A BUILDING INFORMATION MODEL – COUPLING GEOMETRIC INFORMATION AND BUILDING SIMULATION IN THE EARLY DESIGN STAGES OF RETROFITTING

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Over the course of their life cycle, buildings pass through various phases from the initial design, construction and occupation to revitalization or demolition. Over time, important information is often lost and must be newly acquired if it cannot be retrieved from existing documents. A building information model (BIM) is an efficient way to store all kinds of necessary information ranging from geometric information to material properties, possible damages, future use etc. over the whole life cycle.

At the Bauhaus-University Weimar, Faculty of Architecture, a software platform was developed for establishing BIMs. The storage of all kinds of information in a global BIM supports the making of plausible decisions in any stage of the design process. Decisions in the early phases have a particularly high impact on the latter product and therefore need to be especially supported.

As an example, different existing building simulation tools will be linked to the geometric information within the BIM in order to investigate the performance of the building with regard to energy consumption as well as comfort. This example has been chosen as the reduction of energy consumption is one of the main issues in the revitalization of buildings.

Keywords: building information model, building simulation, early design stage

1. BUILDING SURVEYING: CAPTURING GEOMETRIC INFORMATION

The building lifecycle consists of various phases of planning, construction and usage, which are periodically repeated every time the building or parts of it are changed. In the last few years, the proportion of planning tasks concerned with one of the repeated phases has increased considerably in German architectural design practice. The revitalization design stage differs from the initial design stage in that there is an existing built context, which is both the subject and the basis of every planning decision. Accordingly, the recording of information about the building substance is one of the central issues of the early planning stage in existing built context.

Although building surveying and planning proceed in parallel, the planning process determines the relationship of the two processes by defining purpose, kind and amount of the information to be surveyed as well as the method used for surveying.

In the architectural planning process design solutions are usually developed with successively decreasing scale, starting with the building volumes at a large scale and proceeding to the shell of the building, the construction system, the floor plan layout of single units within the building, ending with the detailed construction at the later stages. The building information is acquired in an ongoing parallel process as needed for each stage with increasing depth of detail and measurement precision. The overall building geometry (ground area, height, levels) is acquired first, followed by the structure of rooms and building elements (topology of the building) and approximate dimensions. As the level of precision increases during the later stages, so too does the level of detail and continuous refinement of the building structure.

2. BUILDING INFORMATION MODEL: AN INFORMATION CONTAINER

In a contemporary architectural workflow using modern surveying equipment and computer systems for planning, the surveying data needs to be available in digital form. The use of computer sciences in architecture aims to provide a continuous data flow throughout the building life cycle, planning support through simulation and analysis and on-site-visualisation using augmented reality methods. To fulfil the various requirements of the planning process, the use of a Building Information Model to store all kinds of information in an incrementally extendable information base has become widely accepted in the design of contemporary planning systems.

At the Bauhaus-University Weimar, Faculty of Architecture, a software platform was developed for establishing a BIM. It is based on a server-client structure where the server manages the stored information and the clients access and use the information by providing architectural functionality or services for augmented reality environments. The architectural functionality includes building surveying, on-site-planning, sketching assistance and colour design. In addition to facilitating the prototyping of new clients, this software architecture allows one to change and extend the Building Model at runtime.

The model holds different kinds of information for various domain specific tasks such as building surveying, planning, material development, building physics, etc. These are domains involved in the project “Methods and materials for user-oriented building renovation”.

3. BUILDING PHYSICS: AN EXAMPLE OF PLANNING RELEVANT ANALYSIS

The planning process can be described as a periodic alternation of analysis and synthesis phases. During the synthesis phases design solutions are generated, which can in turn be analysed. Examples for the different kind of planning relevant analyses are functional analysis, cost assessment and thermal performance simulation. Because geometric information is necessary for most of the analytical tasks, it can be seen as a common base for domain-specific information. In the following, we will discuss the coupling of geometric information with thermal performance analysis as an example from the research project.

Building physics are very important aspect that needs considering during the design stage. While cost and geometry are normally considered from the beginning, the assessment of thermal and acoustic insulation is often postponed to later phases. This can lead to suboptimal decisions.

