3D MODELLING OF THE MARKET GATE OF MILETUS DEVELOPED FROM PHOTOGRAMMETRIC EVALUATIONS

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ABSTRACT:

After rediscovery in 1903 the impressive Market Gate of Miletus was transported to the Pergamon Museum in Berlin (Germany) in 1907/08. In 1929/30 the object was rebuilt in the original dimensions (about 30m x 16m x 5m). In more than 70 years the monument had suffered from damages of many kinds. After all, a modern reconfiguration of the Pergamon Museum today requires a complete photogrammetric documentation as a basis for restoration of the Market Gate of Miletus.
Due to the complexity of damage, mapping a digital 3D model of the market gate, generated from high accurate photogrammetric 3D data (+/- 5 mm), was necessary to understand the relations between damage and stress analysis more exactly. To obtain this high accuracy with sufficient economy, data acquisition had to be made with two different camera systems. The front parts were taken by a UMK 1318 while the interior parts were recorded by a SMK120 / SMK40. For determination of the necessary 3D information stereoscopic models had been analysed by an analytical plotter (AP).
Starting from a three dimensional CAD vector model a volume model was developed close to reality. Therefore, comprehensive rendering methods, effects, texture mappings and animations were used. By means of this 3D model, it is possible to visualize the single components of the building, e.g. the original and modern parts which had been classified before by restoration experts.
Through this representation, the interior iron construction of the Market Gate of Miletus can be shown. By computer animation different parts like single columns or architravs can be featured in detail, too.
In future the 3D model will contribute to a spatial information system which will assist restoration activities on the one hand and will be used for tourist information inside the Pergamon Museum on the other hand.

1. INTRODUCTION

The monumental Market Gate of Miletus was built between ca. 120 and 130 AD in the time of the roman emperor Hadrian. Parts of the market gate were rediscovered in 1903 during the archaeological excavations in Miletus. The gate was rebuilt in 1928/29 inside the new Pergamon Museum in Berlin including integrations in modern materials replacing the destroyed parts (Figure 1). Photogrammetric data acquisition was performed by standard cameras, i.e. UMK 1318 for the front parts and SMK120 / SMK40 for the interior parts of the gate, e.g. for the extraction of vertical cross sections, upright projections and special details. The control points were measured by an accuracy of approx. rms=±3mm. In order to fulfil the demands of high accuracy the stereoscopic models were processed at an analytical plotter DSR-11 (Leica). In model orientation an accuracy of approx. rms=±5mm could be obtained. The main contour lines and roughly the main ornaments were mapped. As an example Figure 2 shows one photogrammetric result in terms of a front view of the whole market gate including columns (in this case without flutes) and brickwork of the back plane. The outer solid line is the contour line of the exhibition room. Different grey values represent different depths of the architectural elements (black: front level, dark grey: middle level, light grey: back plane level). More details about the Market Gate of Miletus, its acquisition and analysis can be found in Vögtle et al. (2003). These photogrammetric data are the basic information for a subsequent 3D modeling process. A 3D respresentation of this complex building was to improve the possibilities of visualisation and the spatial impression as well as the evaluation by static experts. For this model it is not necessary to include the (partly) damaged status of the building elements but to represent more or less an idealised shapes reconstructed by means of the real measurements. *SolidWorks*® was used for modelling of the market gate. It provides very well the concept to build up complex structures by combination of simple basic elements. By this procedure the symmetries of the building can be utilised. In the following some representative elements of this reconstruction process will be explained in more detail.

