VERIFICATION OF MODEL DESCRIBING TEMPORARY AREA SUBSIDENCE

VERIFIKACE MODELU POPISUJÍCÍHO POKLES AREÁLU V ČASE

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Abstract

In this paper results of geodetic measurements, related to subsidence of area caused by mining provided on depth of 500 m – 800 m, were analyzed. Analysis of measurements results were firstly used to calculate values of S. Knothe's parameters, taking into account final mining subsidence. Values were calculated twice: taking into account periphery and not considering it. Further part of analysis of measurement's results was related to course of subsidence of chosen points in time. Author's model was used to describe temporary subsidence values. Identification of values of model's parameters was provided using appropriative software. Then, calculated course of subsidence of chosen points was compared to this proved by geodetic measurements. High accuracy of obtained courses proves practical usefulness of used model.

Abstrakt

V této práci jsou analyzovány výsledky geodetických měření, která mají vztah k poklesu půdy v důsledku dolování, které je v hloubce 500 až 800m. Rozbory výsledků měření se nejdříve použily k výpočtu hodnot Knotheových parametrů; braly do úvahy výsledný pokles způsobený dobýváním. Hodnoty se počítaly dvakrát; uvažovaly se hranice dobývacího prostoru a neomezený dobývací prostor. Další částí analýzy výsledků měření bylo hledání průběhu poklesu na vybraných bodech v čase. Autorův model se použil pro popsání hodnot poklesu v čase. Stanovení hodnot parametrů modelu umožnil vhodný software. Pak vypočtený průběh poklesu u vybraných bodů se srovnal s poklesem podle geodetických měření. Vysoká přesnost vypočtených průběhů poklesu dokazuje praktickou použitelnost použitého modelu.

Keywords

mining subsidence over time, transient state, new mathematical model

Klíčová slova

pokles způsobený dobýváním v čase, přechodný stav, nový matematický model

1 Introduction

Economic and ecologic regards oblige us to minimize mining's influence on environment. Deciding to provide mining works according to specific project should be dependent on properly provided analysis of mining subsidence conditions in concerned area. This analysis should also take into account temporary values of mining subsidence rates. Therefore, we should also take into consideration subsidence kinematics. One of available mathematical models is article author's model (Strzałkowski, 1998).

$$\frac{dw}{dt} = c(t) \cdot \left[w_k(x, t_k) - w(t) \right] \qquad (1)$$

For a discrete model (w_k=const.), provided that c = c (t), a few simple mathematical transformations leads to the following dependence:

$$w(t;x) = w_k(t_k;x) + E \cdot e^{-\int c(t)dt} \qquad (2)$$

Where:

w (t; x) – temporary subsidence
w_k (t_k; x) – final subsidence
t_k – time after which subsidence reaches its final value
x – coordinate, $x \in R^2$
E – integration constant, E = w_k (t_k; x)

Tab. 1 The basic data of mining geological conditions in extraction's area

Coal seam	Panel	The start date of extraction	The end date of extraction	Thickness of coal seam [m]	Depth [m]	Coefficient of roof control a
349	809	20-12-2008	30-03-2009	2.1	518	0.7
349	812	01-04-2008	30-09-2008	2.1	543	0.7
349	813	15-08-2008	31-12-2008	2.1	533	0.7
407/4	304s	01-01-2008	30-07-2008	2.5	788	0.8

2 The analyses of the geodetic measurements results

The basic data of geological – mining conditions in the area, where mining extraction was led, are presented in table 1. Location of the observing line in relation to mining workings has been presented on fig. 1.

The values of the Knothe's theory parameters (Knothe, 1953) for final subsidence trough without using periphery were determined as follows:

- Coefficient of roof control – a = 0.70
- Tangent of main influences angle tgβ = 2.1

The value of the percentage error for final subsidence trough was equal to 6.67 %.

The following values of the parameters for final subsidence trough with using periphery were determined as follows:

- Coefficient of roof control – a = 0.77
- Tangent of main influences angle tgβ = 2.1
- Periphery d = 37 m

The value of the percentage error for final subsidence trough was equal to 2.77 %.