A large number of software tools are available for architects to improve the building design related to thermal insulation, energy consumption, acoustic and thermal comfort and fire protection. Software tools to calculate the thermal behaviour of a building under transient conditions, 2-D and 3-D heat flux modelling, computational fluid dynamics and room acoustic software are state of the art. The early use of these software tools coupled with the geometric design and cost assessment could help to improve the end result by comparing different versions, for example where the thickness of insulation and the window quality is varied.

4. THE COUPLING OF GEOMETRIC INFORMATION AND PHYSICAL ANALYSIS

During consecutive planning stages different methods of physical building analysis are applied, according to the requirements of the respective planning stage and the decisions to be made (see Fig. 1). Each of the different methods of performance analysis relies on a specific quantity of geometric data, which in most cases corresponds to the geometric data needed for planning itself or otherwise constitutes a building survey request.

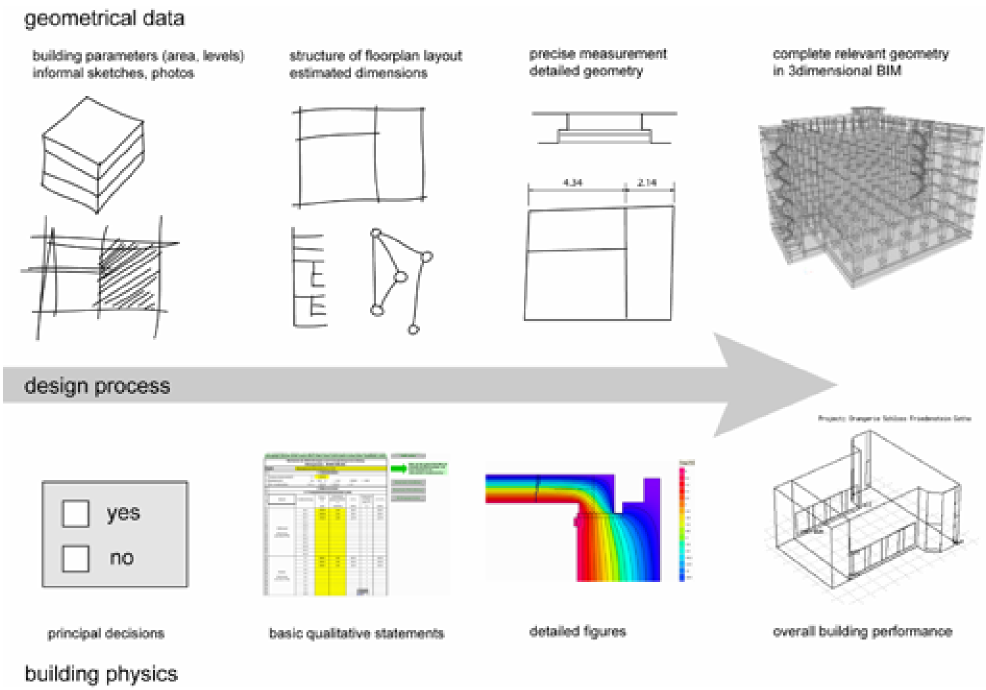

Fig. 1: Design stages showing the relevant issues of building physics and level of detail of the surveyed data

As a result, the amount and density of information is constantly increasing not only during the planning stage, but also during the whole building lifecycle.

Fig. 2 shows the progression of the volume of information with and without the use of a Building Information Model and provides a relative comparison of the gradients for the amount of data generated by building performance analysis and geometric surveying. One main advantage of a common Building Information Model consist in the continuous data flow through the building life cycle, which means that data gathered in one phase of the building lifecycle will be available in later stages and doesn't have to be re-acquired, but only updated.

The use of the same geometric information for the planning and physical analysis of the building performance during the planning stage obviates the need for repeated data capture, data storage redundancy and therefore also reduces inconsistencies. Unambiguous geometric data is a requirement for building performance simulation as well as for reliable planning decisions. The plausibility of planning decisions is enhanced by the results of building performance analysis. If this support is provided in the early planning stages, critical parts of the design can be identified early on and design variants assessed accordingly, leading to greater cost certainty in the long run.

