MONITORING DEFORMATION ON STRUCTURAL ELEMENTS OF CONCRETE

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Comission V/4

Abstract

By means of Analytical Short Range Photogrammetry and using a 5mm "reseau" Rolleiflex SLX 40mm camera, deformations of structural elements of concrete submitted to tests of structural behaviour were monitored at the Paranã Federal University as part of a research program in Short Range Photogrammetry tied to the Graduate Course in Geodetic Science. Photocoordinates were measured with Zeiss Planicomp C-100. A very close accordance with the classical measuring method was verifyed with the advantage that by the photogrammetric method the number of measured points can be increased econommically.

Introduction

By 1983 a research program was activated by the Department of Civil Engineering and the Graduate Program in Geodetic Science at Paranã Federal University aiming to compare the values of the deformations obtained by theory through the method of the finite elements (SANTOS(1984)); by the classical method measuring point by point; and by Short Range Photogrammetry - Analytical Method (MENDONÇA (1984)).

Equipment

The photographs were taken by a ROLLEI-SLX, a commercial camera made by ROLLEY BRAUNSCHWEIG - Gederal Republic of Germany (FRG). This camera was first used in Short Range Photogrammetry by WESTER-EBBINGHAUS (Bonn University), who suggested the incorporation of a "reseau" plate, which was produced by HEIDENHAIN (FRG) and mounted by ROLLEI The "reseau", which does not affect the camera's functions consist of 121 crosses 5mm apart that provide the control for film deformation. See ANDRADE (1982).

The photocoordinates were measured with the Zeiss Planicomp C-100.

Self Calibration

The internal orientation of this camera is not stable (KÖLBL (1976)); then a simultaneous calibration of the camera is necessary. MERCHANT (1968) shows that linear dependency exist when the photos are vertical and the terrein is flat. One solution of this problem was given by KENNEFICK (1972) using convergent photographs.

Mathematical Model

The Mathematical background used were the projective equations extended according to BROWN (1966), to express the position of the principal point and lens distortions:

$$x-x_0-(k_1r^2+k_2r^4+k_3r^6)(x-x_0)-P_1(r^2+2(x-x_0)^2)2P_2(x-x_0)(y-y_0)-$$
$$-c\frac{(X-X_0)m_{11}+(Y-Y_0)m_{12}+(Z-Z_0)m_{13}}{(X-X_0)m_{31}+(Y-Y_0)m_{32}+(Z-Z_0)m_{33}}=0$$

$$y-y_0-(k_1r^2+k_2r^4+k_3r^6)(y-y_0)-2P_1(x-x_0)(y-y_0)-P_2(r^2+2(y-y_0)^2)-$$
$$-c\frac{(X-X_0)m_{21}+(Y-Y_0)m_{22}+(Z-Z_0)m_{23}}{(X-X_0)m_{31}+(Y-Y_0)m_{32}+(Z-Z_0)m_{33}}=0$$

where,
x,y are the fiducial coordinates of the image points.
x_0,y_0 are the fiducial coordinates of the principal point of photogrammetry.
k_1,k_2,k_3 are the coefficients for symmetric radial distortion
P_1,P_2 are the coefficients for decentering distortion
m_{ij} are the elements of the orthogonal orientation matrix M, functions of the Euler angles
and

$$r^2=(x-x_0)^2+(y-y_0)^2$$

Film Distortion
ANDRADE (1982) shows that for 5mm "reseau" interval the general affine transformation is overparametrized and the similarity transformation is the best solution. In this job film deformation due to shrinkages and unflatness was corrected "a priori" by similarity transformation.

The Experiment
For comparison purposes, targets were also located on the same place as the measuring instruments and "computing points" (nodal points). The nodal points are the places choosed by SANTOS (1984) to predicted the displacements using the finite elements method.

Two series of four convergent photographs were taken before and after the concrete plate be submited to a pressure of 65 kg/cm^2 when the fissures starts. The coordinates of the target points were computed for both series of photographs and compared. The difference was statiscally significant and so represents the deformation of the plate - the standard deviation was 0.02mm and the measured deformation are of order of 25mm on the most deformed points.

The table 1 shows typical results (in mm). The value of the displacements according to the three different methods used:

METHOD			DIFFERENCE	
PHOTOGRAMMETRIC (1)	MECHANIC (2)	PREDICTED (3)	(1)-(2)	(1)-(3)
24,52	24.45	22.12	0.07	2.40
25.70	25.65	23.84	0.05	1.86
23.34	23.40	22.12	-0.06	1.12

Table 1. Displacements in mm.

Table 2 shows typical results. The displacements in mm for symmetrical points about the center of the plate are:

DISPLACEMENTS	
25.70	
25.43	25.51
25.26	25.04
24.79	24.85
24.75	24.06
24.52	23.34
21.61	21.25
18.79	18.75
15.21	15.95

Table 2. Displacements on Symetrical Points.

Besides the high degree of accuracy, it is notable the facility the photogrammetric method offers to increase almost without costs, the number of points to be monitored.

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