LONG-TERM MONITORING OF THE CHURCH ST.MICHAELIS IN LUENEBURG

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ABSTRACT

Unstable geological structures and sub soil erosion cause deformations and damages at a lot of buildings in the downtown area of Lueneburg in Lower Saxony (Lamschus, 1989).
The Institute for Photogrammetry and GeoInformation (IPI) has started geodetic and photogrammetric surveys in 1984 to detect and document critical deformations of the church St. Michaelis in Lueneburg.
The threedimensional measurement of about 135 points inside the building was repeated ten times between 1984 and 1999. Deformations up to 14 mm have been detected during that period however without any critical importance for the building.
This paper presents the geodetic and photogrammetric measurements, combined adjustment results and future activities for the architectural monitoring of the church.

1. INTRODUCTION

Due to visible cracks at the interior building long term deformation monitoring and documentation of the church St. Michaelis in Lueneburg has been started in the year 1984. Geodetic measurements as well as photogrammetric surveys have been carried out to detect important deformations of the building to evaluate critical movements of signalized control points inside the building.

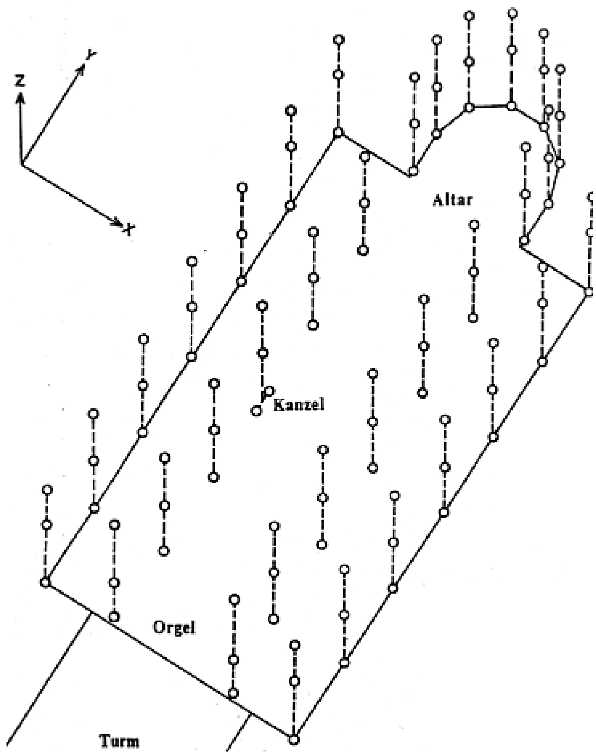

Fig. 1: Signalized points inside the church

2. METHODS

135 point targets have been fixed in three levels inside the building. One level near to the ground, a second level in 7.5 m height and a third level in 15 m height. The designed control point network is shown in Fig. 1.

The used targets are black circular screws with a diameter of 25 mm. To ensure image coordinate measurements in the photographs as well as the observation of geodetic directions with theodolites, the center of each target consists of a white dot with 10 mm diameter (see Fig. 2).

In the first campaigns the vertical and horizontal directions habe been measured with the Zeiss tachymeter Elta-2 (Gröger, 1988). Since 1996 all distances and directions have been measured with an electronic tachymeter Geodimeter 500S.
Measured distances between the control points and camera positions and levelling results between 15 control points were prepared for the combined adjustment.

From 21 positions a total sum of 106 images has been taken with the metric camera UMK 1318/100. Fig. 3 shows four of the metric images.
The main challenge of the project was the design of the complete network, the combined geodetic and photogrammetric observations and the illumination of all targets considering object distances between ten and thirty meters.

Fig. 2: Circular point targets

Fig. 3: Four of 106 metric images with marked object points

Figure 4 shows the camera positions and viewing directions inside the building. At the walls the point positions and numbers of 24 ground level points are shown.

