TACHEOMETRY IN COMBINATION WITH BUILDING-ELEMENT ORIENTED CAAD-SYSTEMS
THE INTEGRATION OF HIGH-PRECISION PLAN, SIMPLE 3D-MODEL AND SUPPLEMENTARY BUILDING INFORMATION IN A SINGLE SYSTEM

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ABSTRACT:

The use of CAAD systems for surveying historic buildings was previously not possible as such system models were not able to reproduce the uneven surfaces and deformations inherent in existing buildings. The use of modifiers applied to the standard CAAD-elements makes it possible for CAAD-systems to respond to the actual plan geometry of existing buildings. This is made possible by using CAAD-software in conjunction with tacheometric software on a common working platform (for instance ADT Architectural Desktop). A 3D-model results directly from the survey and serves as a basis for visualisations, automated calculations (such as surface areas, volumes etc.) and as a 3D unit of reference for further non-geometric data. The practicability of the process was tested and exhibited using a real case study object. The main practical advantage of such an approach is the ability to quickly realise a 3D-visualisation of the surveyed building, in essence a by-product of the survey. This is useful for understanding relationships within the building and for initial planning studies. It is possible to link the model with further information but the results of this combination do not fulfil the requirements of a building information system both in terms of performance and usability.

1. INTRODUCTION

Building surveying and documentation in the field of building conservation and archaeology is characterised by traditional measurement techniques such as tape, measuring-stick, plumb-line and spirit-level. They have not been replaced by purely computer-aided measurement techniques such as tacheometry and photogrammetry. Instead computer-aided techniques are often combined with manual methods. However, even traditional surveying approaches must be oriented towards the requirements placed on the resulting survey by the future users. This is becoming increasingly time-consuming when undertaken using manual techniques:

Very often geometric building surveys are required in traditional 2D representation as plan, section and elevation with a high degree of precision and detail. At the same time many wish to have a 3D representation though rarely at the same degree of precision and detail. In some cases it is also useful to combine non-geometric information such as photos or damages protocol etc. which relate to particular building elements and can be accessed through a room or object log.

At present each of these requirements is typically addressed independently of one another:

- The plan and section is surveyed using a tacheometer to a high degree of detail and accuracy,
- A 3D-model is then created using the survey data
- Non-geometric information is then combined with geometric model using a database.

All three requirements can however be integrated with one another using tacheometric building surveying in conjunction with a building-element oriented CAAD-system. A pre-requisite is that a CAAD-system can exchange information with tacheometric software. At present a handful of CAAD-Systems - such as ADT Architectural Desktop (autodesk, 2003) or Palladio X (acadGraph, 2003) - and tacheometric surveying systems - such as TachyCAD (kubit, 2003) or EITheo (pms, 2003) - fulfil this requirement using the common work platform AutoCAD. Using such hardware and software, efficient 3D-models can be produced with high precision sectional geometry.

2. HIGH-PRECISION TACHEOMETRY AND BUILDING-ELEMENT ORIENTED CAAD MODELS

The process as described above can in part be achieved using currently available software products. Different software modules can be employed in combination with reference to a standardised working platform (ADT Architectural Desktop by AutoDesk). Both the CAAD-system Palladio X5 and the Tachymetry software TachyCAD are conceived as extensions to ADT and as such can be employed as tools in a platform for realising the planning-oriented capture of building information. Of particular relevance is the ability to use the tacheometer as a 3D-mouse (fig. 1b) to directly position Palladio X5 elements (fig 1a) within an overall coordinate system.

