THE ADVANTAGES OF PARAMETRIC MODELING FOR THE RECONSTRUCTION OF HISTORIC BUILDINGS. THE EXAMPLE OF THE IN WAR DESTROYED CHURCH OF ST. CATHERINE (KATHARINENKIRCHE) IN NUREMBERG

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ABSTRACT:

Consecrated in 1297 as the monastery church of the four years earlier founded St. Catherine's monastery, the Gothic Church of St. Catherine was largely destroyed in a devastating bombing raid on January 2nd 1945. To counteract the process of disintegration, the departments of geo-information and lower monument protection authority of the City of Nuremburg decided to getting done a three dimensional building model of the Church of St. Catherine's. A heterogeneous set of data was used for preparation of a parametric architectural model. In effect the modeling of historic buildings can profit from the so called BIM method (Building Information Modeling), as the necessary structuring of the basic data renders it into very sustainable information. The resulting model is perfectly suited to deliver a vivid impression of the interior and exterior of this former mendicant orders' church to present observers.

1. SUBJECT MATTER, INITIAL SITUATION AND SHORT DESCRIPTION OF THE RUIN

Consecrated in 1297 as the monastery church of the two years earlier founded St. Catherine's monastery, the Gothic Church of St. Catherine (Fig. 1) experienced a remarkable and changeful history like not many places in the city of Nuremberg. Only 300 years after the foundation of the monastery the triumphal course of the reformation in Nuremberg allowed no new female novices to join the Dominican monastery.

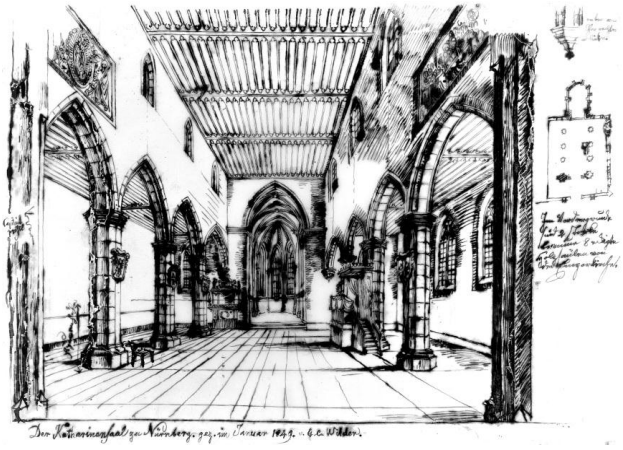

Fig. 1 Historical drawing of St. Catherine´s

Later the church was used for protestant services and became the venue for the voice challenges from 1620 until the end the 18th century. Richard Wagners opera "The Mastersingers of Nuremberg" is set in St. Catherine church. During the German Revolution of 1848 the church was used as meeting place for political presentations. In the following decades the church was used as meeting place for venues or as stockroom. Through the time of National Socialism in Germany Adolf Hitler ordered to put the imperial insignia on display in St. Catherine´s (Fig. 2).

Fig. 2 Display of the imperial insignia in St. Catherine´s

The church was largely destroyed in a devastating bombing raid on January 2nd 1945. Ever since, the ruin is a visible reminder to the consequences of World War II at a central location in Nuremberg. Because the rooms were not used for services for a long period of time before the war, the church was not rebuilt after the war and only the exterior structures are preserved (Fig. 3). While the monastery hosts the public library of Nuremberg, the so called St. Catherine's ruin serves as a place for cultural events such as theatrical performances or concerts. Such usage keeps the St. Catherine's ruin consciously present for many inhabitants of Nuremburg as a venue. At the same time however, remembrance of the original structure is falling more and more into oblivion. To counteract this process of disintegration, the departments of geo-information and lower monument protection authority of the City of Nuremburg decided to getting done a three dimensional building model of the Church of St. Catherine's. A heterogeneous set of data was used for preparation of a parametric architectural model. In effect the modeling of historic buildings can profit from the so called BIM method (Building Information Modeling), as the necessary structuring of the basic data renders it into very sustainable information. This resulting model is perfectly suited to deliver a vivid impression of the interior and exterior of this former mendicant orders' church to present observers.

1.1 Virtual reconstruction of St. Catherine´s church

More than two generations after the devastating bombing raids of 1945 the art historical importance started to overcome the current occupancy of St. Catherine´s. Most visitors of the place are not aware of the historical importance of the church and the current condition of the structure makes it difficult to imagine the original building. While the tracery of the outer walls provides a rough impression of the overall assembly any connection to the internal structures has been completely lost. A 3-dimensional model of the original church was envisioned during the renovation of the public library to provide a lively model of the structures and even the interior decoration for modern visitors.