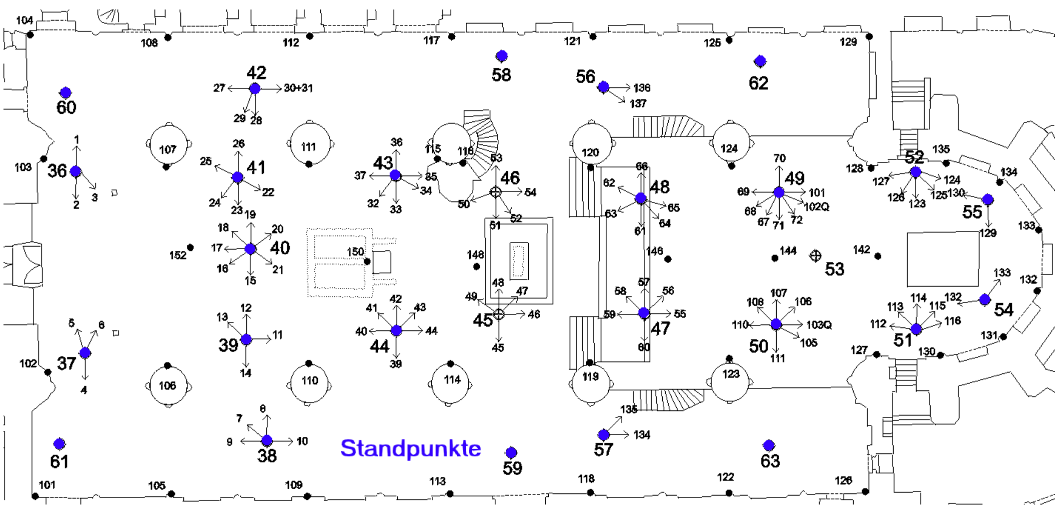

Fig. 4: Camera positions and viewing directions

3. ADJUSTMENT AND RESULTS

The image coordinates of the object points have been measured in all 106 images with the analytical plotter Zeiss Planicomp P1. The adjustment programm BINGO has been used for the combined adjustment of all geodetic and photogrammetric measurements. The results were processed with an image coordinate accuracy of +/- 4 µm and an object point accuracy of +/- 0.5 mm.

In all measuring campaigns the new coordinate values of the 135 points have been transformed via a free adjustment to the zero campaign in the year 1984 and to the campaign one year before the current one (Luhmann, T. , 2000).

The calculation of regression analysis confirm significant moving points at the north-western corner of the building. In general the points at the northern wall show the most important movements. At both sides of the wall the points move to the outer corners of the building. In addition the point at the north western corner of the building is moving with 0.8 mm per year to the ground. For the visualization of the three dimensional coordinate differences several graphical scetches were prepared. The presentation with separated vertical and horizontal planes illustrates the deformations very clearly (see figures 5 and 6.)

