PHOTOGRAMMETRIC METODS OF DETERMINING INDUSTRIAL OBJECTS DISPLACEMENT IN MINING AREAS

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ABSTRACT

The application of the monophotogrammetric method of determining displacement of the gasholder and the elevation of the locomotive building in the mining areas in Wałbrzych has been presented.
The changes of the gasholder radius and the deflection of geometrical axis were determined assuming minimalization function of corner pillars displacement. The horizontal and vertical displacement of locomotive building were determined using time parallax and transformation of the photogrammetric coordinates to the geodetic ones.

INTRODUCTION

The technology of control surveys depends, among others, on the type of the object and its location. In the case of engineering objects sensitive to the ground strains i.e. on the mining areas, the proper technology of surveys should, first of all, take into account the short time of surveys and calculations, representativeness and a high accuracy of determinations. The results presented in numerical and graphical forms must concern geometrical characteristics of the object and its opration.

In this paper the monophotogrammetric method of determining displacement of chosen engineering objects in the mining areas has been presented.

DETERMINING OF DISPLACEMENT OF THE GASHOLDER "MAN"

The gasholder being presented is sytuated in the mining area of the "Thorez" mine in Wałbrzych. In the case of the "MAN" type, too great ground strains cause displacements and deformation of the gasholder making its proper operation impossible which, for example, may result in the wedge of the piston between guides.

The application of monophotogrammetric method is justified first of all by the short time of field and laboratory works providing high accuracy of determinations. This technology of surveys enables determination of two radial components of displacement at each observational level from one camera stand. As far as geometry is concerned the method is analogous to the method of surrounding tangents while determining the location of geometrical axes of objects used in the classical method - Czaja (1977).

The objects of surveys were deflection of corner posts and deflection of the geometric axis of the gasholder. The radial component of the vector of horizontal displacement from the post vertical lines was determined from the permanent camera stand. In succeeding control surveys the external and internal orientation of the photographs by the same camera remained unchanged. The sketch of the photogrammetric stands are presented in the fig. 1.

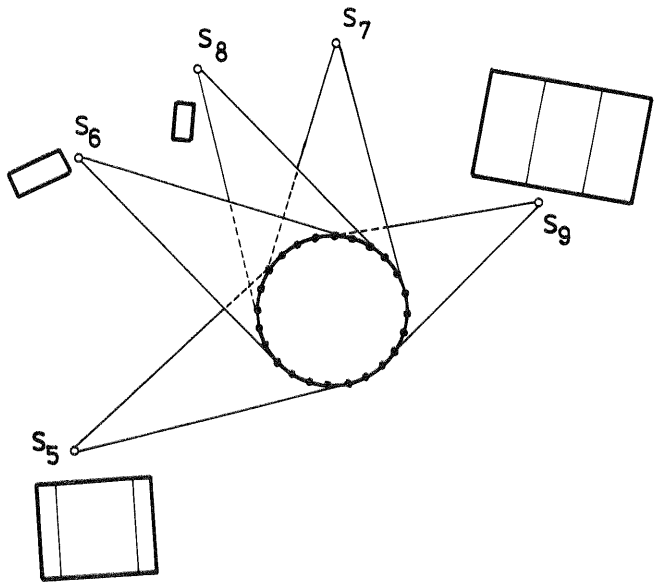

Fig. 1. Sketch of the camera stands.

Numerical values of the radial components were calculated from the simple dependence:

$$d_i = \frac{Y}{c} p_i$$

where: p_i is the difference of photocoordinates between particular levels, or - the time parallax on the time stereogram,
Y is the distance from the observed angle post.

The methodology of surveys and graphic representation of the results are similar to those presented by Bernasik (1982).

