Integral design methodology for sustainable comfort systems

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ABSTRACT: Integration of sustainable energy systems in the conceptual stages of building design is too complex. The communication between architect and contributing building services consultants is difficult. A model of design support has been extended, Methodical Design. In 2000, the Royal Institute of Netherlands Architects, BNA, the Dutch Society for Building Services (TVVL), and the Delft University of Technology, TUD, have started a research project Integral Design. In this project the new conceptual support framework was used in a series of workshops for architects and HVAC-consultant. The results are promising. After the end of the project, a new research is started from within the Knowledge Centre Building & Systems, in which TU/e and TNO Bouw work together. This will result in a new series of workshops in which members of BNA and the Dutch Organisation of Consultants, ONRI, will participate.

Conference Topic: 2 Design strategies and tools
Keywords: energy, comfort

INTRODUCTION

Preservation of energy resources, occupant comfort and environmental impact limitation are the key issues of modern and sustainable architecture. During the last decades, the main focus of research in Building Services was on reduction of energy consumption of buildings. The energy use of the built environment is 40\% of the total energy consumption in the Netherlands. So it is important to try to reduce this significantly. The strong focus on the energy reduction led to situations in which heath and comfort are endangered. As people spend the majority of their lives indoors, almost 90\%, the qualities of the indoor environment are of major importance to national and international concerns regarding health, satisfaction, and productivity of building occupants. By using sustainable energy the negative effects of energy use become less important and the main focus could be turned to health and comfort again. In recognition of the interdisciplinary nature of these concerns, it is necessary to combine fundamental knowledge in building science and comfort (HVAC) with sustainable energy systems and design processes.

At present the application of sustainable energy systems and components is far too complex for integration in the early stages of building design. As a result, these systems and elements are often added on in the final stages of the design. This results in sub-optimal solutions and more often in the rejection of the proposals to use the sustainable energy systems and components. By offering the design teams methodology as a supporting frame work, the application of sustainable energy can be made easier and thus more likely.

A lack of integration between architectural design and the design of the indoor climate make that building service consultants have difficulties adapting their methodological and arithmetic way of working. The building service consultants find it difficult to interpret the artistic and intuitive characteristics of architectural conceptual design. Supporting the exchange of ideas improves the integration between architectural form and engineering analysis. This exchange improves the performance of the architect and facilitates the communication between architects and contributing building services consultants (Hensen 1993).

INTEGRAL DESIGN METHODOLOGY

Communication between architect and building services consultants is based on abstraction, i.e.,
the exchange of abstract descriptions of a design. At the early design stages, only conceptual sketches and schematics, often rough and incomplete, are available. As the design proceeds, more information and detail will be developed. If performance analysis starts early in the generative design phase, then performance considerations can be integrated into the building form and design concept. The best opportunities for improving the performance of a building occur early in the design process.

Abstraction is the selective examination of certain aspects of a problem. The goal of abstraction is to isolate those aspects that are important for some purpose and suppress those aspects that are unimportant. This makes it possible for the representation of design in an acceptable form to match the needs of the design specialist saving time and confusion (den Hartog 2003). In the engineering sciences, a lot of approaches have been developed to structure and optimize design processes: concurrent engineering, value engineering, design for manufacturability, systems engineering, quality function deployment, strategic design, etc. To develop the required model of design support an existing model has been extended: Methodical Design (van den Kroonenberg 1979, Blessing 1994).

Many ongoing research efforts aim at introducing these approaches to building design or architecture, and linking architectural design with HVAC-design; in the Netherlands this has resulted in a strong interest in ‘Integral Design’. In 2000, the Royal Institute of Netherlands Architects, BNA, the Dutch Society for Building Services, TVVL, and the Delft University of Technology, TUD have started a research project called Integral Design. Observations in the construction industry show a fractionated process by different parties achieving their own aims, working on the same building. Different cultures and different traditions, many times conflict with the common aim of completing the building. Breaking barriers between different disciplines may be the first step to a better-built environment. Integral Design unfolded ways to implement, investigate, teach and learn the integral approach. The integral approach encompasses the built environment from initiative, design, construction and real estate management as a seamless whole. This seems to contradict with the subdivision of the construction industry in phases, parties with different interests, resulting in disintegration and waste. Co-ordination of these independent phases, scales, decision making and disciplines are crucial to create a built environment in which people concerned, feel comfortable. This is the core of the integral approach.