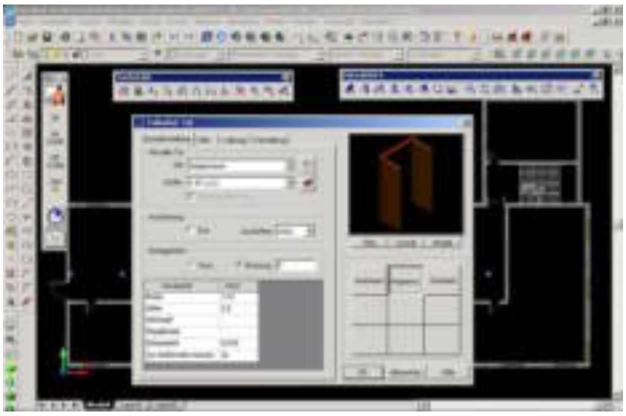

Figure 1a. Definition of building elements in Palladio X5

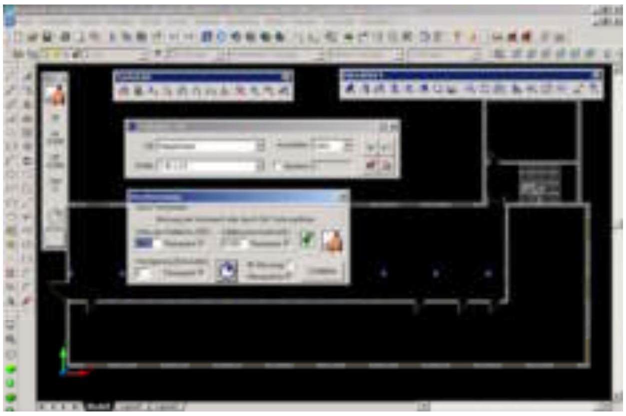

Figure 1b. Positioning of building elements with TachyCAD and tacheometer

The different modifiers defined in ADT and usable with Palladio X5 can also be used with the tacheometer. The ability to adapt standardised building elements (e.g. walls) to their actual object geometry is essential in order to able to model existing buildings with all irregularities within an object-oriented system (fig 2).

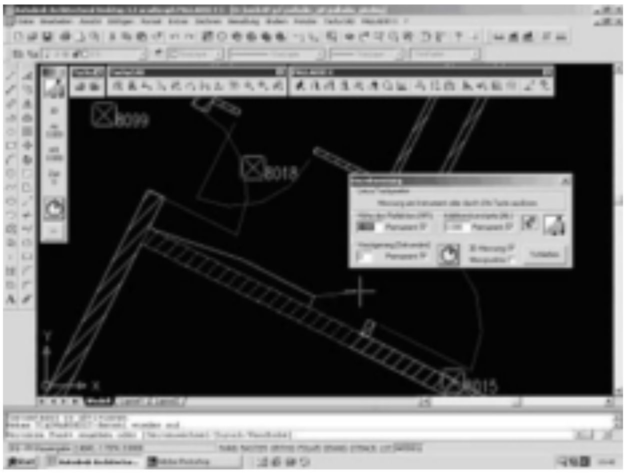

Figure2a. Adaptation of wall surface profile using tacheometric measurements – screenshot

Measurements provided by the tacheometer adapt the standard CAAD wall element to the actual surface form with the help of so-called modifiers (fig.2b).

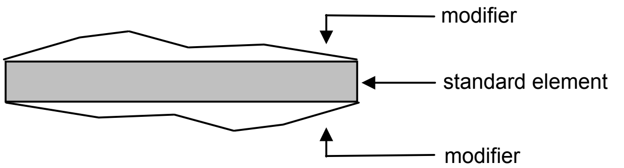

Figure2b. Adaptation of wall surface profile using tacheometric measurements – principle

This approach allows the typical 2D-geometric building survey to be expanded into a quantifiable building-element related 3D-model.

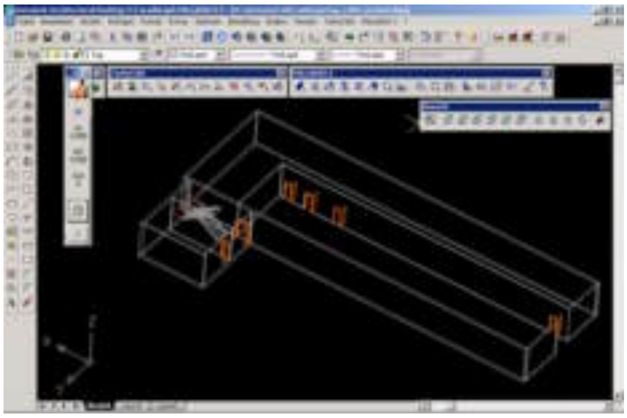

Figure 3a. Sketch model

Palladio can also be used as a first stage for sketching out a rough building model (fig. 3a) which can then be 'intensified' using surveying methods to develop as precise and detailed a 3D-model (fig. 3b). This combination means that it can be used as surveying tool at both a simple and highly detailed level. A high density of information can be employed selectively throughout the entire process.

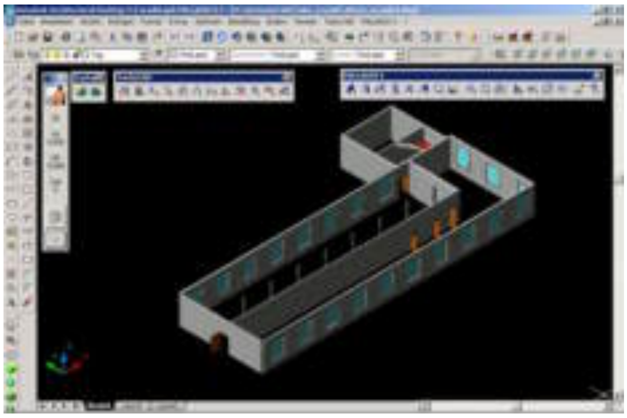

Figure. 3b. Extended and intensified detail model

The retrieval and allocation of further information to or from building elements can be undertaken using the resulting CAAD-model. Standard information retrieval methods in Palladio include room stamps and lists of building element (Fig. 4). Additional modules allow surface and volume quantities to be calculated for later use in specification of conservation works.