Figure 1. Reconstruction of the Market Gate of Miletus inside an exhibition room of the Pergamon Museum (Berlin), c. 1930/39 (Antikensammlung Berlin, Archiv)

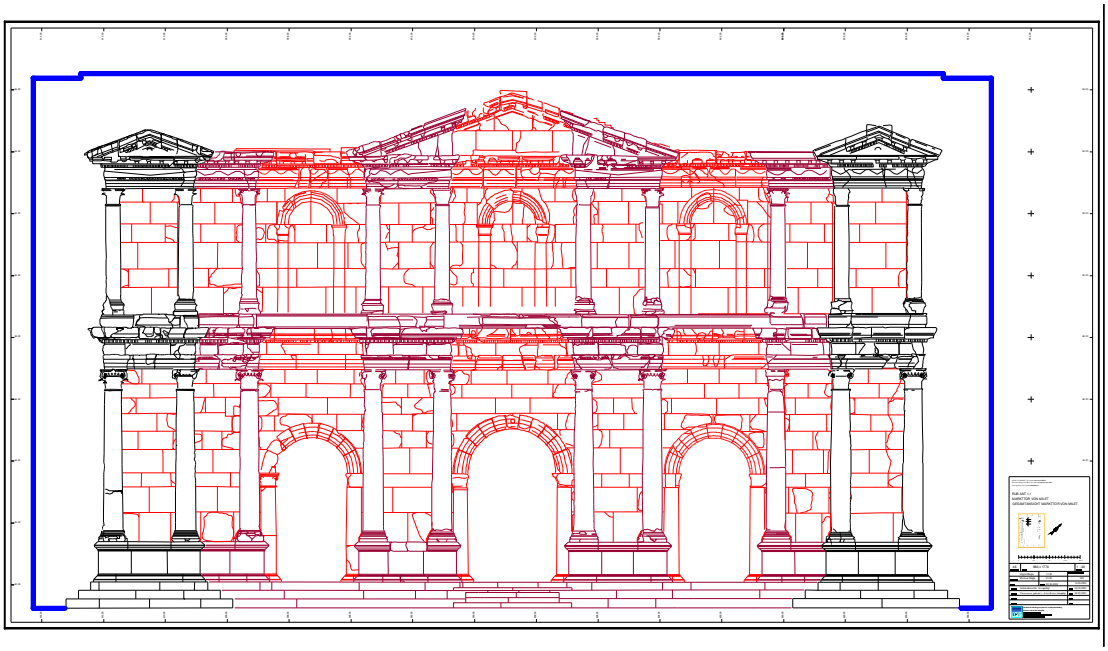

Figure 2. Photogrammetric plan of the front view of the whole market gate (outer line: contour of exhibition room)

2. 3D RECONSTRUCTION OF THE MARKET GATE OF MILETUS

2.1 Reconstruction of architraves

The architrave of the market gate consists of many small edges and a lot of very detailed ornaments like leaf mouldings, festons and rosettes. For reconstruction of the architrave the photogrammetric measurements of the different edges were used to create a profile line (vertical cross section) which was extended to obtain a solid surface of the architrave (Figure 3). The horizontal dimensions were again derived from photogrammetric data. The manifold ornaments were excluded in this first phase of reconstruction

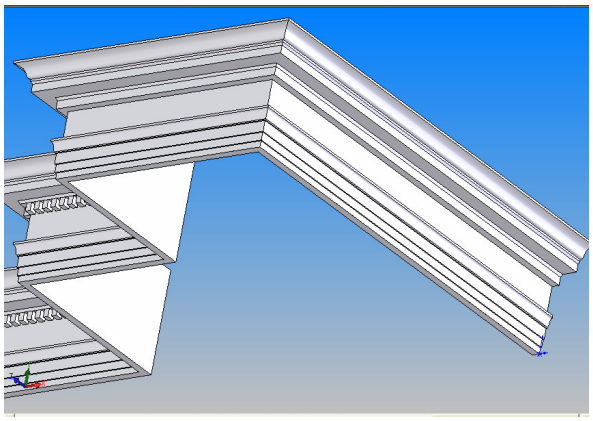

Figure 3. Shape of the reconstructed architrave

After completion of the architrave by adding some main elements like brakets it was integrated in the final building model (Figure 4).

2.2 Reconstruction of the ceilings

The market gate has two storeys each with a complex coffered ceiling. Because of symmetry two basic types of coffers (Figure 5) had to be reconstructed to compose the complete ceilings.