Integral Design is meant to overcome the difficulties of design team cooperation, with early involvement of consultants, by providing methods that make it possible to communicate the consequences of design moves on areas such as construction, costs, life cycle and indoor climate at early design stages, between the different disciplines. When attempting to integrate sustainable energy aspects into design decision-making, the process must identify opportunities for sustainable energy and the resulting indoor climate consequences. Instead of developing new design methods, this research attempts to connect to the existing architectural design characteristic and decision making for the introduction of sustainable energy resulting in good indoor climate. This implies defining a methodology that acts as a bridge between architectural elements such as shapes and material on the one hand, sustainable energy use and the aspects of indoor climate issues such as overheating and ventilation on the other.

Designing takes place in an environment, which influences the process, it is contextually situated (de Vries 1994, Dorst & Hendriks 2001). The context of the model of designing is defined by means of a “world view”. The model of de Vries consists of 3 worlds and is extended to four worlds: the real world R, the symbolic world S, the conceptual world C and the specification world M.

![Extended model analytic schematic interaction model of designing](image)

Part of the integral design research project of TVVL-BNA-TUD, was a series of workshops for architects and HVAC-consultants. In order to get a better understanding of one another's position in the design and construction process different forms of workshop have been tested in the Integral Design project. A key aspect was to test this methodology in the context of architectural and building services design. To that effect, a design project that is complex enough and innovative was selected. A series of different type of workshops with experienced professionals from the TVVL and BNA have been organized investigating the relevance of the approach.

In the Integral Design project TVVL-BNA-TUD, different concepts of workshops have been tested;

- Workshop 1: Expert multidiscipline participation, October 2001;
Workshop 1: teams prepare conceptual design and get primarily design from another team.

Within this workshop some of the leading architects and building service consultants have participated and worked together in 4 groups of six people. One observer with each group had to write down the actions during the sessions. The results were evaluated in a separate session with the participated experts.

Workshop 2: Mono disciplinary, January 2002;

In this workshop 26 building service consultants were asked to think about different aspects of the design process. They gave reactions and came with ideas and suggestions for improvement of the current situation.

Workshop 3: Change of role and position in the conceptual design phase

**Traditional role pattern**

Architect

Building services consultant

**Alternative role pattern**

Building services consultant as architect

Architect as BS consultant

- Workshop 3: Combined design teams BNA-TVVL, September/October 2002;

In this concept the members of the different organisations participated and changed their role.

The architect became building service consultant and visa versa. Each group had two observers who wrote down the actions concerning certain aspects during the design sessions.
The results of the workshops were evaluated by 9 criteria. Students evaluated the 31 designs, in which more than 130 architects and building service consultants participated.

By using a methodology and transfer it from domain-independent design theory to a specific multi-domain approach, a “bridge” between architecture and building services will grow. The research for this methodology is done in close cooperation with the designers of the different domains. Bridging the gap between design theory and daily practice will become reality. Working with experiences designers from different disciplines is not often done. Mostly the verification of a new methodological concept is done by experiments with student groups (Segers 2002) or with design groups within one company (Blessing 1994). The relevance of the research for the daily design practice, improves by using experienced designers, as there is a major difference in approach between novice and experienced designers (Ahmed et.al 2003, Kavakli et.al 2003).

CONCLUSION

The HVAC-industry has identified a need to better integrate comfort and sustainable energy systems in buildings. In current practice HVAC-systems are often treated like an add-on component that is designed after the building design has been completed. This is even more extreme for the application of sustainable energy components. Many researchers see this as one of the causes of the low use of the combination of building and sustainable energy in general. In order to overcome this problem there is a need to develop a specific approach for the design and optimization of sustainable energy components in connection with HVAC-systems that can be applied in ongoing building design projects; Integral Design. This approach is been tested in different workshops with experts from the different disciplines. New research is started from out the Knowledge Centre, the cooperation between TU/e and TNO Bouw. This results in a new series of workshops between the ONRI and the BNA in which an improved concept methodology will be tested

ACKNOWLEDGEMENTS

The Integral Design project has been supported by TVVL, BNA and TU Delft. The follow up project is supported by the Knowledge Centre Buildings & Systems TU/e - TNO Bouw.

REFERENCES


Cuperus Y., 2003, Quality by Integral Design, OBOM (Open Bouwen Onderzoeks methodologie) TUD, Delft


Hartog J.P.den, 2003, Designing indoor climate, a thesis on the integration of indoor climate analysis in architectural design, thesis manuscript dated 01/09/2003, Delft University


Kavakli M., Gero J.S., 2003, Difference between expert and novice designers: an experimental study, in U. Lindeman et al (eds), Human Behaviour in Design

Kroonenberg H.H. van den, Methodisch Ontwerpen (WB78/OC-5883), University of Twente, 1978.