The comparison of mining subsidence measured and calculated with determined values of parameters are shown on fig. 2.

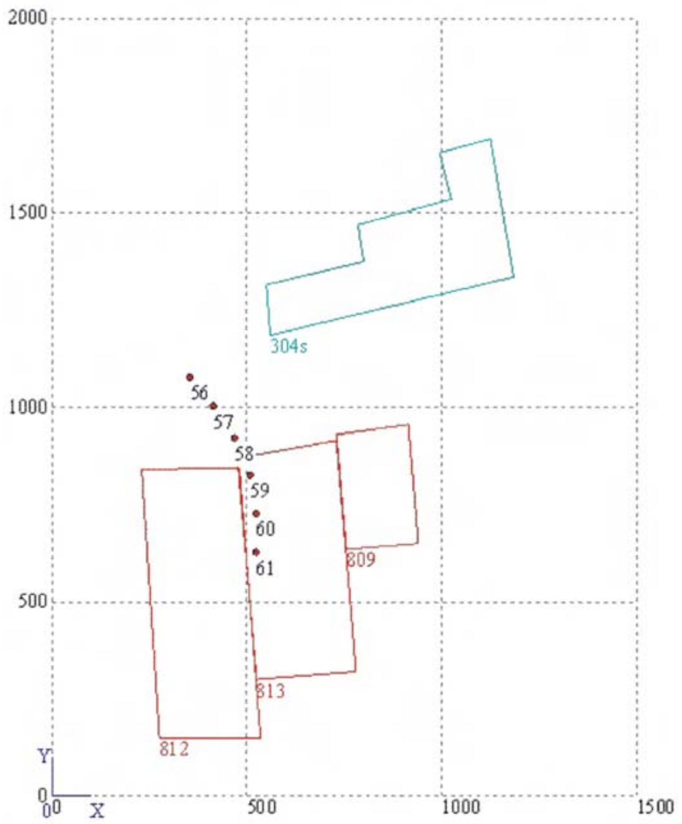

Fig. 1. Location of the observing line in relation to mining works.