1.2 Data acquisition

In a first step the department of geo-information of the city of Nuremberg conducted a total station building survey (documentation of setting-out points and conservation status) in the April of 2009. A photogrammetric survey of the exterior walls (Fig. 3) was added a few weeks after the total station survey.

Fig. 3 Placement of photogrammteric survey markers around the building – supported by supported by the fire department of the city of Nuremberg

The photogrammetric survey was not only used for the virtual reconstruction of the building, but also for documentation of the building history of the church this is especially useful as the masonry was partly reconstructed in between 1950 and 1970 without thorough documentation making it difficult to distinguish historic from modern masonry. Images for photogrammetric analysis were captured with an Alpa 12 Metric camera (Rieke-Zapp) in combination with a Leaf Aptus 75 digital medium format camera back with 33 megapixel resolution (Fig. 4). Elcovision 10 software in AutoCAD 2008 was employed for bundle block adjustment and subsequent analysis of the imagery.

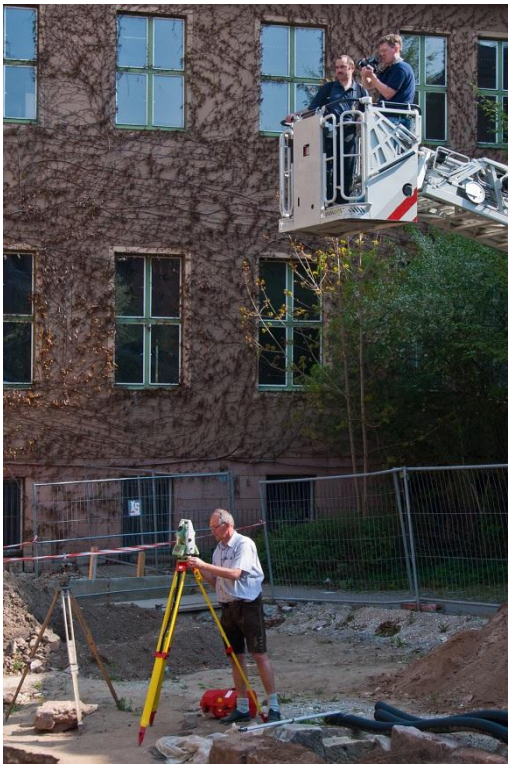

Fig. 4 Simultaneous total station and photogrammetric survey

In addition to modern data historic sources, i.e. photographs, drawings, footprints of the building were available for the virtual reconstruction. No data of the original roof framework was available. Therefore an analog roof framework was employed for the model. The roof framework is based on the French Church in Bern, Switzerland.
The visualization project of St. Catherione´s was part of a summer school organized by for by the Bern University of Applied Sciences for students from architecture and related fields. The church was used as practical showcase for 3-dimensional reconstruction of building with different software programs. The students used ArchiCAD, Vectorworks and Revit software. In the following the advantages of parametric will be explained. The reconstruction of building from a heterogeneous data set is quite challenging. A building information model (BIM) allows the collection and organization of all data that belong to a given structure in an organized fashion. BIMs are typically used for new buildings but in this manuscript we show that the same approach may be useful for reconstruction of historic edifices.

2. EVOLUTION OF THE PROJECT

The reconstruction of a building is in iterative and often a recursive process based on an data set that typically grows and changes significantly while project time progresses. A parametric BIM is much more flexible than classic 2d/3d drawings. The use of a parametric architectural model allows for a change in design even at a later time in the working process, because of the possibility to access the original geometric definition at all times. This is especially helpful for extensive building research projects that frequently produce new evidence in the course of the ongoing work (e.g. through new findings on excavation sites).

It is important to note that the possibility of changes in the model later in the workflow should not result in imprecise work at any stage of the project.

2.1 BIM support a non-linear workflow

Furthermore the approach allows for a step by step working process from the reconstruction of coarser to finer elements. Thus projects can be realized within a given time frame. In effect the modeling of historic buildings can benefit from the so called BIM method (Building Information Modeling), as the necessary structuring of the basic data renders it into very sustainable information. This also means that the applied rules and parameters of the geometry generation remain clear, comprehensible and editable for all other users of the data.

2.2 Teamwork and documentation of data

A BIM allows for the separate investigation of sub-projects. Parts of the modeling that appear too complex at a given point of time, may be filled with placeholders and individual working groups of a team can tackle different work packages simultaneously. As a result a basic model of the bulding emerges rapidly from data and the level of detail may be increased with time.

It is important to note that team work requires thorough coordination and that standards and templates should be defined prior or as early as possible in the project.