Figure 4. Completed architrave integrated in the final model

The exact position of these basic elements were determined by means of the upright projections derived from the digital photogrammetric data. Again the numerous ornaments were not integrated in the model. One of the resulting reconstructions of a ceiling is shown in Figure 6.

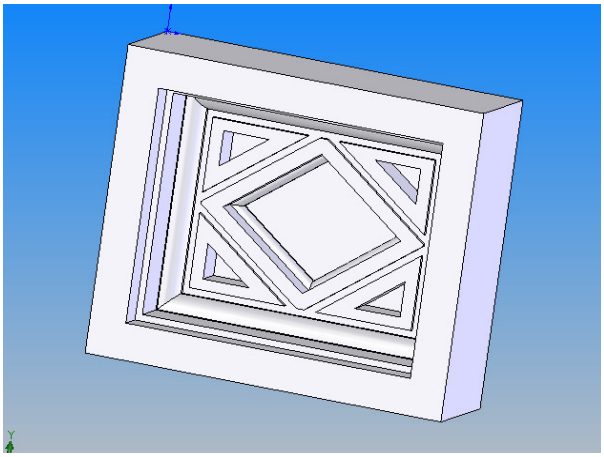

Figure 5. Example of a basic type of a coffer

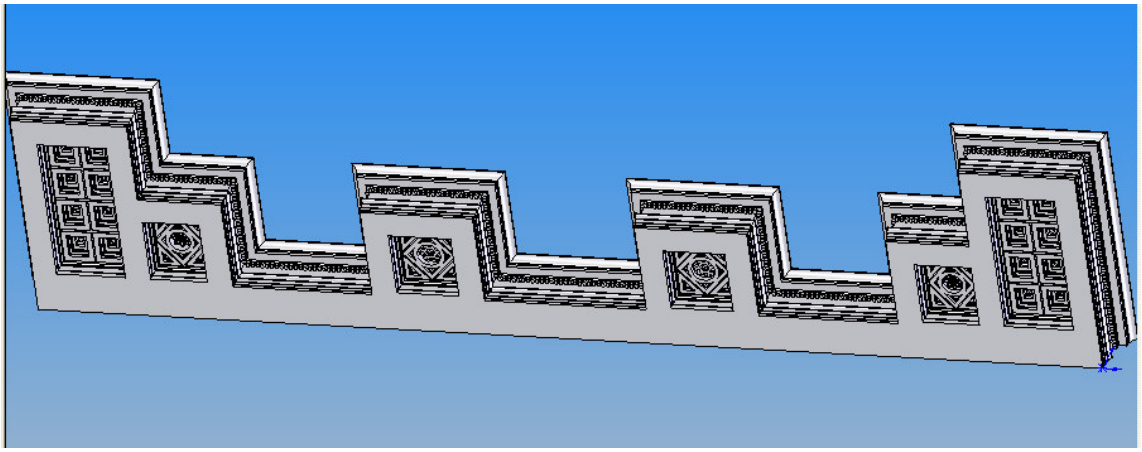

Figure 6. Upright perspective of the reconstruction of the upper ceiling

2.3 Reconstruction of the columns

The most difficult parts of this reconstruction are – without any doubt – the columns with detailed bases and artistically elaborated capitals. Besides the aspect that nearly no column base without damages is available, additionally the fact has to be taken into account that the columns could not be acquired by photo-grammetry from all directions due to spatial restrictions. In contrast to the architrave the bases consist of a lot of curved surfaces as it can be seen in Figure 7. A realistic representation can be obtained by combination of different circular discs, annuluses and zylinders (Figure 7).