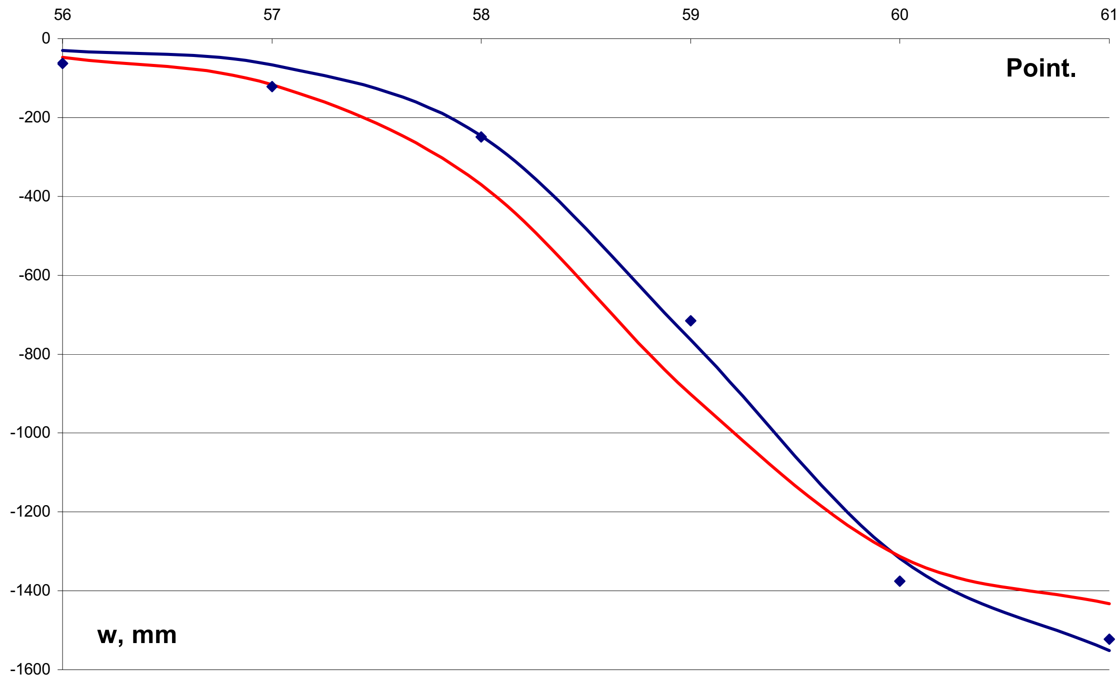

Fig. 2. Mining subsidence obtained from measurements and calculated using Knothe's theory. Red line – subsidence calculated without periphery. Blue line – with periphery.

Afterwards identification of parameters from formula (2) was determined basing on the course of subsidence of chosen points over time. Points 60 and 61 were chosen to detailed analysis because of the fact, that in this area the highest value of subsidence was measured. Simulations provided with DEFK-Win-ST (Ścigała, 2008) software, with usage of S. Knothe's theory parameters; let us assign average values of model's parameters:

- $a_1 = 7.5$
- b = 250 [days]
- d = 0

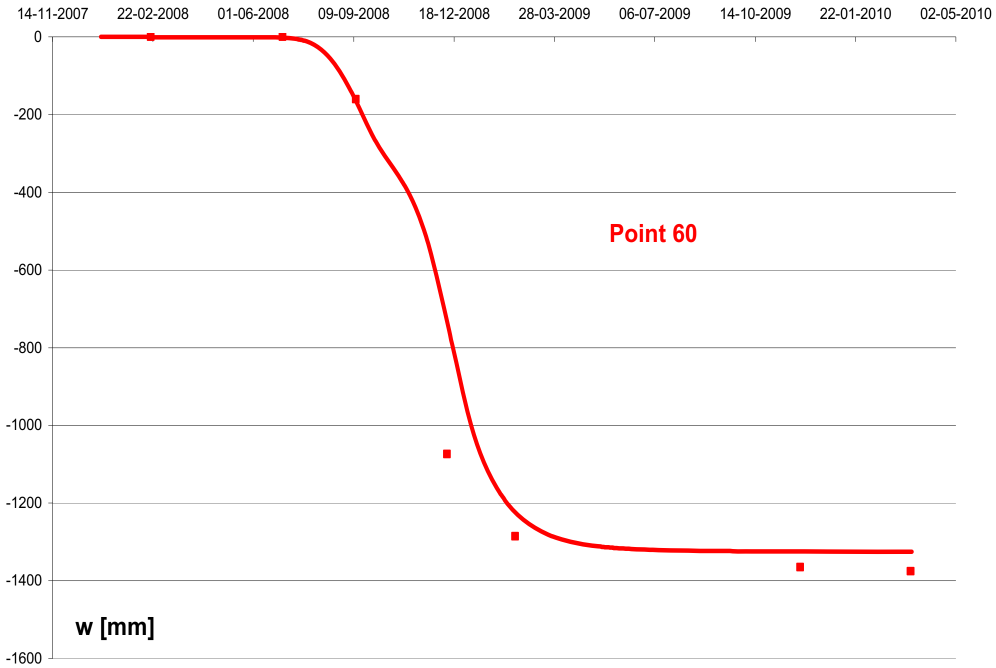

Fig. 3. Mining subsidence over time calculated and measured – point 60

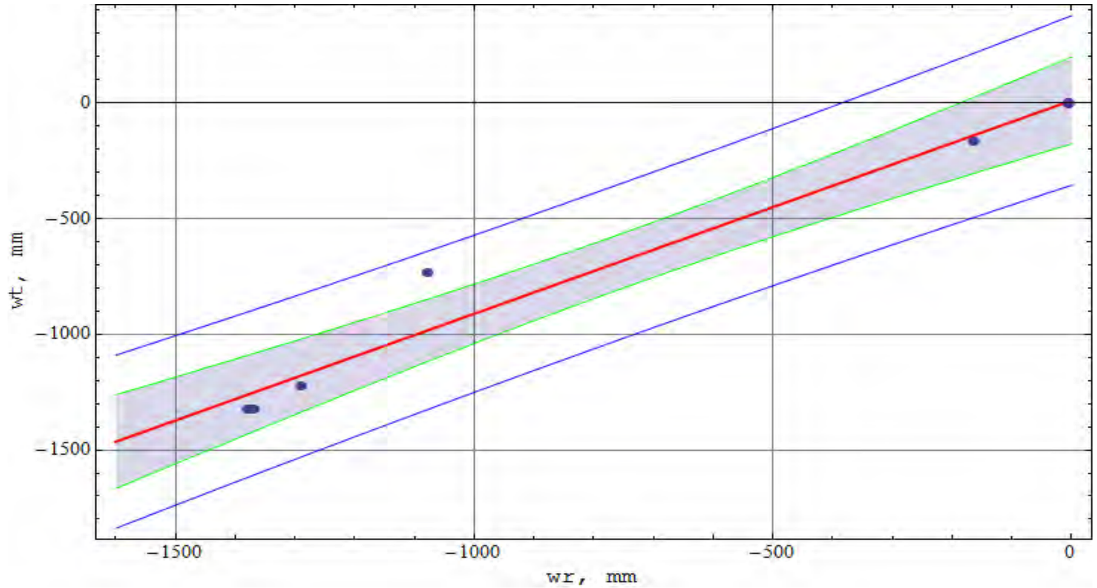

Fig. 4. Mean prediction bands and single prediction bands for point 60 for confidence level 0.95. Mining subsidence calculated using authors model – wt, against subsidence obtained from measurements – wr.

Subsidence of point nr 60 over time, affirmed by measurements and calculations are presented on Fig. 3. Fig. 4 presents values of subsidence obtained from measurements – wr and calculated for time horizons corresponding to measurements –wr. Regression line's formula presenting dependence between these values is formulated:

$$wt = 0.9226wr + 11.457 \quad (3)$$

The value of correlation coefficient is R = 0.98.

On the same pictures uncertainty lines for regression line (dimmed area) and for single observation were presented. Analogically reasults of calculations for point 61 are presented on figures 5 and 6. Regression line's formula for that point is formulated:

$$wt = 0.8952\,wr - 34.847 \qquad (4)$$

The value of correlation coefficient is R = 0.991.Analyzing calculation's results, presented on figures 1-6, and values of correlation coefficients, we should confirm obtaining high accuracy of mathematical model, in comparison to measurement's results.