2.3 Ready and open for future developments and technology

Building Information Modeling is also open for technological advances and can readily take advantage of new computing power, i.e. cloud computing. Documentation and storage formats of a BIM become important in the long run.

It is important to note that digital data should be stored in a sustainable digital format to allow future users to work with the data.

2.4 Parametric modeling approach

A parametric modeling approach is best suited for similar shapes that can be derived of each other parametrically, e.g. Capitals or Gothic tracery (Figs. 5, 6, 7). Furthermore the method can be used for the generation of simplified abstract models, for example for plausibility checks during the reconstruction process. The method's advantages can be described particularly with its simple way of adding new data to the model and the adaptive level of displayed detail. The use of pre-defined component libraries facilitates collaborative teamwork, allowing numerous scientists to work simultaneously on one reconstruction project. The resulting models, so-called Solid models, are not only quite suitable for weight calculations but can be equally well applied as the basis of 3d model prints.

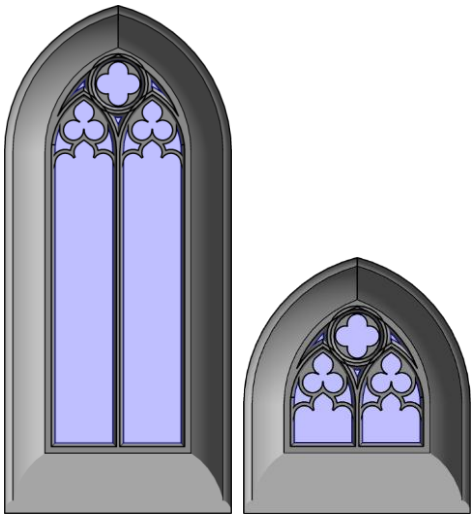

Fig. 5 Parametric variation of the height of a window

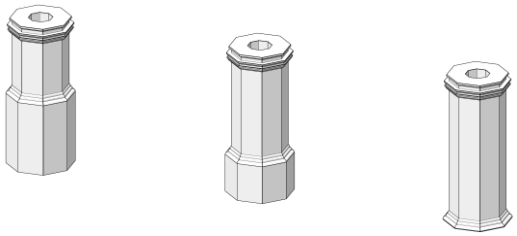

Fig. 6 Parametric variation of the base of a column

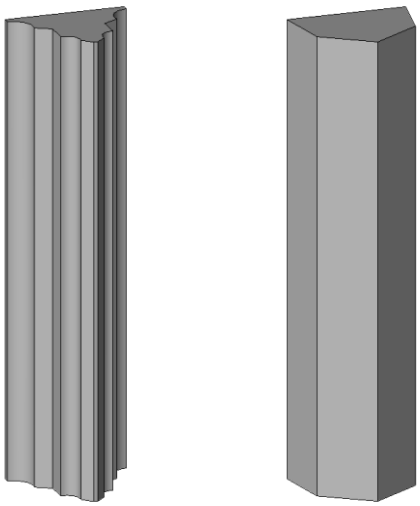

Fig. 7 Variation of the level of detail

3. THE PROCESS OF RECONSTRUCTION

The work process started with a thorough and intense investigation of the heterogeneous set of available data. Prior to the actual modeling process it was determined what part of the model should be represented by parametric functions and what parts will be modeled in a static way. As not all the necessary information could be derived from the available sources there was some leverage for interpretation and educated assumptions. In some cases data appeared contradictory or were not suitable for precise reconstruction. In such cases a decision had to be made by creative users and was not supported by software.

The reconstruction was based on the total station survey. The church was divided in a regular grid whose dimensions may still be changed later on since the modern survey would did not porefectly represent the historic outline that had been changed or reconstructed in some areas in recent times. High quality historic photographs served as the most important source of information. The most important dimensions were fixed by the historic plan and the modern survey and were made available as basic structure to all team members. Special attention was directed at the reconstruction of elements like windows, staircases, arches, doors, roofs, etc. Elements that appeared in similar form at several places were parameterized to reduce the amount of time spent into modeling. This procedure allowed at the same time to apply changes to all elements of the same kind at the same time. Individual team members were able to check their elements against the master model at all times. A new model of an element was implemented in the master model right after its completion. This allowed observing the modeling process on a daily basis increasing the team spirit within the group.

In the very beginning it was not certain that the reserved time frame would be long enough to finish the project. Therefore a rough sketch was prepared to evaluate possible pitfalls early in the process. Afterwards the reconstruction process started. The deductive approach allowed easy progression in the project and was fully supported by the software. The reconstruction by five students took approximately 7 days and required strict observation of the work schedule. The focus of the summer school was directed towards the experience of the methods and workflow rather than to the complete reconstruction of the church. Nonetheless the work resulted in a printed 3-dimensional model of St. Catherine´s
The parametric model also proved useful during the 3-dimensional printing process. It was straight forward, for instance, to adjust the size filigree elements to make them printable by changing the properties of the elements. Even finer details like the window tracery could not be printed and had to be omitted from the print model.