The methodology of determining the displacement of the geometrical axis consists in calculating coordinates of the circle centres in the first measurement for all levels with which the coordinates of the circle centres, determined in the control measurement, are compared. All coordinates are related to the coordinates of the centre at the 0-level in the initial measurement. The coordinates of the remaining circle centres in the first measurement can be calculated from the following formulae:

$$S_{x_i} = S_{x_o} + p_i$$

$$S_{y_i} = S_{y_o} + q_i$$

where:

$$p_i = \frac{2S_n - n\,\Delta x_i}{n}$$

$$q_i = \frac{2S_n - n\,\Delta y_i}{n}$$

$$x_i = d_i \cos \alpha_i$$

$$y_i = d_i \sin \alpha_i$$

In a similar way the coordinates S_x' of the circle centre from the centrol measurement are determined taking into account the new measurement of deflections values of the post (d_i), whereas the azimuts are the same as in the initial survey.

The displacement values do not include possible changes of the gasholder radius which, as being constant, is very significant in the case of the gasholder of the "MAN" type. The values R_i and R_i' can be calculated assuming the minimalization of the functions $L(S_{x_i}, S_{y_i}, R)$ and $L(S_{x_i}, S_{y_i}, R)$.

$$L = \sum \left[\sqrt{(x_i - S_{x_i})^2 + (y_i - S_{y_i})^2} - R \right] = \text{minimum}$$

Thus:

$$\frac{\partial L}{\partial R} = -2 \sum \left[\sqrt{(x_i - S_{x_i})^2 + (y_i - S_{y_i})^2} - R \right] = 0$$

$$\sum \sqrt{(x_i - S_{x_i})^2 - (y_i - S_{y_i})^2} = nR$$

$$R = \frac{1}{n} \sqrt{(x_i - S_{x_i})^2 + (y_i - S_{y_i})^2}$$

In the similar way the values R from the control measurements were determined.

The accuracy of the values determined depends mainly on the accuracy of determining the values of vectors d_i and d_i' assuming the internal and external orientacion of the elements being constant in each measurement cycle.

The presented way of calculations was verified by the comparison of the results of determinations with the analytical method. In the method for each measured deflection of the post at a given level the approximating aquations are given in the form:

$$v_i = \Delta x_i \sin \alpha_i - \Delta y_i \cos \alpha_i \pm dR - l_i$$

where: x_i, y_i is the gasholder axis deflection components,
dR is the correction for the approximated value of the radius,
l_i is the measured value of the angle post deflection
$\alpha = \varphi + 90^\circ$
φ is the azimuth of the vector of the radial displacement.

Beside the values of the unknown Δx_i, Δy_i and dR, there are determined the corrections v_i defining the defferences between the measured and theoretical values in horizontal planes.

DISPLACEMENTS OF THE ELEVATION OF THE LOCOMOTIVE BUILDING

The aim of the photogrammetric observations was determination of the effect of the mining works in the pillar of the main railwaystation on the deformations of the facade and the roof the locomotive building. The immediate target of surveys was determining the mutual horizontal and vertical displacement of chosen

object points. Similary to the case of the gasholder, the monophotogrammetric method was applied. The fan-shaped object made it possible to take a series of photographs from one stand situated at the central point of the turn-table. The photos were taken using the camera Photheo 19/1318 in each cycle from the same stand and with the constant orientation of each photo.

In order to determine the geometrical structure of the object in the first inventory survey, the analytical relations resulting from fig. 2 were used:

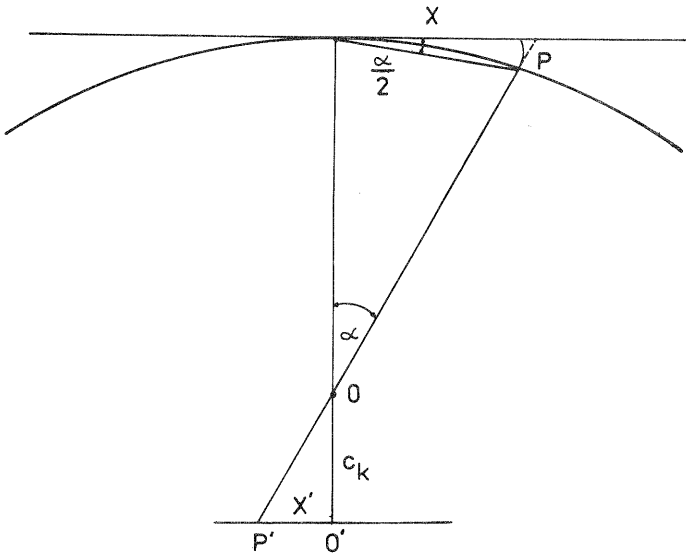

Fig. 2. The relation between photocoordinates and locomotive building coordinates.

$$X_i = 2c \sin \frac{\alpha_i}{2} M_i$$

$$Z_i = z_i M_i + z_o$$

where:

$$\alpha_i = \operatorname{arctg} \frac{x_i}{c}$$

$$M_i = \frac{R_i}{\sqrt{x_i^2 + c^2}}$$

x, z is the photocoordinates,
R is the distance from the point to the centre of the turn-table.

In control surveys the displacement values were determined making use of the time parallax of photos taken from the same point with the same orientation.

Graphical results of vector displacement are presented in the fig. 3.

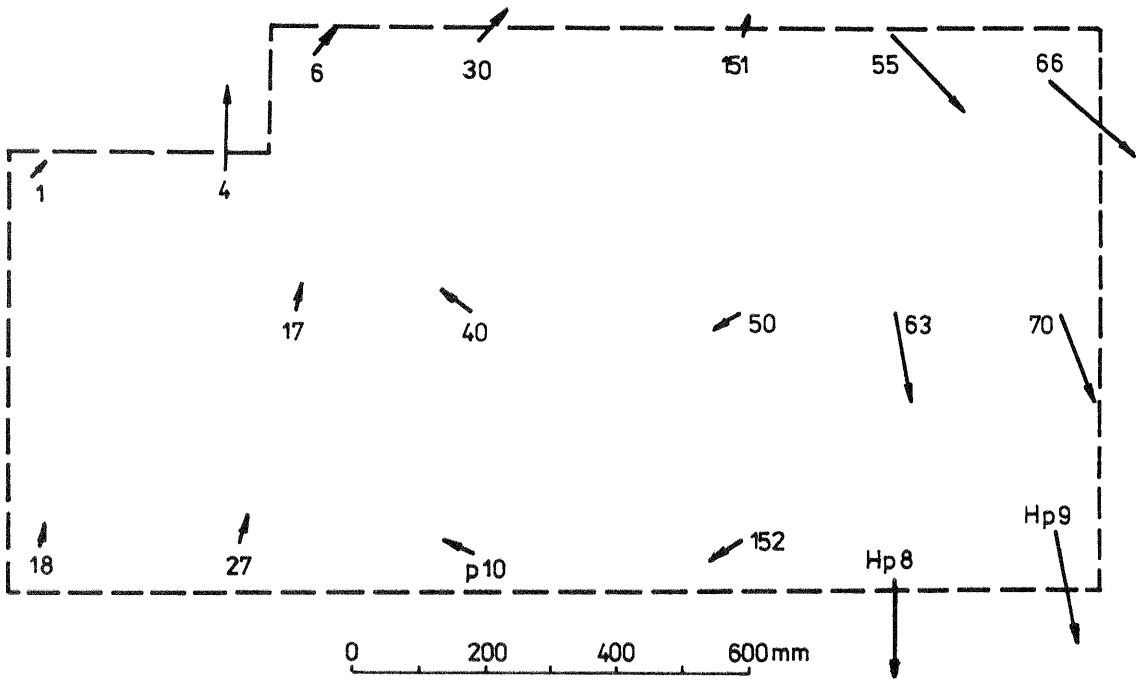

Fig. 3. Vectors of displacement of chosen points in the locomotive building.

The vertical displacements of points are determined in the way of transformation of the photogrammetric system to the geodetic one.

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