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DEFORMATION MEASUREMENTS IN LARGE SCALE

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Abstract:

In connection with the development of new material types for roof covering it was of interest to know the deformations to which the material is exposed at different states of temperature and humidity. It was desirable to follow the deformations of the whole plate in intervals of a few minutes. The roof plate, which was to be tested, had a size of 1.09 x 1.22 m with undulations of appr. 5 cm.
Points were signalized on the plate in a gridpattern of 10 cm. Above and below the plate solid frames were placed for establishing absolute reference points. By means of a Zeiss Jena UMK 1318 terrestrial camera appr. 70 photogrammetric models of the roof plate were recorded at regular time intervals of 5 minutes. Modelscale was 1:14.
Monocular measurements were performed of the single points in the photos with a coordinate RMSE of less than 3 µm. The model coordinates to the individual signalized points on the roof plate were computed using the on-line analytical aerotriangulation method of Aalborg University Centre. The deformations of the roof plate have in this way been computed with a very high precision which in the xy-plan amounts to 0.05 mm and in z-direction 0.1 mm.

DEFORMATION MEASUREMENTS

IN

LARGE SCALE

Introduction

This report documents application of photogrammetry to high precision measurements in industry. The object of the project, executed by Aalborg University Centre, was to determine deformations in roof plates, due to effects of moisture and temperature changes. The deformations should be determined with an accuracy of 50 µm. The project was - by request of Dansk Eternit-Fabrik, Aalborg - executed as a pilot project to demonstrate the ability of the photogrammetric technique for material control.

Statement of the Problem

A roof plate, with dimensions 109 x 122 cm^2, is mounted in a frame simulating its actual mounting at the roof and is exposed to approximately 60 cycles of (simulated) rain and sunshine, with each cycle lasting 5 minutes. The deformation in each cycle has to be recorded. For selected cycles, which are chosen by the client after completion of the test, its magnitude is measured. The required relative accuracy of the measurements is 0.05 mm on the object.

The Survey Mission

For image recording two terrestial cameras from Carl Zeiss Jena (UMK 1318, c = 10 cm, glass plate), were used. By using the minimum focusing distance of 1.4 m, a photo scale of 1:14 was attained. The greatest possible base-height ratio was used to ensure the best possible accuracy in the third dimension (z). The photo mission is shown in figure 1.

Signalized points are mounted on the roof plate at locations chosen by the client. The distance between these points varied from 5 to 20 cm. A total of 52 signalized points were involved. The points had to be of exact circular shape, of diameter 1.1 mm, so as to match the size of the measuring mark of the Zeiss Jena, Stecometer stereocomparator, which was used for the measurements.

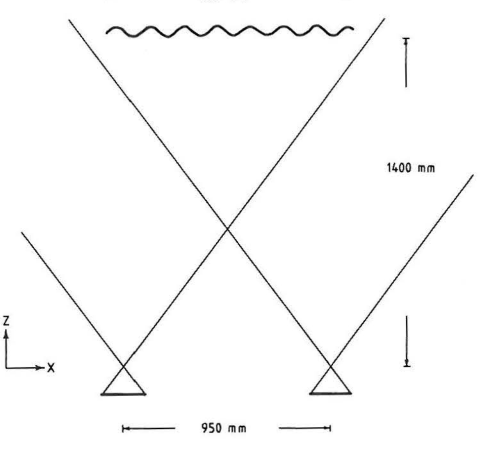
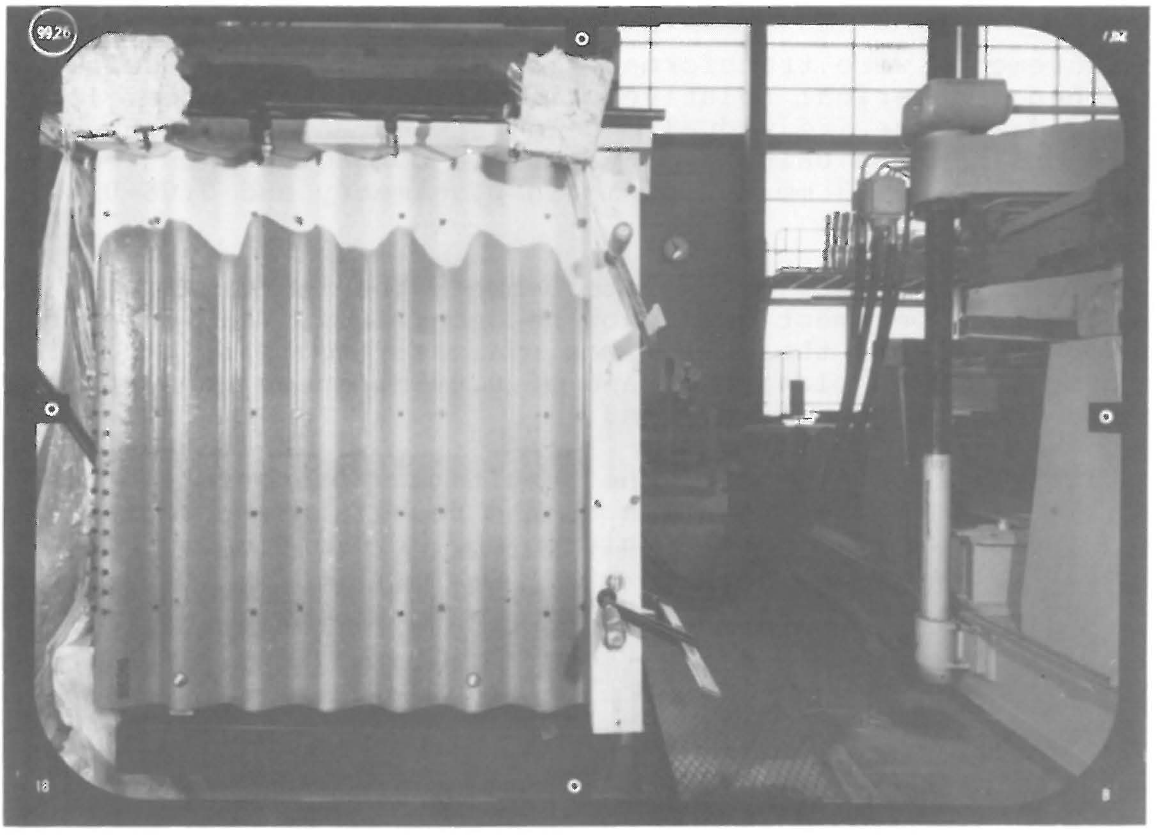