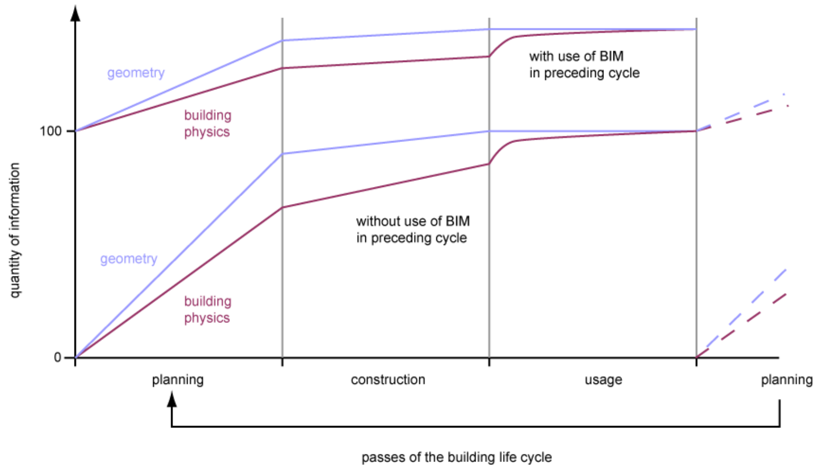

Fig. 2: Relative volume of information for building physics and geometrical survey (with and without use of a BIM)

Using the client-server-framework mentioned in section 2 the coupling of building physics, planning and building surveying will be shown through a newly developed client. Depending on the complexity of the building performance assessments in the different planning stages, the client will either provide a data exchange connection to existing building simulation tools or integrate simple building physics calculations into tools that support the early design stages.

Figure 3 shows a schematic diagram detailing the connections between building surveying and building physics analysis as determined by the needs of the planning process, and their storage in a central common Building Information Model.

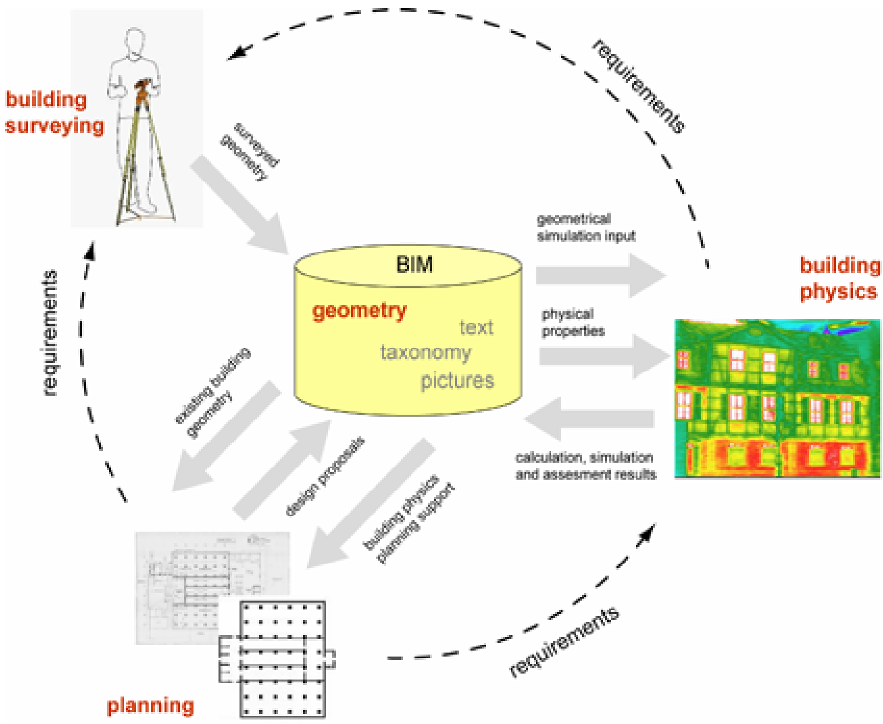

Fig. 3: Data flow between surveying, planning and simulation