Integral approach for adaptable indoor comfort;  
Building and occupants follow the sun 

Wim Zeiler 

Technische Universiteit Eindhoven, The Netherlands 

Corresponding email: w.zeiler@bwk.tue.nl 

SUMMARY 

The focus on the needs and drives for adaptation of the building automatically leads to changing needs and demands of the occupants of the building. Building should really take care of its occupants and show adaptable behaviour and reaction to the changing outdoor environment during the day. Design for adaptability should start with the occupants needs for comfort and indoor air quality. These are partly influences by the changing environmental forces as wind and sun. Weather predictions and the aggregated voting of users about their thermal comfort, should be the leading parameters to adaptable comfort and the adaptable building.

INTRODUCTION 

Building design is a fascinating, it starts with a blank sheet and ends with a building with spaces and materials. Since the future is unknown, it is only possible to paint scenarios, possible futures, buildings have to meet. A building usually has to comply with more demands than mentioned in the list of specifications, for example because they were overlooked by the client, or necessary changes during the design process. In the continous analysis, there are hard to quantify demands, such as comfort, beauty, social acceptance and safety. The designers has to pay due attention to all aspects, how trivial or unexpected they may seem.

Inappropriate formation of the design team may result in ineffective designprocess and solutions. Many problems emanate from a lack of integration between architectural design and design of indoor climate. After the industrial revolution, the natural relationship between design, construction and the built environment disappeared and has been replaced by a complex system of decision making, complex legislation, a subdivision of a whole integrated building into subsystems and disciplines in the construction process.

METHODOLOGY 

The making of the built environment has become complex. In the conceptual design phase, in order to create conditions that assure a built environment that gets better, the ingenuity of the whole design team existing of different disciplines should be used, not only architecture. The quality of the team should be combined with a well considered process of decision making. Techniques are selected and put together by a team in an integral design process. In addition to the application of proven construction methods, the integral approach demands an attitude of openness and appreciation of the other participating disciplines and their positions.
This approach makes it possible to combine and develop different kind of aspects in interaction to each other. During the design process participants and their decisions are structured at several levels of decision-making; the infill-level, the support-level and tissue-level. On each level there has to be made a balance between the performance of supply and demand for the building during the life-cycle. The basis of this ‘level-thinking’ is that of the Open Building [1]. As often such new ideas take a long time before being implemented. The Osaka Gas NEXT 21 Project in Shimizudani, Tennoji-ku, Osaka City, Japan, realized in October 1993 is a very nice example of the realisation of the open building approach, see figure 1.

Figure 1: Publication by Habraken, NEXT project interesting realisation of the ideas

Open building is primarily intended as an organised way of responding to the demands of diversity, adaptability and user involvement in the built environment. 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.

Techniques are available to help further organize the complexities of environment as a subject into its component parts and wholes. Dissecting a subject into its intrinsic parts and then shifting to how those parts are organized into a whole, allows access to content as well to the way parts connect and, therefore, to a full definition. To characterize connections a hierarchy is needed to outline sequence and progression and to illustrate part-whole relationships.

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.

Abstraction is the mapping from one representation of a problem to another, which preserves certain desirable properties and reduces complicity [2]. Abstraction is the selective examination of certain aspects of a problem. The goal of abstraction is to isolate those aspects that are important for a particular purpose and suppress those aspects that are unimportant [3]. This enables representations to take an appropriate (abstract) form that matches the needs of the design specialist, thus saving much time and confusion.

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.

This integrated design model must:

- be able to distinct related information,
- support distinctions related to the different levels of abstractions (views) by being structured into corresponding sub-models,
- ensure the satisfaction of consistency and completeness constraints linking different levels of abstraction in the design process.

Methodical Design [4,5,6] can be described at the conceptual level as a chain of activities which starts with an abstract problem and which results in a solution. The original methodical design process is extended from three to four main phases, in which eight levels of functional hierarchical abstraction can be distinguished, see figure 2.

![Design process: Different levels of Functional abstraction](image)

Figure 2: Functional Hierarchy Methodical Design
Hierarchy can be used as a simplifying organizational tool to order and relate the parts of a subject in range-large to small most important to least, etc., used in a neutral sense where all parts are unique and important. Hierarchy theory in this way, frees minds from the analytical mode without requiring them to reject it and provides, as well, glimpses of a wider, more diverse world. Hierarchies suggest an interplay between parts and wholes and between the two basic modes of thinking:

- **Analysis**: separation of a whole into its component parts, the examination and study of each part;
- **Synthesis**: the composition or combination of parts or elements so as to form a whole.

This organizational structure provides a way to study and design complex issues. With regard to the built environment the parts human, built and natural environments can be analysed separately and then synthesizing the parts together to form a composite definition to obtain more meaning like a word integrated into a phrase and then into a sentence.

To work effectively with methodology, practitioners should learn to work with, and understand, the role of methodology in the building design process. Often means and goal are mixed up. More and more the insight is growing that it is not the building to be designed that should be central but the needs of the humans for which the building is intended.

**FOLLOW THE OCCUPANTS NEEDS**

For about 40 years there is an evolution of thinking and research in this way, strongly related to the integration of disciplines in process and product. The most important new idea is taking man in his environment as the departure point, variable and criterion. The comfort of the occupants becomes leading.

