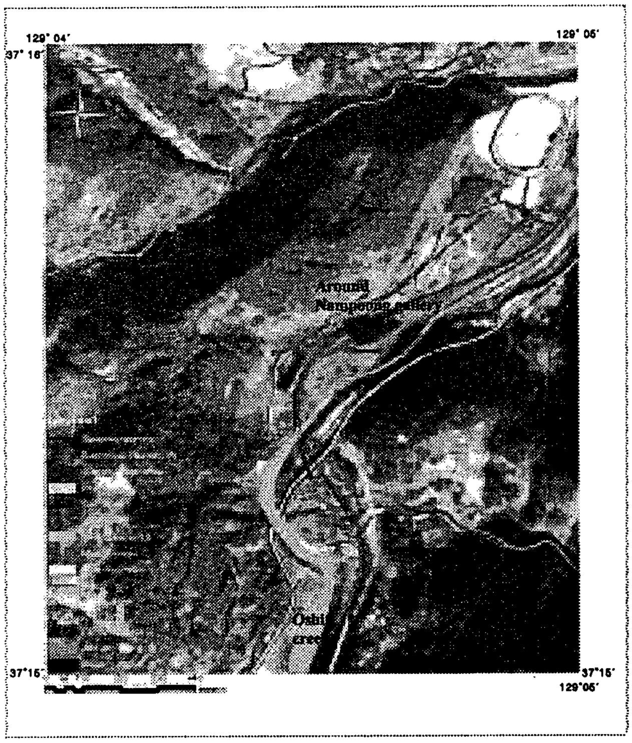


Figure 1. Location Map of Study Area.

3. METHOD AND DATA

This study was conducted with calculated weights from backpropagation neural network analysis and the review of seismic reflection and electrical resistivity survey data using GIS. Image database and attribute database concerning about ground subsidence were constructed and analyzed by ArcGIS. One for each line were selected among 6 electrical resistivity survey lines and 3 seismic reflection survey lines near Nampoong gallery, and the analysis of underground structure from them was compared with the ground subsidence area.

3.1 GIS Database

Many studies indicated important factors related with ground subsidence around coal mines(Waltham, 1989). Table 1. shows factors commonly affect the sink-hole type ground subsidence according to time (CIPB, 1997).

Table 1. Factors Affect Sink-hole Type Ground Subsidence.

Occurrence of Ground Subsidence	Progress	Ground Collapse
During time after abandoned mine →		
• Mechanical character of Rock mass • Flow of ground water • Structure of geology (joint, fault, dyke) • Caving method • Rate of caving • Back filling	• Flow of ground water • Structure of geology • Rate of cubical expansion • Rate of mining	• Mining depth • Height of cavity

Refer to above factors the image and the attribute database of existing ground subsidence area were constructed as displayed in Table 2.

Table 2. Constructed GIS Database Including Factors Connected with Ground Subsidence of Study Area.

Category	Factors	Remark
Geology	Geology	Type of strata
	Lineaments	Bufferig of fault line
Topography	DEM	TIN process to get elevation data
	Slope	Analyze slope by degree
Land use	Land use	Classification of 12 landuse types
Mining Tunnel map	Depth of drift	DEM minus Water level of drift
	Height of drift	Disregard this factor. Almost 2.5 ~ 3m along the study area
Borehole*	RMR	IDW Interpolated from 28 bore holes
	Ground water lever	IDW Interpolated from 24 bore holes
	Permeability	IDW Interpolated from 25 bore holes

*35 boreholes from investigation in 1999, some boreholes do not have value of relating factors.

Most literatures said that major factor of ground subsidence is scope of mined cavities. Therefore, constructing database of depth and width of mined cavities is very important work during this study. To achieve the object, (1)GPS measurement was used to find out an exact position of a minehead and (2)vectorizing a hard copy of mined tunnel map with it. (3)After converting the vectorized mined tunnel map to an ASCII grid file, minus it with DEM raster data. There were 35 boreholes at the study area but some boreholes did not have values, so Inverse Distance Weighting(IDW) interpolation method was used to contour the value and reclassified it using ArcGIS. Then, weights result from neural network analysis were given to the above factors separately to produce a presumptive ground subsidence area map as shown in Figure 2 (Kim, 2005).

Figure 2. Analysis Map of Presumptive Ground Subsidence Area with Weights Result from Artificial Neural Network Analysis.