Fig.1. The photo mission

Above and below the roof plate absolute reference points were



Right photo of the stereo pair

established on an iron frame, which defined the absolute coordinate system.

The cameras were mounted on a concrete bar, specially produced to survey mission, in order to assure - as far as possible - stability of the camera positions and orientations.

Measurement and Computations

The deformation analysis was based as well on restitution of the photogrammetric model at the different points of time as on measurements using different photographs of the left camera only.

All measurements were carried out monoscopically on the Stecometer from Zeiss Jena. The use of stereoscopic measurement was unfavourable due to the large base-height ratio.

No corrections for systematic image errors were applied in the computation process. It was not the absolute position of the signalized points, but rather their deformation, which was of interest. The stable mounting of the cameras ensured constant systematic image errors at the individual image points throughout the whole test.

All points were measured in two complete rounds. The root mean square error (RMSE) of the measurements varied from 1.5 µm to

2.0 μm.

The measurements were transformed (conformly) on the fiducial marks. Then a numerical relative orientation was executed. Its RMSE varied for the individual models between 2 μm and 2.5 μm. Absolute orientation using the 6 absolute control points resulted in a RMSE of 0.03 mm - 0.06 mm in planimetry and 0.05-0.09 mm in z-direction.

The deformations of the roof plate between the individual cycles of the experiment could now be determined. They were of the order of 1.5 mm, their RMSE was evaluated to be in the order of 0.05 mm in planimetry and of 0.09 mm in z, thus satisfying the initial specifications.

A practical representation of the results was prepared in order to facilitate the interpretation of the results. Representative results are shown in figure 2, giving the deformation for one particular cycle.

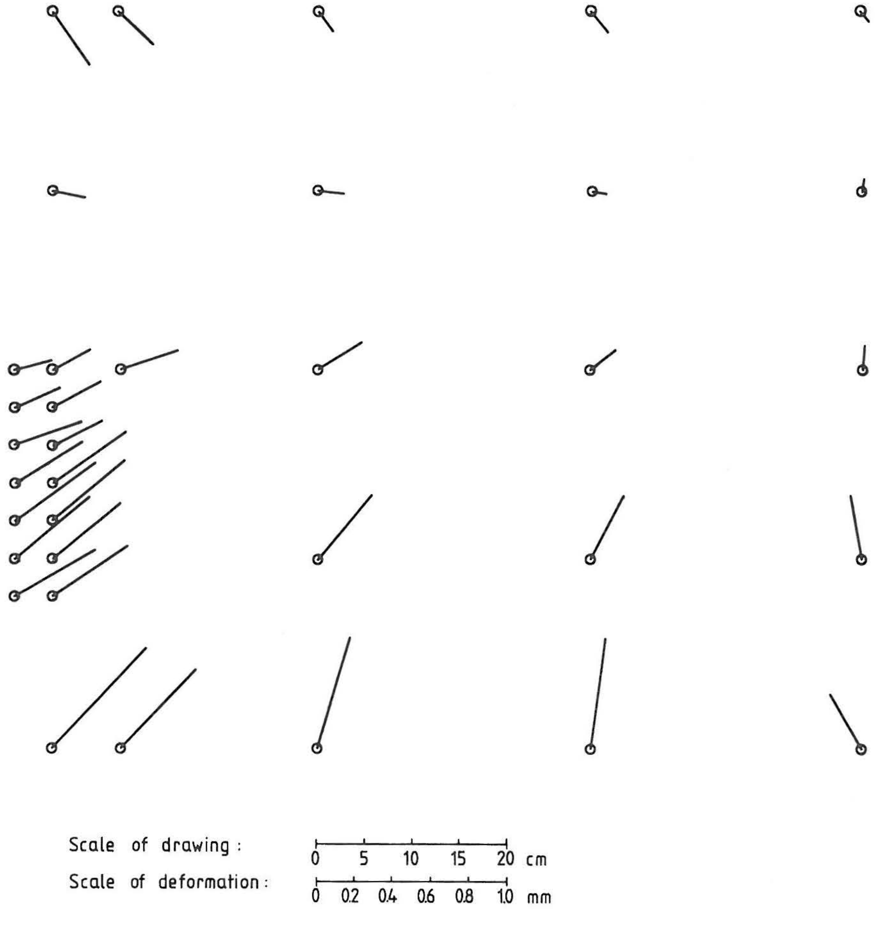


Fig.2. Deformations in planimetry for one cycle

Conclusion

The project proves the high grade of perfection, photogrammetric instrumentation and technique have reached, thus enabling photogrammetry to meet the high accuracy specifications required in industrial mensuration.

References

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