Back to the future: Integral Open building design

Wim Zeiler, Perica Savanovic

Technische Universiteit Eindhoven, Faculty of Architecture, Building and Planning, Eindhoven, Netherlands, w.zeiler@bwk.tue.nl

Abstract: To improve the outcome of the building process it is very important to look at the main areas for striving towards improvements. Although these areas are interdependent the path to success starts with the design process. Therefore there is a strong urge for better design methods and tools. Although it is interesting to look into new design methods of other disciplines, we think it is also good and maybe even better to look in the developments of our own discipline from the past which might be forgotten by some of us in their strive to innovation. Such design approach might be open building.

The “thinking in levels” approach of Open building was introduced into the building industry to improve the design and decision process by structuring them at different levels of abstraction. The paper will deal explicitly with the added value of an open building approach to shape the future built environment.

Key words: Open building, Integral design

1. Introduction

The construction industry is plagued with several problems in the last decades such as poor resulting product quality, delayed delivery, low economic results and high risks which lead to distrust [1];
- development of a solution: including consultation with the client and development of product specifications and design;
- implementation of the solution: the construction or refurbishment of the facility that will satisfy the client needs and those of the project participants: and
- the project process: the roadmap or framework that is used for undertaking the project activities and that delivers value to the supply chain parties.

Although these aforementioned areas cannot be considered in isolation as they are all interdependent, the development and design is the crucial starting point. That is the reason why there is a strong focus on raising design quality and value in the built environment [2]. Decisions taken during the conceptual design phase of a project have fundamental and extensive effects on both cost and performance [3]. There are growing demands on design teams to generate better solutions with improved added value. At the early design stages, usually only conceptual sketches and schematics are available, often rough and incomplete. Architects tend to develop their designs in a drawing-based, graphical way (prototypes are used to investigate the design concepts). It is important to mention here that (building) design is a creative process based on iteration: it consists of continuous back-and-forth movements as the designer selects from a pool of available components and control options to synthesize the solution within given constraints.
To meet these demands, more efficient and effective design methods and processes are required. In this search for new methods also design methods of other disciplines such as the software industry are investigated. Emergent design is a recent model of software engineering accounting for incremental and unexpected modifications of the design state space. There are a lot of similarities between emergent design and building design: both creative processes are based on iteration consisting of continuous back-and-forth movements as the designer selects from a pool of available components or subroutines and control options to synthesize the solution within given constraints. It seems that emergent design de-emphasises “design” in favor of “coding”, making this approach seem unprincipled and lacking top-down guidance. By using an ontological model a better understanding of emergent design can be gained and emergent design is seen as a complement rather than a alternative to top-down approaches. This ontological model should offer the possibilities to facilitate both the incremental and the unexpected modifications. In the building planning process domain the thinking about design has already quite a tradition and history from which lessons can be learned. Emergent design leads to reflecting on the open building principles.

The “thinking in levels” approach of Open building was introduced to improve the design and decision process by structuring them at different levels of abstraction. In section 2 the general ontological approach is described leading to the Open Building approach described in section 3. The application of the approach is given in section 4 and a result is given.

2. Methodology: a change in design conceptualisation, the ontological perspective as a first step

One of the major problems in modeling design knowledge is in finding an appropriate set of concepts to refer to the knowledge, or - in more fashionable terms- finding an ontology. In the knowledge engineering community, ontology is viewed as a shared conceptualization of a domain which is commonly agreed by all parties. It is defined as ‘a specification of a conceptualization’ [4]. ‘Ontology’ in philosophy means theory of existence in the broadest sense. It tries to explain what is being and how the world is configured by introducing a system of critical categories to account things and their intrinsic relations [5]. Ontology aims to capture the conceptual structures in a domain by describing facts assumed to be always true by the community of users. Ontology is the agreed understanding of the ‘being’ of knowledge: consensus regarding the interpretation of the concepts and the conceptual understanding of a domain [6]. Currently the design of building environment and the necessary energy infrastructure are done by totally different and separated groups of designers. Therefore there is no shared perception (i.e. an ontology) of the design activities which designers perform in the design process of an energy infrastructure on the different levels of scale within the building environment.

Without the shared perception it would not be possible to develop adequate design methodology or approaches for design support that are systematic, consistent, reusable and interoperable.

We looked at ontology’s in the built environment for integrating the users. Ontology’s are formal conceptualizations not made l’art pour l’art, but to help to achieve a goal or to perform a task by an actor. In this case, the task involves knowledge-intensive reasoning to understand the world not just static, but to serve practical purposes of action by the actor in his world [7]: a model to support the process at hand.

