Go to contents 03

The Use of Design Cases to Test Architectural Building Models

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The IDEA+ project aims at developing an Integrated Design Environment for Architect designers, in which design tools and computational tests make use of one and the same core building description. Such a description must be apt to describe architecture in a full-fledged way. Hereto, the authors have put the IDEA+ model to the test with actual design cases. These cases have been used to test isolated design concepts and to mimic the global design process.

Keywords: *building model, CAAD, case, object-oriented, architecture*

The architectural model

The IDEA+ project aims at developing an Integrated Design Environment for Architecture, allowing the modelling and testing of a design with access for all professionals. A gradually refined design representation takes a central position in this environment. At the appropriate time, additional software tools that are in tune with the precision of the design at that moment can be plugged in and use/complement the design data. In cases where an automatic data transfer between tools and model is not obvious, the environment can distil suitable views on the design data to ameliorate 'manual' transfer. The environment (fig. 1) basically consists of: (1) A theoretical or conceptual framework for architectural design. (2) A core object model to hold the building description, comprising all data, concepts and operations involved in the design process. (3) An efficient data management system to store the model while designing. (4) Test and design tools to assist the architect while designing (fig 1).

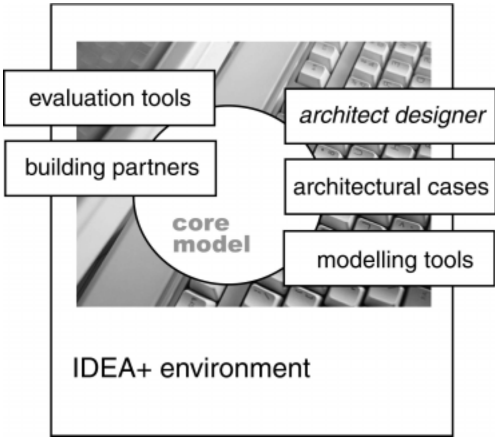

Figure 1. The IDEA+ integrated design environment.

Whereas the project relies on a present theoretical framework (Neuckermans, 1992) the efficient data management and the assisting tools are still subjects of research (e.g. Geebelen and Neuckermans, 2000). As to the core object model, the conceptual version of it has been developed to a large extent and specific topics have been implemented (Hendricx, 2000). Some of the main features that distinguish the IDEA+ core model from those models elaborated in the context of other product modelling initiatives are the systematic approach in the construction of the model by using an object-oriented analysis method, and the respect for the evolutionary nature of architectural design (Hendricx and Neuckermans, 2001). This paper concentrates on another distinguishing feature:

Go to contents 03

the testing of the conceptual object model with actual and complete design cases.

The design cases

The design environment should not confine the user to evident, routine design and trivial architecture, but must enhance the creation of creative and high quality architecture. Therefore, a building description should be apt to represent (most of the) architectural products in a full-fledged way. As to architectural quality, the designer, of course, cannot disclaim responsibility, but at least she should not be limited in her design efforts.

One author who detects the incomplete testing of building models as a typical weakness is Clayton (1996, referred to in Björk, 1999). During research, IDEA+ concepts and prototypes have been tested with three complete design projects, widely (at least in Belgium) recognized to be specimens of non-trivial design solutions. They are all located in Belgium and involve architects part-time employed at K.U.Leuven University, which has allowed us to discuss the projects with the architects and to get access to original sketches, plans and photographs. The three projects are:

- the De Smet-Claus residence: a detached single-family house in Aalst – architects Henk De Smet and Paul Vermeulen, designed in 1992 (fig. 2).
- House P: a single-family terrace house and workshop in Antwerp – architects Poponcini and Lootens, designed in 1997 (fig. 3).

