

## *Shorter Contributions*

# HELICOPTER SUPPORTED PHOTOGRAMMETRIC SURVEY OF RAMSBERG CASTLE

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### *Abstract*

*Ramsberg Castle is to be restored and renovated to allow a new use of the building. This requires extensive structural and architectural analyses based upon metric documentation. The façades of the castle were recorded photogrammetrically. Photography from the ground was impossible due to the steep terrain on three sides of the building. For this reason, the photographs were taken from a helicopter. A 4 × 5 inch Linhof Metrika réseau camera was used.*

*Because of the adverse topography, only a few control points could be determined by on-site theodolite measurement. Therefore the control network was achieved by means of photogrammetric bundle triangulation. Stereorestitution was performed using an analytical plotter connected with a CAD system. Drawings at 1 : 50 scale were then derived from the as-built CAD model.*

### INTRODUCTION

RAMSBERG CASTLE is situated on the edge of the *Schwäbische Alb* in the state of *Baden-Württemberg* in Germany. The castle complex, with a basically triangular ground plan, is built on the spur of a hill (Figs. 1 and 2) being flanked on two sides by steep slopes and on the third by a deep defensive ditch. The castle courtyard, which lies within an enclosing wall up to 2 m thick, is reached via a bridge. The castle itself was erected in the mid 13th century. The prominent residential building belongs to a later period, having been constructed around 1550 in the Renaissance style.

The castle is used as a stud farm at present. The ground floor of the main building has been fitted out as stables, whilst the upper storeys are still partly in residential use. Damage in recent years to the main building and the enclosing wall has not been repaired, and this has led to increasing deterioration in the condition of the building.

It is now intended to put the castle to new use. The conservation and restoration of the building requires extensive investigations which are expected to yield information on the structural and architectural history. Survey and analysis of the castle was performed by the *Landesdenkmalamt Baden-Württemberg* in Germany. Ground plans and sections inside the building were produced by traditional hand measurement. The façades and part of a medieval cellar were recorded photogrammetrically.

The photogrammetric survey was characterized by the use of a 4 × 5 inch réseau camera for helicopter based photography, thorough application of analytical photogrammetric methods for the determination of control information, and stereorestitution in an analytical plotter connected with a CAD system.



FIG. 1. Ramsberg Castle from the helicopter. The photograph was taken with a Linhof Metrika.

#### PHOTOGRAMMETRIC SURVEY OF RAMSBERG CASTLE

As described in the introduction and shown in Figs. 1 and 2, the terrain on two sides of the castle slopes steeply away, whilst on the third side is the defensive ditch immediately bordered by dense woodland. Camera stations suitable to record the façades from the ground can only be found within the courtyard. Therefore it was decided to take the survey photographs from a helicopter. The main advantages of helicopter supported photography are the short time required for taking the photographs and the excellent view provided of the site and its environs. In the case of Ramsberg Castle, a photogrammetric survey without the aid of a helicopter platform would not have been feasible. The main drawback of the method, apart from the rental costs, lies in vibrations and unexpected movements of the platform which can lead to blurred images. For this reason, a short exposure time (of the order of  $1/250$ s) should be chosen.

The topography of Ramsberg Castle also influenced the determination of control information required for the absolute orientation of the stereomodels used to produce the façade drawings. Theodolite based survey yielded a sufficient number of control points within the castle courtyard, but only a few points could be observed on the other façades of the castle. Therefore the photographs taken from the helicopter should form a closed image block around the object enabling the photogrammetric determination of control information by bundle triangulation with reference to the co-ordinate system of the points measured by geodetic means. This procedure resulted in the three dimensional co-ordinates of object points for the orientation of the stereomodels.