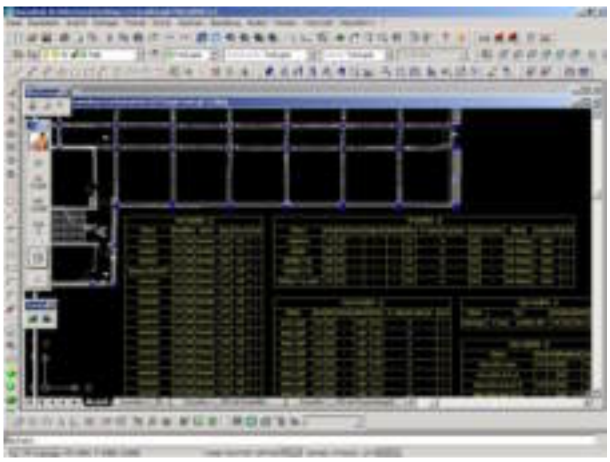

Figure 4. Automatically generated list of building elements

Information can be allocated using the standard database interface in Architectural Desktop.

3. EXAMPLE: BUILDING SURVEY OF A FORMER FIRE-SAFETY FACTORY (BUILT 1938/39 BY EGON EIERMANN)

The combination of tacheometry and a building-element oriented CAAD-system is used to develop a plan representation as well as a building-element oriented CAAD-model which can then be used as an information repository. The survey of a factory building by Egon Eiermann built in 1938/39 served as a test scenario. The four-storey workshop building was part of a fire-safety factory in Apolda, Thuringia, Germany. The development of the model can be seen in the example taken from one story of the building (Figs. 4-6):