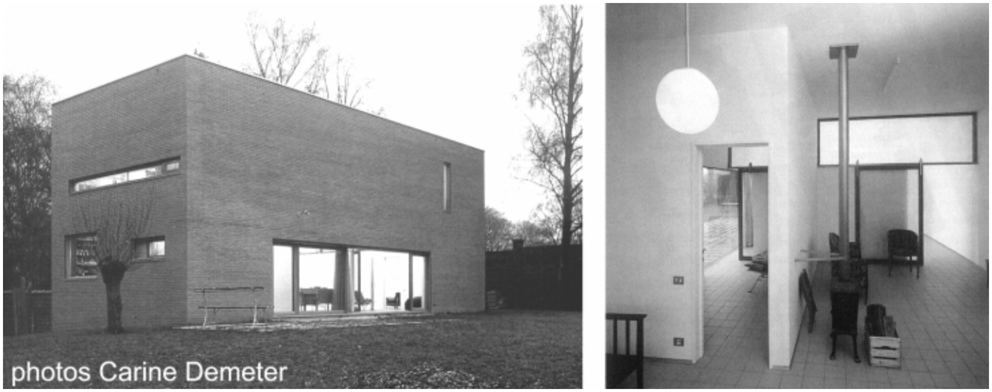

Figure 2. The De Smet-Claus residence, view from northwest and living room.

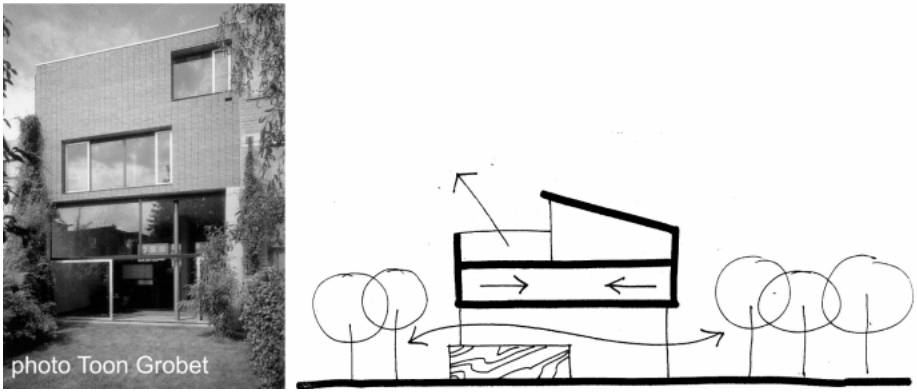

Figure 3. House P, garden view and architect's sketch.

Go to contents 03

- Hogenheuvel College: a university complex of offices, a library, lecture rooms and rooms with representative functions, architects Paul Van Aerschot / Poponcini and Lootens, designed in 1994 (fig. 4).

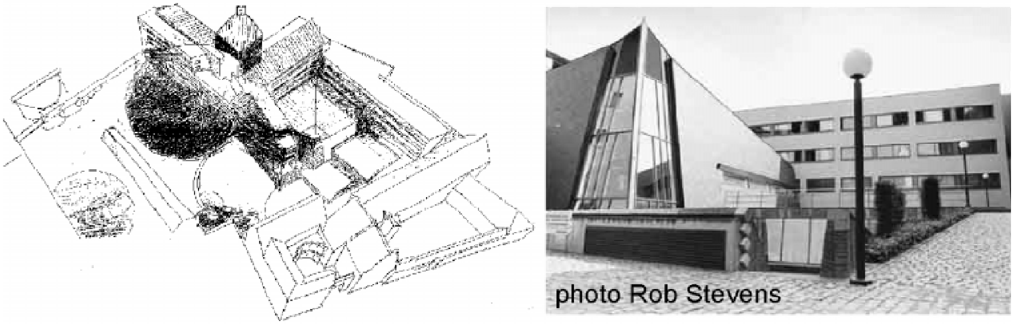

Figure 4. Hogenheuvel College, general overview with new buildings greyed in, existing building to be renovated in line drawing (architects'sketch), view on the central library with office wings (right).

The principles

Due to the complex nature of architectural design, the object classes of the core object model are subdivided in three categories (called layers), ranging from general principle classes to detailed libraries of building elements. A particular design case is described by a set of instances derived from the object classes of the core model. The generic principle layer at the top contains the object classes describing the main principles concerning both representation and semantic meaning of design entities. Here, any design ELEMENT is subdivided in its semantical parts (CAAD ENTITY) and its representations (GRAPHICAL ENTITY). This splitting of an entity's features enhances the modelling of changes occurring in the course of the design process. In figure 5, for instance, the staircase in the House P evolves from a slope with a certain width towards a more detailed design entity. The object scheme of the generic layer allows switching between design representations as well as the progressive adding of design information.

