Synthesis Subsidence Prediction Method due to Underground Mining integrated with GIS

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Background and Purpose

Surface subsidence due to underground mining is a major problem, especially when stratified deposits are completely extracted. Tensile and compressive strain, vertical and horizontal displacements develop at the surface due to the collapse of the longwall cavity. To predict subsidence on the large extraction area, complex seam layers, time dependence and three-dimensional visualization are main difficulties encountered in solving problems.

The purpose of this research, to propose a method for predicting surface subsidence due to underground mining integrated with Geographic Information Systems (GIS).

1. GIS-Based Subsidence Prediction Method

Stochastic model for predicting mining subsidence

The stochastic model assumes the rock mass as a stochastic medium to explain ground displacement behavior associated with mining subsidence The development of movement in a stochastic medium can be explained in terms of a rhombic packing of spheres as shown in Figure 1. If the sphere in field C is removed, a neighboring higher sphere from field A or B can only fill the vacant space.

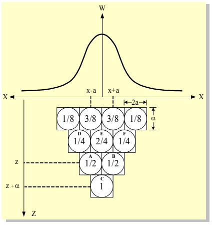


Figure 1: Development of movement in a stochastic medium

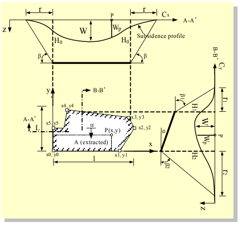


Figure 2: Irregular extraction of panel with subsidence profiles

The fundamental stochastic model can be solved for tabular evaluation of irregular working panel in flat-lying measures (Fig. 2). The calculation point *P* (*x*, *y*) being located at the origin of the local coordinates, the subsidence of a surface point *P* can be derived as follows:

$$W_P(x,y) = W_{\max} \cdot C_x \cdot C_y,$$

Influence function method for calculating subsidence at surface points P(x,y)

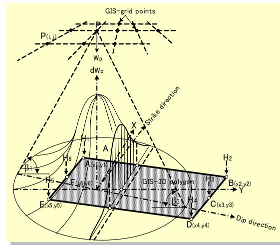
$$W_{\max} = a \cdot m \cdot z.\cos\alpha,$$

Empirical method for predicting maximum subsidence

$$C_x = \frac{1}{\sqrt{\pi}} \int_{\sqrt{\pi}\cdot\frac{x-l}{r}}^{\sqrt{\pi}\cdot\frac{x}{r}} e^{-\lambda^2} d\lambda, \quad = \frac{1}{2}\left(erf\left(\sqrt{\pi}\cdot\frac{x}{r}\right) - erf\left(\sqrt{\pi}\cdot\frac{x-l}{r}\right)\right),$$

$$C_y = \frac{1}{\sqrt{\pi}} \int_{\sqrt{\pi}\cdot\frac{y-L}{r_2}}^{\sqrt{\pi}\cdot\frac{y}{r_1}} e^{-\lambda^2} d\lambda, \quad = \frac{1}{2}\left(erf\left(\sqrt{\pi}\cdot\frac{y}{r_1}\right) - erf\left(\sqrt{\pi}\cdot\frac{y-L}{r_2}\right)\right).$$

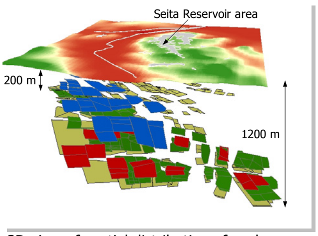
Profiles function method for calculating subsidence profiles (Cx and Cy are subsidence trough in x and y directions)



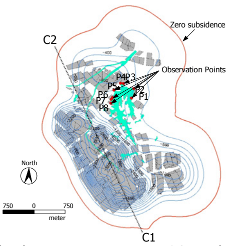
Illustrating 3D GIS-polygon for calculating subsidence at GIS-grid points

2. Mining Subsidence Prediction and Simulation

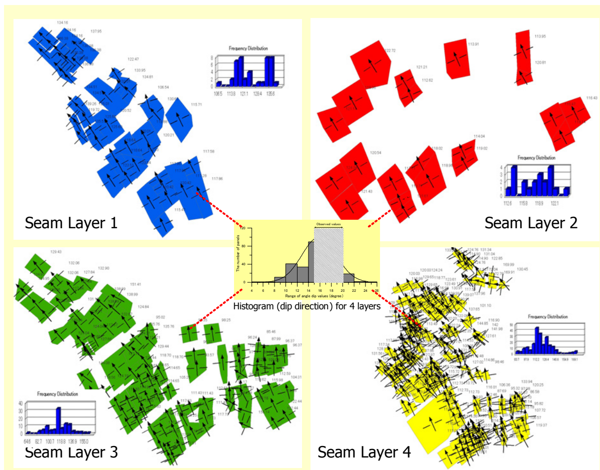
A case study: An abandoned mine in Seita Reservoir area, KitaKyushu, JAPAN



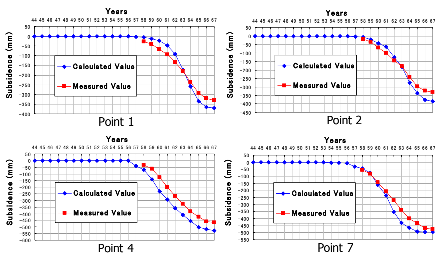
3D view of spatial distribution of coal seam layers with DEM around Seita reservoir area



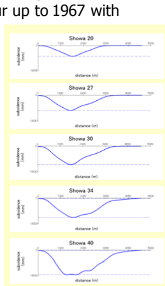
Subsidence contour up to 1967 with observation points



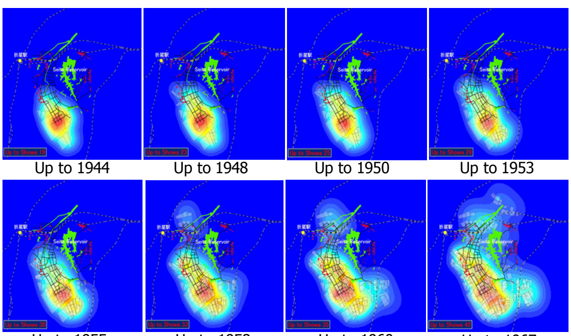
GIS analysis for panels inclination (Strike and Dip directions)



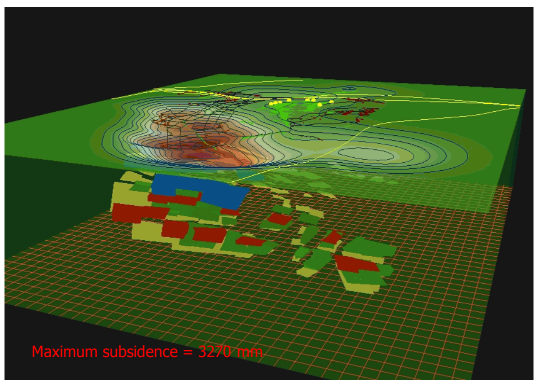
Comparison of calculated and measured subsidence value



Subsidence profiles simulation (C1-C2)



Sequential subsidence calculations simulating the excavation process between 1944 and 1967



3D view of final subsidence model and underground mining layers in GIS

Conclusions

The proposed method can predict maximum subsidence, subsidence profiles, and spatial distribution of subsidence along any directions with induced large complex underground excavation layers. With the help of GIS functions, it is possible to analyze complex seam layers for accurate input parameters and effectively organizes data on large extraction area specifically in case of time-dependence.

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