During design support, it is important to transfer the essentials of the proposed structures and mechanisms, without overloading other member of the design team with unwanted details. This information control can be achieved by use of abstraction. So far, many building teams have been sending their partners detailed drawings, thus relying on
the addressees to make the necessary abstraction themselves. With the increasing use of product information models, it is now possible to incorporate multiple abstraction levels in the design representation. Throughout the different levels of abstraction, the description of the building design gradually becomes more and more detailed. The various levels of abstraction should be considered as representations of a particular view on the total information available for a design.

Therefore a new building design strategy is needed which offers more flexibility. Instead of design for one building application situation, the building design process should be based on using different user scenario’s. When a building is more suitable to new users it has a greater value in future and as a building is a kind of prediction based on the ever changing needs of organizations a new design strategy should be applied, see Fig. 1.

![Figure 1. Flexible building design strategy versus traditional approach (Rutten 2004)](image)

Such a flexible building design strategy was promoted by the Dutch government in their IFD (Industrial Flexible Dismountable) building program. An IFD-building is seen as an expedient for an optimal useable and efficient building process. The IFD-programme was a joined initiative of the Netherlands Ministry of Housing, Spatial Planning and the Environment and the Netherlands Ministry of Economic Affairs. IFD-building is strongly related to ‘Open Building’, based on the ideas of N.J. Habraken [8].

3. The path to solution

3.1 Open Building

Open building is primarily intended as an organised way of responding to the demands of diversity, adaptability and user involvement in the built environment [9]. In open building the built environment is approached as a constantly changing product engendered by human action, with the central features of the environment resulting from decisions made at various levels. A central idea in Open Building is to respond to the various needs of individual users through the phasing of the design and implementation process. In order to provide prospective occupants with the opportunity to influence their building, the elements decided by the occupants must be easy to change. Thus adaptability is not merely a means for modifying the dwelling during use; it is first and foremost a
strategy for enabling the fulfilment of individual wishes without compromising. Thinking in levels is the basic Open Building principle. On each level, there has to be made a balance between the performances of supply and demand for buildings during the life-cycle. The levels of city structure, urban tissue, support, space and infill were usually distinguished. The “thinking in levels” approach of Open Building was introduced to improve the design and decision process by structuring them at different levels of abstraction. Open Building lends formal structure to traditionally and inherent levels of environmental decision making [10], see Fig. 2.

![Figure 2. Decision-Making Levels in Open Building. Diagram courtesy of Age van Randen[10].](image)

3.2 Integral Design Methodology

To develop our required model of design support, an existing model from the mechanical engineering domain was extended: the Methodical Design model Methodical Design it was based on the combination of the German (Kesselring, Hansen, Roth, Rodenacker, Pahl and Beitz) and the Anglo-American design schools (Asimov, Matousek, Krick). This in the Netherlands familiar model [11] was used by us because it is one of the few models that explicitly distinguishes between stages and activities, and that emphasis the recurrent execution of the process on every level of complexity [12]. A feature of our extended model of Methodical design, Integral Design, is the occurrence of a four-step pattern of activities in each stage.

By introducing different levels of abstraction the designer can limit the complex design question to smaller sub-questions. The design task can be viewed on each individual level of abstraction. The emphasis at higher levels of abstraction lies on the problem definition phase and generation, while at lower levels of abstraction the emphasis is on developing details of the design product. The whole decomposition of the design process leads to a design process map in which the design phase activities are the steps and the different design focuses during the process form the stages. Within the different phases the main focus is on different steps on a specific abstraction level of the design process. In the matrix stages can be found as well as the four-step pattern of activities.
Integral design is meant to overcome, during design team cooperation, the difficulties raised in the early conceptual phase of building design. This is achieved by providing methods to communicate the consequences of design steps between the different disciplines on areas such as construction, costs, life cycle and indoor climate at early design stages. The aim is to support all disciplines with information about the tasks and decisions of the other disciplines. Supplying explanation of this information will improve understanding of the combined efforts. It is possible to connect between the principles of Open building and Integral Design is made see Fig. 3.

![Figure 3. Comparison between hierarchical levels from the Integral design method and the abstraction levels of Open building and Integral Design](image)

Within this Integral Design model it is possible to focus on the different characteristics of each level of abstraction within the design process and the context in which the process takes place.