The poor state of preservation of the façades caused serious problems in the definition of these object points. This necessitated a high redundancy of photogram-

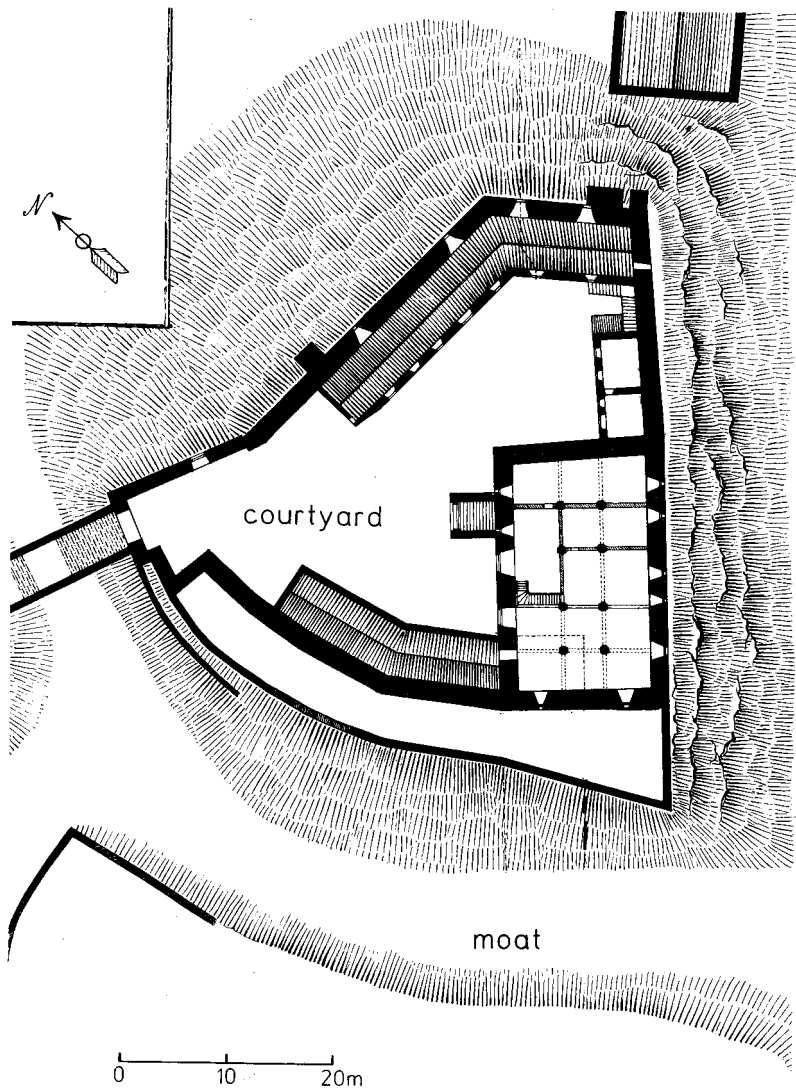


FIG. 2. A ground plan of Ramsberg Castle.

metric measurements, to provide as large a number of ray intersections per point as possible, so as to establish a satisfactory best fit.

#### IMAGE ACQUISITION AND MEASUREMENT

For the recording of Ramsberg Castle, a  $4 \times 5$  inch Linhof Metrika (Peipe, 1990) was used. This réseau camera (Fig. 3) consists of the camera housing and an interchangeable film magazine. The housing contains the permanently mounted lens, a glass plate with grid crosses, and the electronic control and power supply unit. The standard version of the Metrika provides  $9 \times 11$  réseau crosses with 10 mm spacing. The rollfilm back includes the vacuum system for film flattening, the film transport device and two daylight loading cartridges for 5 m of 126 mm black and white or colour film, equivalent to approximately 50 exposures.



FIG. 3. A Linhof Metrika with 150 mm lens.

Three lens systems are available: 75 mm and 90 mm Schneider Super Angulon wide angle lenses and 150 mm Schneider Apo Symmar normal angle lens. The focusing mount of each lens is equipped with a number of click stops. Each focusing stop defines a set of interior orientation parameters which remain stable once determined by camera calibration (Peipe, 1990).