Fig. 8 Ruin and digital reconstruction

Fig. 9 Visualization of the reconstructed 3D model

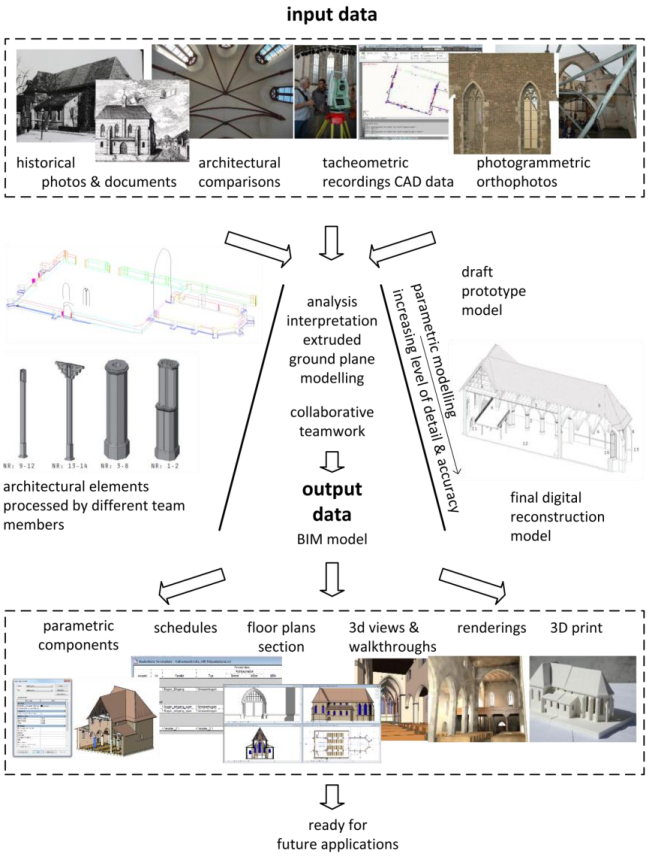

Fig. 9 Parametric workflow for the St. Catherine´s church

4. OUTLOOK

In addition to the already finished work and the existing 3-dimensional printout (Fig. 10) a 1:200 scale model will be prepared for display in the public library that is accommodated in the renovated monastery part of St. Catherine´s.

Fig. 10 3-dimensional printout of the model

The model will be printed in two pieces to allow observers a look into the church as well. The new model will also be employed to solve and discuss open questions about the art historic composition of the interior of the church. A number of original elements, i.e. an altar or statues, have been preserved in Bavarian museums and may be integrated into the virtual as well as the physical model based on high-resolution 3-d scans. IN addition to that parts of the original wall decoration have been preserved by color imagers taken by the national heritage protection agency prior to the destruction of the church in World War II. Information from these images may be used to texture the interior of the building (Fig. 11).

Fig. 11 Paungartner Altar by Albrecht Dürer – Pinakothek, Munich

4.1 Parametric modeling, an innovative approach for visualization in Cultural Heritage

The example of the St. Catherine´s church showcases the parametric modeling of historic buildings. Application of this method allowed the generation of a complete, 3-dimensional model within two weeks' time. The resulting model not only provides a lively impression of the destroyed church, but also of the atmosphere of the church´s interior thus preserving the memory of a building important city history. The parametric BIM approach allowed parameterization of elements where not all information was available from the input data. The workflow entangles quite nicely the interest of historic building research and visualization and is thus suitable for a wide group of users, i.e. archeologists, architects and visualization specialists. The modular modeling approach allowed several groups to work simultaneously on the object. Originally envisioned for planning of building projects, the parametric modeling approach was appears well suited for applications in Cultural Heritage.

4.2 References

Rieke-Zapp, Dirk 2010: A digital medium-format camera for metric applications – Alpa 12 Metric. The Photogrammetric Record, 25(131): 283-298.

4.3 Acknowledgements

The Fire Department of the City of Nuremberg is thanked for provided a ladder truck that allowed image acquisition all around the church and from different heights. The Archive of the City of Nuremberg is thanked for providing historic photographs and plans of the church.

5. FURTHER INFORMATION

If you have questions about the technical content, submission procedure, layout, or editorial requirements, please contact the relevant individual of the meeting organizing committee as listed in the author's kit.