### 3.3 Technology layers

The design environment influences the process and as such it is contextually situated [13, 14]. The context of a model of design could be called its “world view”. Our design process model works view consists of 4 perspectives coupled to specific abstraction levels based on the technical vocabularies in use, so called technology-based layers [15]:

1. Information Level: knowledge-oriented, representing the "conceptual perspective". This level deals with the experts’ knowledge of the systems. One of the essential ideas behind this is that human intelligence has the capacity to search and to redirect search. This information processing capacity is based on prior design knowledge.

2. Process Level: process oriented, representing the "symbolic perspective". This level deals with physical variables, parameters and processes. The set of processes collectively determines the functionality of the variables that represent the properties of a device. Modelling at the functional level involves the derivation of an abstract description of a product purely in terms of its functionality. This abstraction reduces the complexity of engineering design to the specification of the product’s desired functionality.

3. Component Level: device orientation, representing the "real perspective".
This level describes the hierarchical decomposition of the model in terms of functional components and is domain dependent. Generic components represent behaviors that are known to be physically realizable. They are generic in the sense that each component stands for a range of alternative realizations. This also implies that the generic components have yet to be given their actual shape.

4. Part Level; parametric orientation, representing the” specification perspective”. This level describes the actual shape and specific parameters of the parts in the form of which the components exist. Relevant technical or physical limitations manifest themselves in the values of a specific set of parameters belonging to the generic components. These parameters are used to get a rough impression, at the current level of abstraction, of the consequences of certain design choices for the final result.

The technology-based layers can be combined with the abstraction levels from the Integral Design methodology. The method/contents matrix, represents the recursion of the design steps of a design process from high abstraction level to lower abstraction levels and is now combined with the principles of Open Building and the technology-based layers of building services, see Fig.4, which shows the relation between the technology layers of building represented in relation to the conceptual world view model as well as the special focus related to building services design.

![Diagram](diagram.png)

Figure 4. Technological layers and the hierarchical levels for the building services domain

4. Application layered approach

Functions have a very significant role in the design process. Generally, designers think in functions before they are concerned with details. During the design process, and depending on the focus of the designer, functions exist at the different levels of abstraction. An important decomposition is based on functions. Function-oriented strategy, preferred by experienced designers [16], allows various design complexity levels to be separately discussed and,
subsequently, generated (sub)solutions to be transparently presented. The function-oriented strategy allows various design complexity levels to be separately discussed and, subsequently, generated (sub) solutions to be transparently presented. This way the interaction with the other participants of the design process is aided, and at the same time design process information exchange is structured. In Fig. 5 an example of the different abstraction level morphological overviews are presented.

Combining the concept of morphological overviews with hierarchical functional abstraction levels leads to a structure of different sets of morphological overviews for cooling, heating, lighting, power supply and ventilation. In these overviews the alternative solutions for generation, central distribution, central storage, local distribution, local storage and supply are presented to fulfill the need on the specific abstraction level of built environment, building, floor, room, workplace and person. The overviews are used to generate new possibilities for a flexible energy infrastructure in and between buildings to optimize the combination of decentralized power generation, use of sustainable energy source on building level and traditional centralized energy supply.

The overviews are used to generate new possibilities for a flexible energy infrastructure in and between buildings to optimize the combination of decentralized power generation, use of sustainable energy source on building level and traditional centralized energy supply, see Fig. 6. The energy flows of heat, cold and electricity have to be optimized together. The work on these subjects within the project will continue till 2010.
This approach led to innovative concepts for conditioning not in the traditional way on room level but on the level of individual working place level, see Fig.7. This concept makes it possible to improve individual comfort and save energy at the same time. At the moment this concept is tested in a laboratory of the faculty of architecture, building and planning of the University of Technology Eindhoven. This shows the added value of the new approach for building design.
5. Conclusion

To support architects more effectively with their tasks new design methods for conceptual design are needed. Transforming a design methodology such as the domain-independent design theory of Open building to a specific multi-disciplinary integral design approach helped to construct a design method that can be a used in a flexible way. Flexibility is a critical attribute of a process: it is needed in order to cope with uncertainty [17]. However an interesting observation was just only recently made that the concept of flexibility is today where the notion of quality was some 20 years ago: vague and difficult to improve yet critical to competitiveness [17]. The proposes combination of Integral Design and Open Building shows a promise to help transform flexibility into a engineering attribute in system design within the building domain.

6. Acknowledgement

Kropman bv and the foundation “Stichting Promotie Installatietechniek (PIT)” support the research. Flexergy project is financial supported by SenterNovem, project partners are Technische Universiteit Eindhoven, ECN and Installect.
7. Literature


[14] Vries, T.J.A. de, 1994, Conceptual design of controlled electro-mechanical systems, a modeling perspective, PhD thesis Twente university, Enschede