The architectural aspects layer specializes the CAAD ENTITY and as such defines and relates the main design entities observed in building descriptions: physical objects, spaces and user activities. Both the object instances of these design entities and the relationships between them have been modelled in the concrete projects. Figure 6 shows some object instances in the De Smet-Claus residence: spaces and physical entities.

This testing of the principles on actual projects often has led to a refinement or even total rearrangement of the entity-relationship schemes of the object model. The PhD dissertation by Hendricx (2000) provides detail information on the final proposal and the research road leading to it.

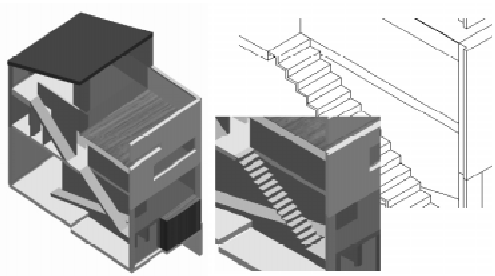

Figure 5. A general (left) and more detailed (right) on-screen representation of the same staircase in House P.

The design process

In order to achieve a workable design environment, the core model must have the ability to reflect the actual design process. This is why, apart from the testing of isolated topics and principles, we have simulated the different design stages in actual and complete projects. This simulation concerns not only

Go to contents 03

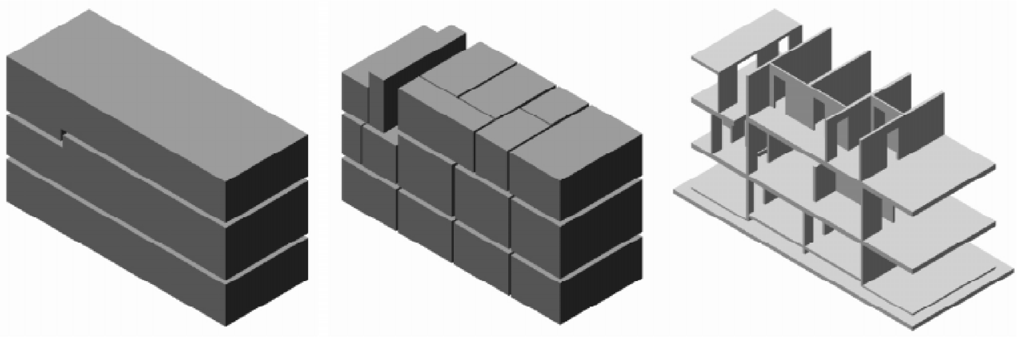

Figure 6. Some spaces of the De Smet-Claus residence linked in a hierarchic structure (left and centre), and some of the connected space dividing physical entities (right). PHYSICAL CONTACT LINKS, SPACE DIVIDING LINKS and IMAGINARY BOUNDARY LINKS provide the necessary links between - respectively - a physical entity and a physical entity, between a space and a physical entity, and between two directly related spaces.

the modelling of the different stages but even more the transition between these stages. The remainder of this paper presents the design process of Hogenheuvel College in Leuven. In this case study, a Microsoft Access relational database contains the core building description; the on-screen modelling took place in AutoCAD. In the Access database, every conceptual object is transferred into a table. The object core relationships are realised by defining relationships between the different tables. Each GRAPHICAL ENTITY record in the database is linked to its AutoCAD counterpart by referring to the AutoCAD entity's unique handle name.

Phase 1: modelling the building site, including the terrain and the existing-and-remaining building blocks. Adjacent building blocks are linked by PHYSICAL CONTACT LINKS. The same link is used to relate the building blocks and the terrain. By following the SPACE DIVIDING LINKS between the (always present) space "outside" and the building blocks, one knows which surfaces expose a building block to the outdoor climate. See figure 7.