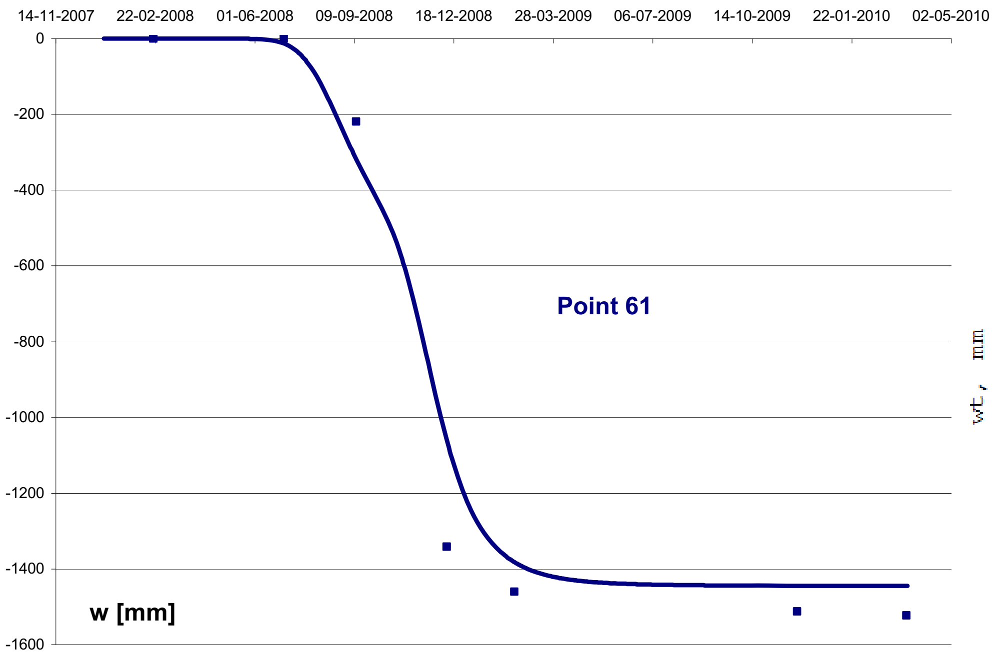

Fig. 5. Mining subsidence over time calculated and measured point 61.

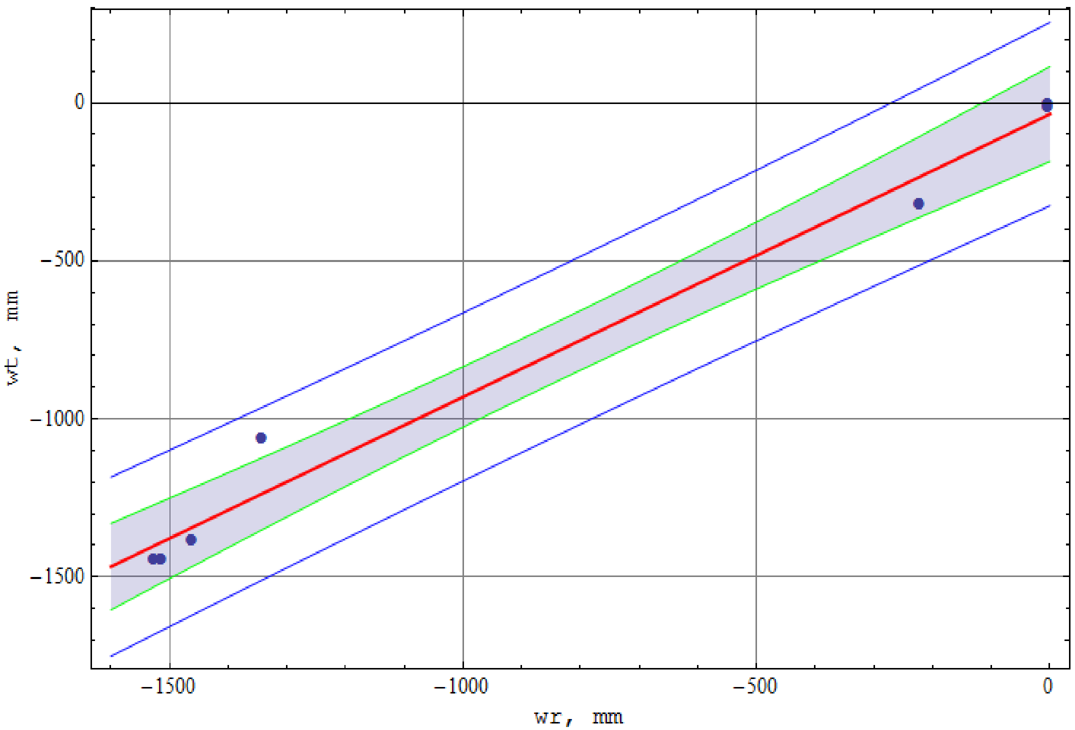

Fig. 6. Mean prediction bands and single prediction bands for point 61 for confidence level 0.95. Mining subsidence calculated using author's model – wt, against subsidence obtained from measurements

3 Summaries

Analysis of geodetic measurements presented in this paper provides us to conclusion, that mathematical model, describing kinematics of deformation process, lets us gain statistically accurate results in comparison to geodetic measurements. As a result we can assume this model is adequate, and its forecast's quality depends exactly on taken values of parameters required for calculations. Parameters should be calculated on the basis of geodetic measurements provided in forecast area. Basing on this analysis we should assume, that presented mathematical model can be used in practice.

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