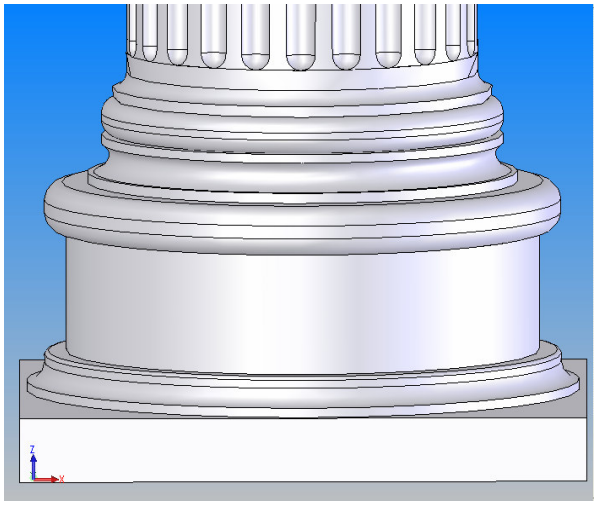

Figure 7. Reconstructed base of a column.

The flutes were constructed by a horizontal contour line extracted from photogrammetric measurements. A vertical displacement leads to a volumetric description of the column (Figure 8).

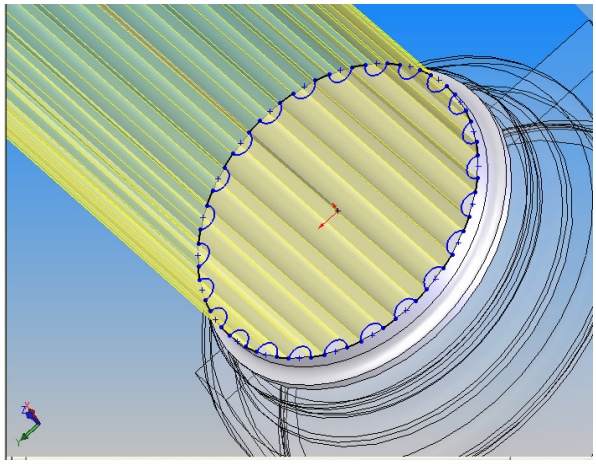

Figure 8. Basic element of the column

Each storey has its own type of columns and capitals (Figure 9 and 10). For each type of capital a special generalised model was constructed. Both are strongly abstracted by a basic shape element, i.e. a zylinder combined with a frustum respectively a hyperbolic body supplemented by four rosettes and volutes (Figure 11).

Figure 9. Example of capital type I (lower storey)

Figure 10. Example of capital type II (upper storey)

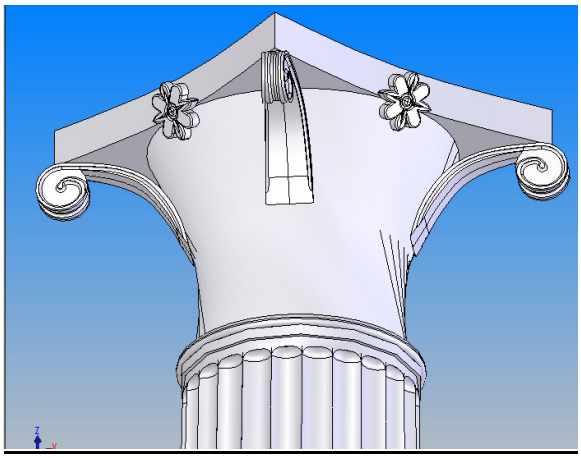

Figure 11. Reconstructed capital (type of upper storey)

First experiments have been performed concerning textur mapping. The main idea is to define relatively abstract basic elements for representation of the real geometries and add detailed information by mapping photorealistic textures of these objects. First experiences show less encouraging results. Caused by the high complexity of the surface geometries of these architectural objects not fully satisfying texture mapping can be achieved for the columns including capitals (Figure 12) and the arcs. A more convenient scenario can be found for the back planes, podium and stairs due to simpler geometries of these building elements. Therefore, further investigations have to be done, e.g. by partitioning of complex structures into sub-elements.

Figure 12. Capital with texture mapping (first tests)

2.4 Resulting building model

All basic parts of the market gate, i.e. all elements described above, additionally the back plane, roof planes, podium and stairs, have to be combined for the final building model. This model allows a good impression of the proportions of this impressive building (Figure 13).