The vacuum system combined with the *réseau* technique allows the elimination of global dimensional changes of the film and also of local deformations in relation to the accuracy demands of the measurement task. The degree of accuracy required in architectural photogrammetry does not usually necessitate the measurement of the full set of  $9 \times 11$  *réseau* marks of the Metrika. The vacuum system ensures sufficient mechanical film flattening.

The castle was recorded with a total of 43 photographs. A Metrika with 150 mm normal angle lens was used in order to achieve a relatively large image scale without requiring the helicopter to fly too close to the castle. The photographs could be taken with the hand held camera in a matter of minutes. To facilitate the procedure, one door of the helicopter was removed. Because all the camera operations, with the exception of exposure metering, are fully automated it only remained for the photographer to select the correct view and press the release button at the correct moment.

The image block included photographs at an image scale of 1 : 200 to 1 : 300 (Fig. 4) for the stereorestitution of the façades, as well as a series of convergent photographs, partly taken from a greater distance, necessary for bundle triangulation



FIG. 4. A photograph of a part of the south-east façade of Ramsberg Castle.

(Fig. 1). (The camera used had a very dense réseau grid of 2.5 mm spacing required for special applications in industrial metrology but not necessary, of course, for the photogrammetric survey of the castle.)

#### BUNDLE ADJUSTMENT

Phototriangulation by bundle adjustment has proved to be an efficient tool for the determination of control information and photogrammetric network densification in architectural photogrammetry (Wester-Ebbinghaus, 1978; Kotowski *et al.*, 1988; Hell *et al.*, 1989). The triangulation of Ramsberg Castle was achieved by means of the CAP adjustment program (Hinsken *et al.*, 1992).

The image block was first calculated as a free net. Three dimensional co-ordinates were determined with a standard deviation of  $s_x = s_y = 5$  mm and  $s_z = 3$  mm (height). Because the photographs formed an image block completely encompassing the castle, the interior orientation parameters of the camera could be calibrated simultaneously within the bundle adjustment.

In the second step, the photogrammetric network was transformed onto the geodetically measured control points related to the user defined co-ordinate system. In this process, significant differences appeared because several points, determined geodetically as well as photogrammetrically, were not identical and had to be rejected. However, it appears reasonable to assume that the accuracy of the highly redundant photogrammetric co-ordinates was of a higher order than that established by geodetic survey. Finally, the discrepancies between the point co-ordinates determined by both methods amounted to  $DX = 13$  mm,  $DY = 15$  mm, and  $DZ = 13$  mm (r.m.s. values).