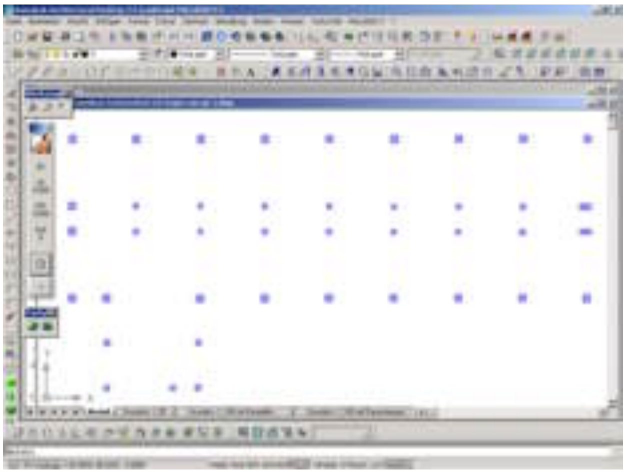

Figure 4a. Plan: Columns

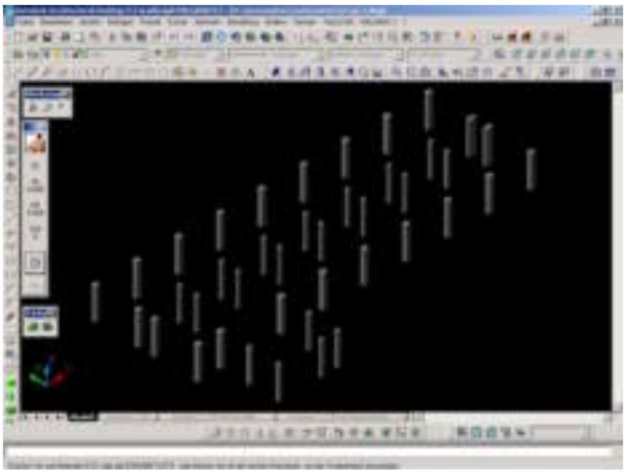

Figure 4b. 3D-model: columns

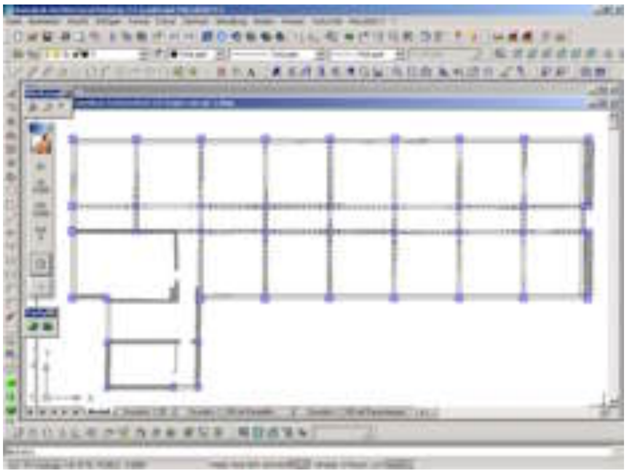

Figure 5a. Plan: Columns, beams, walls

Figure 5b. 3D-model: Columns, beams, walls

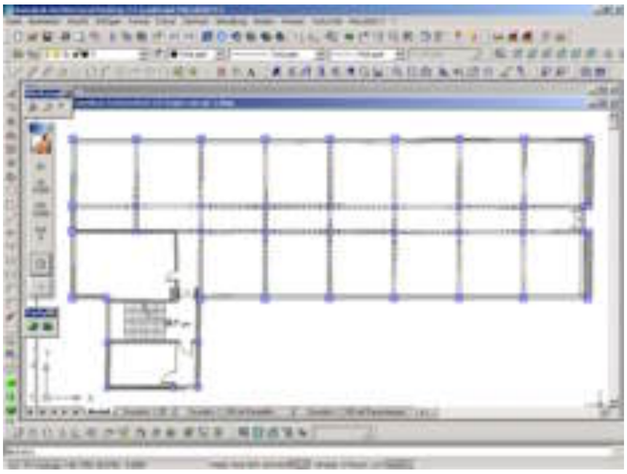

Figure 6a. Plan: Columns, beams, walls, windows, doors, stairs

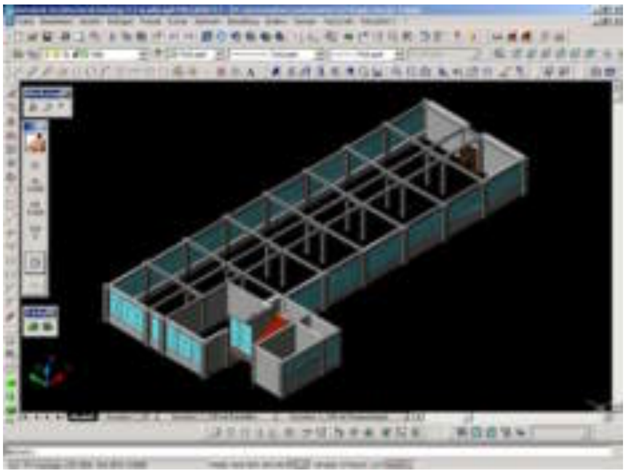

Figure 6b. 3D-model: Columns, beams, walls, windows, doors, stairs

The approach described in this paper has the following advantages and disadvantages:

- The use of CAAD-building elements is coupled with a height-parameter resulting in 3D-extruded objects. A simple shadowed or rendered model can be generated immediately from within the CAD-system.
- The creation and adaptation of CAAD-building elements using tacheometry ensures a high-precision plan representation which can, as necessary, be dislocated from the rest of the building model for independent editing.
- The three-dimensional model allows the generation of simple system sections.
- The geometric area or volume of individual building elements can be calculated automatically with a view to determining areas and bills of quantities.
- Individual building elements can be assigned attributes or parameters so that this information becomes integral to the building model.
- The 3D model is not detailed enough for special requirements, because deformations in the extruded surface cannot be included or are difficult to model – walls and ceilings are flat.
- Information management does not fulfil more complex requirements such as those which can be expected from a GIS-system. Information assigned to building elements should be restricted to essential properties.

4. CONCLUSION

The use of CAAD systems for surveying historic buildings was previously not possible as such system models were not able to reproduce the uneven surfaces and deformations inherent in existing buildings. The use of modifiers applied to the standard CAAD-elements makes it possible for CAAD-systems to respond to the actual plan geometry of existing buildings. This is made possible by using CAAD-software in conjunction with tacheometric software on a common working platform (for instance ADT Architectural Desktop). A 3D-model results directly from the survey and serves as a basis for visualisations, automated calculations (such as surface areas, volumes etc.) and as a 3D unit of reference for further non-geometric data. The practicability of the process was tested and exhibited using a real case study object. The main practical advantage of such an approach is the ability to quickly realise a 3D-visualisation of the surveyed building, in essence a by-product of the survey. This is useful for understanding relationships within the building and for initial planning studies. It is possible to link the model with further information but the results of this combination do not fulfil the requirements of a building information system both in terms of performance and usability.

The potential offered through the combination of surveying equipment and software should be examined in more detail. The usability of such systems should be simplified through the provision of a tailor-made interface and tools which are oriented around the demands of practitioners in conservation and archaeology.

5. REFERENCES

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