THE PHOTOGRAMMETRIC MEASUREMENT OF CHARLES' BRIDGE IN PRAGUE

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ABSTRACT:

The aim of project is to make out a documentation of the oldest bridge in Prague grounded in the year 1357. The documentation will serve for assessment of the current building condition. The high moisture content of the bridge fillers and their contamination by salts cause damaging of stone structure of the bridge and reduce its durability. The photogrammetric data enable connection of different other data (chemical, biochemical, physical observations) and numerical analyses. Various cameras were used and more than 300 images were taken. Low cost but power-full software package PhotoModeler Pro has been used. The all investigations allow right decision of methods and ways for repairing of the Charles ' bridge. Information system of bridge will be created

1. INTRODUCTION

The king Charles IV. put foundation of the stone bridge in the year 1357. The 515,76 m long bridge has 16 spans, 10 of them are above the river Moldau. The building of bridge was finished in the year 1406, but it already was functional in the year 1378. The construction of the bridge was damaged several times on large floods. In September 1890 were pulled down 3 spans. The

Figure 1. The Charles' bridge in Prague

quality of reconstruction works tested the huge flood in the year 2002, when the bridge resisted of impact more than one hundred water. The Charles' bridge belongs to the most important monuments of Prague. During several last years the Charles' bridge became object of many research investigations (Witzany, 2002). Different opinions have been discussed of bridge condition. It seems to be unbelievable, that till the year 2001 nobody needed accurate and complete geometric data about the bridge. Without such data can not be created any information system of bridge.

2. THE PHOTOGRAMMETRIC MEASUREMENTS

In June 2002 (before flood) were carried out the first part of the photogrammetric works on the 10 spans Charles' bridge above river Moldau, see fig. 1, including taking of images and geodetic measurements for determination of targeted control points. The side images and the vault of arch images were taken as show fig.2,3. The images of side walls of arches were taken by midle format semi-metric camera Pentacon Six with built-in reseau. The wide angle 50 mm lens and Fuji Provia film were used. The image scales were approximately 1: 900. The

images of vaults were taken by non-metric digital camera Canon EOS D60 having 6Mpix (pixel size $7.5\mu m$) and 35mm lens (80 images). The digital camera, that have been borrowed with out possibility to choose of size lens, were used in worst light conditions under bridge. The images were taken from small boats, no difficulties appeared there.

Figure 2. The Charles' bridge, arch N. VIII

Figure 3. The Charles' bridge, image of vault

The 26 targeted control points were placed on the walls and piers and determined from points of special network that serves for monitoring of quay walls see fig. 4 . The 3D coordinates of control poinst were determined by adjustment using module

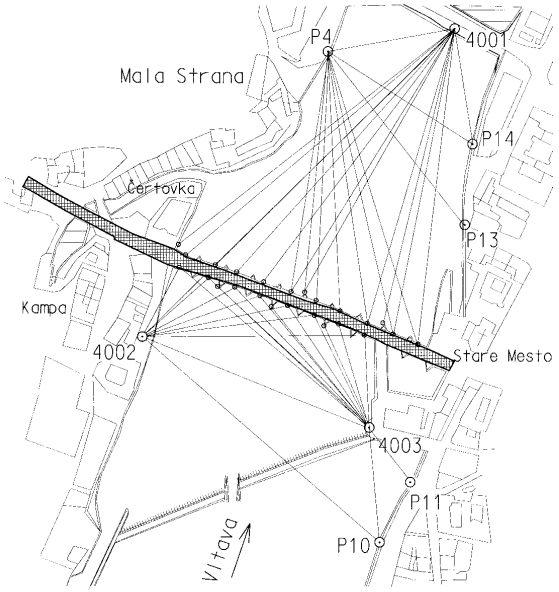

Figure 4. Geodetic network

Polar of the programme system ORIENT (Kraus 1997). Having no experience with software PhotoModeler Pro 4.0 (EOS Systems Inc.) we used older technology in space of spans III. - X. for image triangulation were used 64 images of side walls. The images were measured on comparator Stecometer and coordinates of 70 untargeted points (top of lamps, significant crossing of joints) were determined by adjustment using programme system ORIENT. These targeted and untargeted points served as control points for evaluation in PhotoModeler, when each span has been evaluated separately. The accuracy of all control points is given in tab. 5. The axis X of coordinates system is approximately in axis of the bridge, the axis Y is oriented against the stream of river. The important result of adjustment was also proof inner orientation elements of camera Pentacon Six. For processing images from camera Pentacon Six in PhotoModeler were images digitised using scanner Zeiss with pixel size $15\mu m$. Each point on bridge is determined by intersection of 3 rays or by intersection 2 rays with condition (group of points lie in line or plane with given accuracy). The average accuracy of mass points on bridge sides is 0.02 m in X and Z axes and 0.05 m in Y-axis. The points on vaults of arches have accuracy 0.02 m in each axis. Digital camera Nikon Coolpix 5000 (5 Mpix) was used for taking images of the second part of bridge in the year 2003. Condition for photogrammetric works has been more worse than in the first part of the bridge. The reason of it are obstacles as trees and building standing too close to the bridge. The images configurations have been not favourable and more images have had to be done (160 images).

Control points	targeted	untargeted
σ_X (mm)	8	13
σ_Y (mm)	10	22
σ_Z (mm)	8	10
Number of points	26	70

Tab. 5 Accuracy of control points

3. CONCLUSION

The result of photogrammetric works will serve for creation information system of the Charles' bridge and for statical computation. I know that this paper can not bring any new photogrammetric knowledge, but I would like to show only that the state with many monuments of cultural heritage have not necessary documentation of all important monuments till the present time. It is possible to obtain this with help of teachers and students of university.

References

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