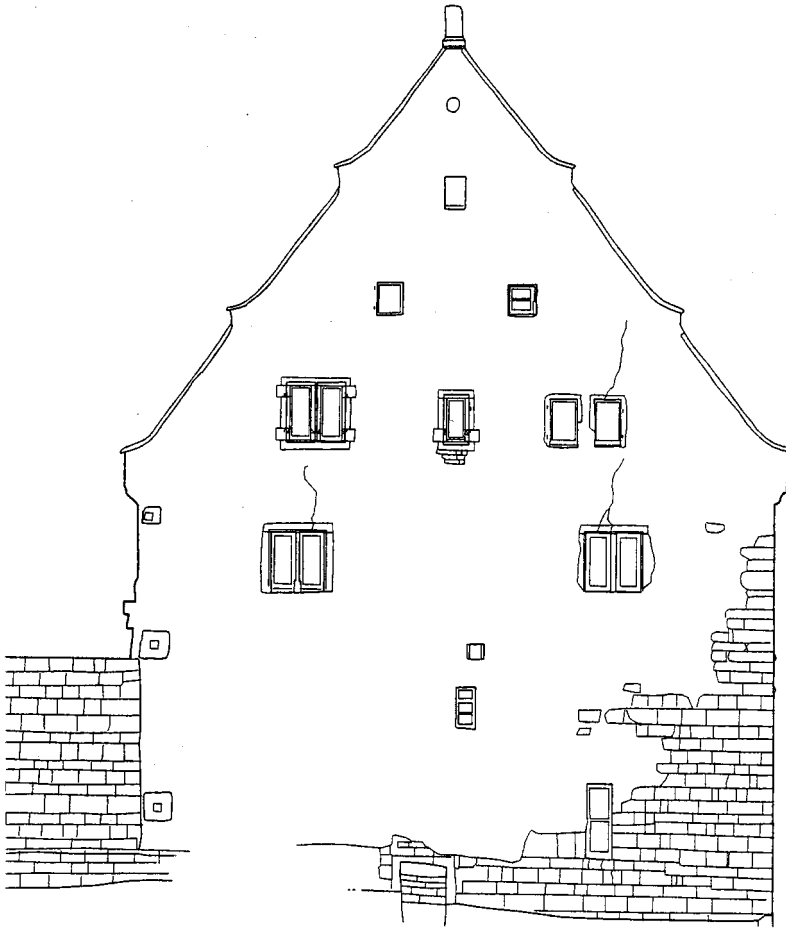


Fig. 5. A CAD plot of the south-west façade of Ramsberg Castle.

#### STEREORESTITUTION

In order to document the fabric of the building and to support the further planning of renovation, photogrammetric drawings of the façades were produced from stereophotographs. The stereocompilation was carried out in a Zeiss Planicomp C100 connected with the Intergraph MicroStation PC CAD system. Plans at a scale of 1:50 were derived from the CAD model and plotted off-line using a Versatec plotter (Fig. 5).

#### CONCLUDING REMARKS

It was possible to undertake the precise and economic documentation of the façades of a large architectural object by photogrammetric means even though it is situated in topographically difficult terrain. A helicopter was used as the photographic platform, a 4×5 inch réseau camera as hand held sensor, bundle triangulation software for calculating control points and an analytical plotter for point measurement

and stereocompilation. Finally, an information system was applied to collect and edit the photogrammetric data and to combine these data with further information required for planning, restoration and historical analyses.

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#### Résumé

*Le château de Ramsberg doit être restauré pour permettre une nouvelle utilisation des bâtiments. Pour cela il faut procéder à une analyse architecturale et structurelle complète en s'appuyant sur les documents métriques. Aussi a-t-on saisi photogrammétriquement les façades du château. Mais l'escarpement du site rendant impossible la photographie depuis des stations au sol sur trois des côtés du bâtiment, on a pris les photographies en hélicoptère, en utilisant une chambre à réseau Linhof Metrika de format 4 × 5 pouces. Etant données les difficultés de la topographie, on n'a pu déterminer que quelques points d'appui par des mesures au théodolite sur le terrain. Aussi a-t-on établi le canevas des points d'appui au moyen d'une triangulation photogrammétrique par faisceaux. On a effectué la stéréorestitution sur un appareil analytique relié à un système de CAO qui a permis de bâtir un modèle d'où l'on a tiré les plans à l'échelle de 1/50.*

#### Zusammenfassung

*Schloß Ramsberg soll saniert und renoviert werden, um eine neue Nutzung des Gebäudes zu ermöglichen. Dies erfordert umfangreiche Untersuchungen, basierend auf einer metrischen Dokumentation. Daher wurden die Schloßfassaden photogrammetrisch aufgenommen. Auf drei Seiten des Gebäudes waren wegen des steilen Geländes Aufnahmen vom Boden aus nicht möglich. Die Bilder wurden mit einer 4" × 5" Réseaukamera Linhof Metrika von einem Hubschrauber aus aufgenommen.*

*Außerdem konnten wegen der ungünstigen Topographie nur wenige Paßpunkte durch Theodolitmessung vor Ort bestimmt werden. Das Paßpunktnetz wurde durch photogrammetrische Bündeltriangulation verdichtet. Die Stereoauswertung der Fassaden wurde an einem analytischen Plotter in Verbindung mit einem CAD-System durchgeführt. Aus dem CAD-Modell des Gebäudes wurden dann Pläne im Maßstab 1:50 abgeleitet.*