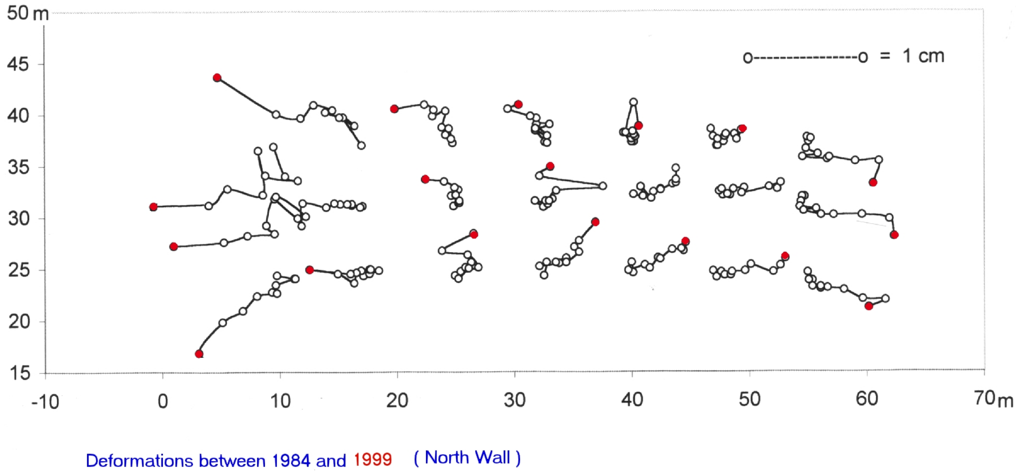

Fig. 5: Deformations at the North Wall

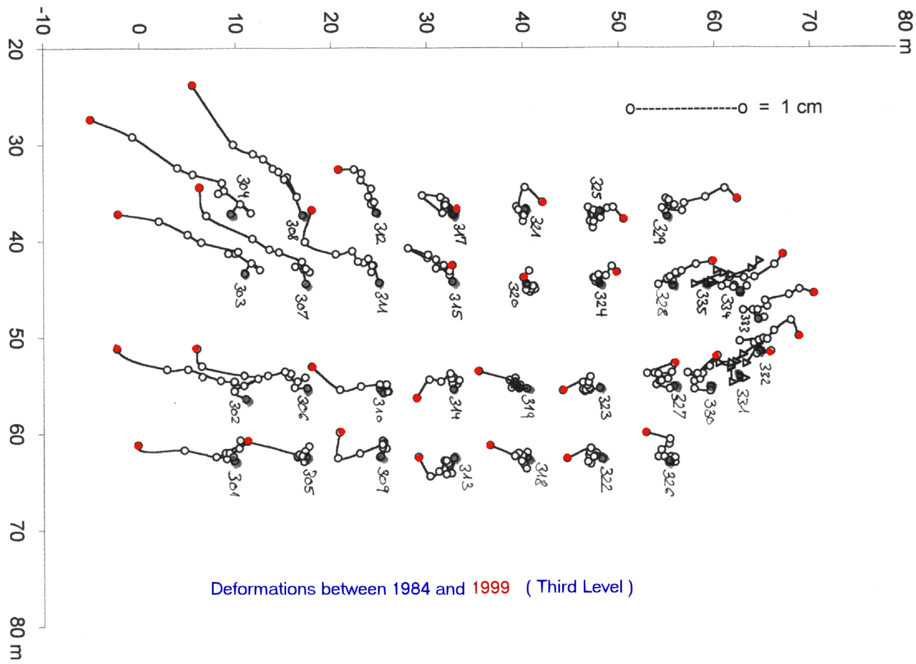

Fig. 6: Deformations at the third ground level

The calculated movements in each campaign were always smaller than 1 mm. The long-term deformations after 15 years are about 15 mm. Mean deformations for that time range were calculated between 3 and 5 mm. The standard deviation has been calculated for all three object coordinate directions between +/- 0.5 and +/- 0.8 mm.

4. FUTURE ACTIVITIES

Current investigations consider the application of modern digital cameras and electronic theodolite systems. In all cases the overall network design will be used also for future measurements (Hödl, 2000). The capability to collect digital documentations of the walls and the threedimensional visualization of photogrammetric modells will be additionally offered in the near future.
For first comparisons the analogue metric images were scanned with a photogrammetric scanner with a scanning resolution of 10µm. The resulting digital images with dimensions about 13000 x 18000 pixels show the high information potential of the original analogue film.
Today there are no operational digital cameras with a comparable resolution. The IPI owns a Kodak DCS 460 with an image size of 2036 x 3060 pixels. Using a digital camera of that resolution more images to larger point targets are necessary to ensure the same accuracy for the resulting object point coordinates as processed with analogue images before (Schütze, 1999).
The next measurement campaign is terminated for October 2002. It is planned to use the analogue metric camera UMK 1318/100 once more. The simultaneous application of the digital camera Kodak DCS 460 or DCS 660 will allow comparison tests and evaluations, whether the new digital photogrammetric methods are sufficient for following projects.

5. CONCLUSIONS

The geodetic and photogrammetric measurements inside the church St. Michaelis have been successfully carried out to detect building deformations between the years 1984 and 1999. Several refinements of the geodetic and photogrammetric network had been considered in the ten measuring campaigns (v. Roux, 1993). Regression analysis could confirm the significance of the detected movements. The point documentations have been presented to the customer „Klosterkammer Hannover“ for detailed interpretation of the results.
The total sum of measured movements are not critical for the stability of the building but have to be monitored also for the following years to forecast long-term deformations. The combination of geodetic measurements and photogrammetric image aquisition has been carried out with high accuracy. In the near future digital photogrammetry and image processing methods have to be investigated and will be introduced in the following measuring campaigns (Wiggenhagen, 2000).

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