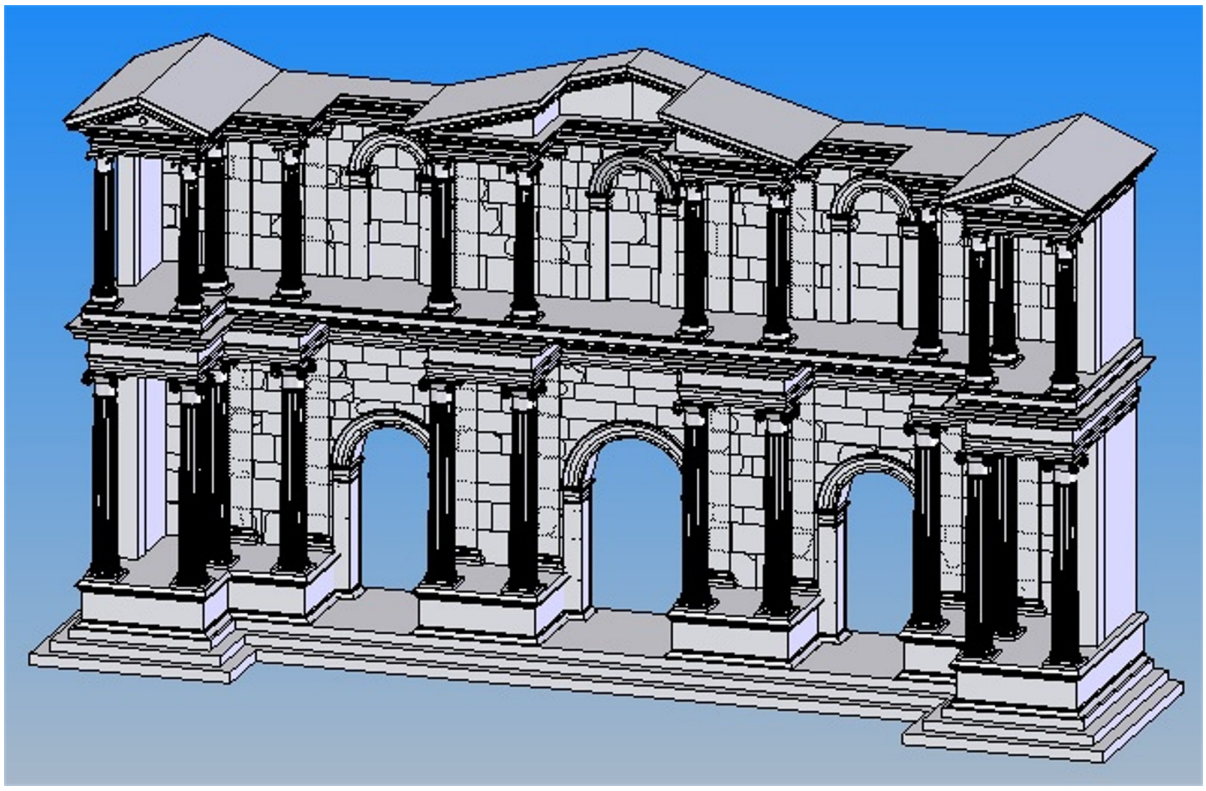

Figure 13. Final 3D building model of the Market Gate of Miletus (first phase)

3. CONCLUSIONS

The geometry of the famous Market Gate of Miletus was acquired by photogrammetry. Based on these data a 3D reconstruction was performed by means of SolidWorks®. This representation is used for different applications. Besides visualisation purposes – especially for an improved spatial impression of complex building parts – these 3D data are used as one base for a building information system. Architects and restoration experts may use it for a detailed damage mapping by including additional information like material, state of preservation and comments about construction details. This information leads to the definition of necessary conservation activities (Maischberger, 2003). Another aspect is the creation of an expert's report where the statics of the market gate will be evaluated in terms of possible damages and negative influences caused by the planned conversion activities of the museum building.

In the next future, additional experiments concerning texture mapping have to be carried out. Especially the plane parts of the architrave with its manifold ornaments which are not included in the photogrammetric data in this phase of the project have to be integrated in the 3D model of the market gate (e.g. Ringle, 2001).

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