3.2 Electrical Resistivity Survey Data

Among the various geophysical exploration methods, electrical resistivity survey has been used widely in the field of prospecting the metal deposit, coal mine and ground water. With that method we can get information about the electrical resistivity distribution of the subsurface using the various arrays of electrode (Ward, 1990). It is very hard to analogize the lithofacies of underground directly from the electrical resistivity, however we can recognize it from the relative difference between them. Generally, the sheared zone or fault zone has lower resistivity than circumference because it contains fluids such as clay minerals, ground water, etc. and pores of them act as a good conductor(Van Nostrand and Cook, 1966). There were 6 dipole-dipole array lines within study area to survey but only 1 line was selected to compare with ground subsidence.

Figure 3. shows a result that low resistivity zone at the depth of about 15m from the surface, and it can be analyzed as the slackened zone due to the gobs formed by excavations. Another result shows that possible extended cavities exist at the depth of 40~55m which are not recorded in the mined tunnel map of study area.

3.3 Seismic Reflection Survey Data

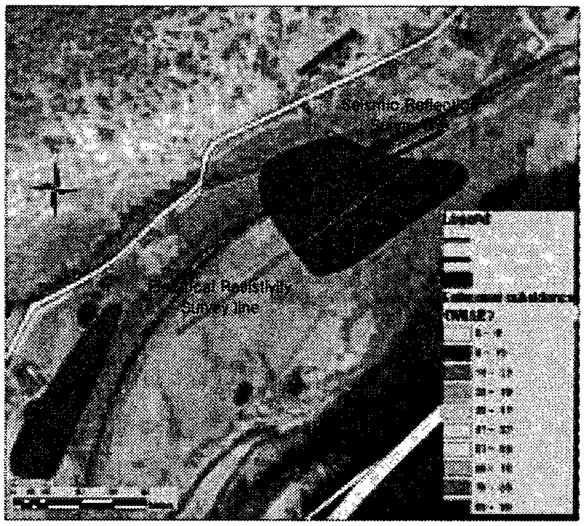
The high resolution shallow seismic reflection survey has been strongly used for the close examination of underground geological structures in the field of civil and architectural engineering since 1980's(Steeple and Miller, 1998). For the interpretation of underground structure in the subsidence area with the analysis of seismic wave velocities, seismic reflection survey was performed for 3 lines along Youngdong rail road around Nampoong gallery. Among them 1 survey line near ground subsidence area was analyzed for this study.

Figure 4. summarizes that the reflection events in the first layer(depth of 50~60m) is corresponding to the same depth of mining tunnel and some area under survey line seems to affect the first layer according to the serious fracturing, because the seismic survey data showed no continuities of reflector and severely disturbed signal.

4. RESULSTS AND FURTHER STUDY

As shown in Figure 2., the accuracy of coincidence between the actual subsidence area and the estimated subsidence area is almost more than 75%, so quantitative analysis of the estimation of ground subsidence area around coal mines using GIS might be possible. According to the comparative study of electrical resistivity survey data and seismic survey data with the ground subsidence area, it seems very effective to verify the assessment of presumptive ground subsidence area with them. Especially, the electrical resistivity survey data showed close affinities in the interpretation of estimated subsidence area.

For further studies, the reliability inspections for the 9 factors relating to ground subsidence with probability and statistical method are required and the relations with other factors are to be considered also. The geophysical surveys in this study area were conducted in 1999, so the field survey and a new geophysical survey near estimated ground subsidence are will be demanded. Figure 3. and Figure 4. show the result of the correlation between the estimated subsidence area and the electrical resistivity survey data and the seismic survey data respectively.



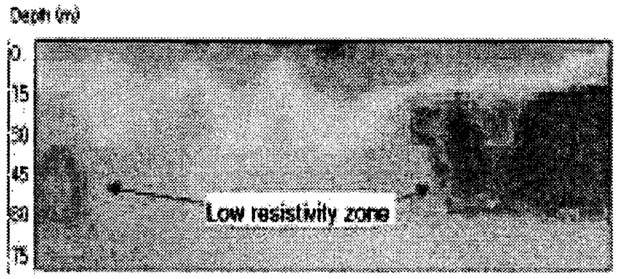


Figure 3. Analysis of the Electrical Resistivity Survey

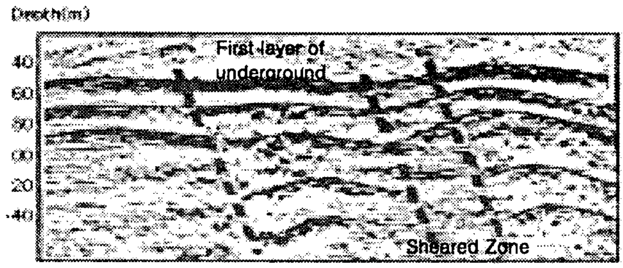


Figure 4. Analysis of the Seismic Reflection Survey

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