Phase 2: modelling the overall layout of new building blocks, including the appropriate PHYSICAL CONTACT LINKS and SPACE DIVIDING LINKS (also figure 7).

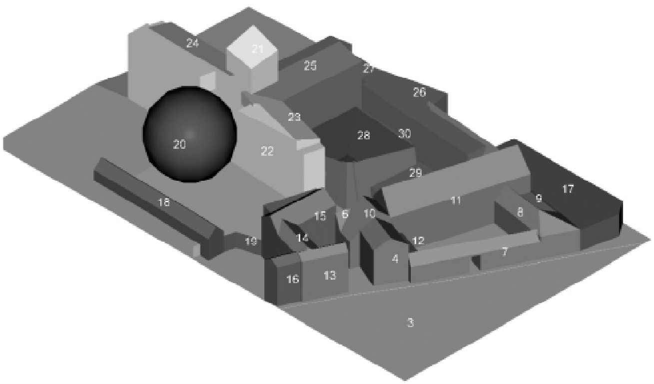

Figure 7. Phase 1 and 2, modelling the terrain and (both existing and new) building blocks of the masterplan. The numbers on the geometrical entities refer to the primary key of the corresponding ELEMENT in the Access database. The main building block and tower (in lighter colour) will be further elaborated in later design stages.

Go to contents 03

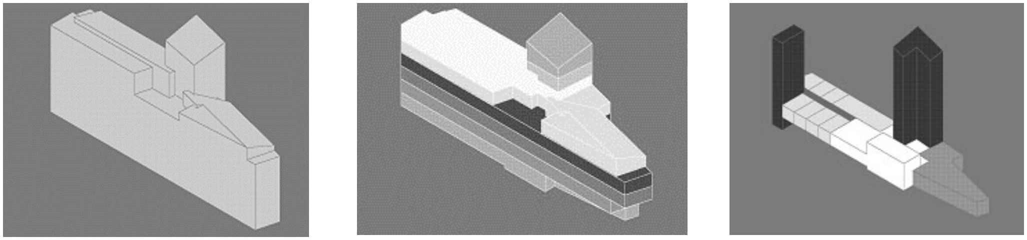

Figure 8. Modelling of spaces on the building level (left), floor level (centre) and room level (right).

Phase 3 and 4: modelling the main building block (general building envelope and floors, see e.g. left image in figure 9), modelling the highest level of user spaces (left and centre image in figure 8) and the user activities. Both the physical entities and the highest level of spaces are linked to the building block they belong to. Lower level spaces are linked to the higher-level ones, resulting in a hierarchic system of spaces. By following the USER ACTIVITY LINKs, one knows which space houses which activity.

Phase 5: modelling the physical entities (walls, columns, glass panels…) as well as the necessary links (centre image in figure 9).

Phase 6: modelling the user spaces, the user activities and the appropriate links on a more detailed level (right image in figure 8)

Phase 7: modelling the additional openings and the appropriate links in the building envelope. A hole – in this case a window hole - is defined as a special kind of SPACE (sometimes, a big window hole even may become a user space), so that the general boundary system can be applied to model the contact areas between holes and their surrounding entities (right image in figure 9).

Conclusion

Testing the object model in the course of the research process with actual and complete design cases has allowed us to fine-tune and even drastically change intermediate model proposals. Indeed, several shortcomings and missing links in these proposals came to light. For instance, the possibility to represent full 3D compositions (instead of the so-often achieved 2.5D), the need for an 'imaginary boundary' to define spaces not completely defined by physical boundaries, and the attention for a project's context (modelling the terrain, difference between old and new components of a building…) are aspects that easily could have been neglected or forgotten without this thorough testing.

Some drawbacks remain. For one, the testing has been performed by the researchers and not by the designers themselves. Secondly, we reconstructed the building representations after instead of during the design process. At present, a complete prototype of the core model and a (elementary) user-friendly interface to store the model while designing are being implemented. With these instruments at hand, and with the cooperation of volunteer designers, a testing more ample and accurate should be possible.

Figure 9. Modelling of the physical entities floors (left), walls, columns and glass panels (centre) and modelling additional openings in the building envelope (right).

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Go to contents 03

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