The first guidelines for thermal comfort in the Netherlands were developed in the late seventies and eighties. They were based on the theory of Fanger and resulted in the PMV-PPD relationship, which predicts the percentages of dissatisfied occupants. Extensive field research however by de Dear showed that people have various adaptation mechanisms with most important people’s expectations of the building’s climat, based on the actual outdoor temperature. New thermal comfort models based on the human adaptability were developed over the past years. Applying adaptive thermal comfort, a distinction was made between different types of buildings, usage and climatic circumstances. An important feature to distinguish between the differences here is the possibility of individual control [7].

The representation of situations with multi end-users, multi-individual control, was realized by developing an individual voting system. This voting system implied that every user in a thermal zone could enter his or her vote, warmer or colder, within a voting period, e.g. one hour, while seeing the aggregated voting of other users in his zone at the moment of voting.

The new user behaviour control strategy was implemented in a BMS(Building Management System). This BMS was extended with an external real-time information system to improve energy and comfort control.

To further enhance comfort and at the same time reduce energy consumption of buildings, new control technology is needed. Technology in which the end-user behaviour and
preferences are integrated into a responsive ambient surrounding. Improvement of the energy consumption is made possible by agent-based systems for energy management in buildings, as well as new possibilities occur to enhance individual comfort of occupants.

On this philosophy, design teams can develop buildings with contrastful attributes for temperature, wind, humidity, daylight and smells. Buildings similarly gain a contrastful microclimate that changes in accordance with the time and the outdoor conditions, as well as a more pleasant interior, a space that will endure longer than we may imagine.

INTEGRAL APPROACH

The search for a building that functions better within its surroundings forces architecture into every closer company with engineering. These buildings take advantage of the prevailing climatic conditions in combination with the familiar physical principals of natural draught, sunlight, wind, precipitation etc. The climatic conditions of the location are highly determinative for the form of the building, thus producing a climate-related and regionally distinctive architecture. Intensive collaboration with technical consultants takes place from the outset in these designs.

In 2000, the Royal Institute of Netherlands Architects, BNA, TVVL and the Delft University of Technology have participated in 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. The initiators of the Integral Design project had the vision that breaking the barriers of different trades may be the first step to a better built environment. It was named Integral Design and unfolded ways to implement, investigate, teach and learn the integral approach (2). The Integral Approach in relationship to Integral Design has to deal with different scale-levels and different ‘kind’ of aspects. To give the range of aspects which are related to the Integral Approach, not in the way to give a definition, in the way of describing, shows the interweaving mechanism between the several aspects and the area and approach which belongs to the word ‘Integral’[8]

The ‘umbrella-aspect’ is the flexibility and bandwidth in process, design methodology, construction methodology and facility-management. The integral approach will guide, interdependent to the value-frameworks, will control and correct and will leave room to the specific method or solution for the several participants during the total process.

The Integral Approach is conceptual and therefore inhabits the several ‘specific methods’ such as for instance Strategic Design, Sustainable Design and LCA-Design. The Integral Approach is related to the longer term for different (time, site, process and program) settings; a sustainable approach [9][10], [11].

The integrated building design process is one which considers all aspects of a building, its environment and life cycle, and is undertaken by a team which includes all relevant professionals and stakeholders working together throughout the process rather than sequentially and independently.
INTERNAL ADAPTABILITY

Internally, structures satisfy and symbolize human spatial needs, wants and values; externally they provide and symbolize a protective envelope, an interrelationship with the outside environment. The external enclosure can be considered the “third skin” of the human body and its comfort (light, fresh air, optimum temperatures, etc.) is based upon human senses and either provided for by natural means (windows for light, solar energy for heat, shade for cooling, etc.) or by artificial means (electric lights, heating, air conditioning, etc.). The project ‘rotor haus’ of Colani shows how internal adaptability of use of specific functional rooms is possible. Nevertheless because of the major influences of the sun, outside adaptability is more important in relation to energy and esthetics.

OUTSIDE ADAPTABILITY: ADAPTIVE BUILDINGS TO THE SUN

The external character of a building form is shaped not only by internal requirements, but also by fitting a building to its elusive environmental context. Designing with local climates and sun orientation, with similar construction methods and materials, can increase human comfort and reduce energy consumption. Building, indeed, must consider and respond to its built environmental context but also to its natural environment. Technologies should resolve conflicts between what the natural environment provides and human needs, sustenance and comfort.
To let the building react on the thermal comfort demands, it is effective to let the building react to the path of the sun. By letting rotate the building, its sun protection or both, with the turn of the sun the heat of the sun can be left outside the building or when needed let into the building. Different solutions were already realised in built projects. But there are more solutions to make buildings adaptive to the sun and the comfort needs of the occupants. Some of the realized projects show completely different ways of solution.

Figure 3. Draai test woning ECN Petten 2002, Waterwoning H.Hertzberg, Middelburg 2002 and Heliotropp, Rolf Dish, Freiburg, 1994

Figure 4: Gemini Haus, Erwin Katenegger, Steiermark, Oostenrijk, 2001
If a building is a working whole, a system, we can distinguish subsystems: the load bearing construction, the envelope, inner partitions, HVAC and MEP installations and many more, as can be seen clearly in figure 4 the Gemini Haus designed by Erwin Katenegger and built in Steiermark, Oostenrijk, 2001. Instead of such a drastic and complete approach there are also solutions which are less drastic e.g. the headquater of Ellesse International in Perugia. In this project only the sunprotection is moving around the building and following the sun. Still the effect of such an adaptation to the sun gives a interesting dynamic architectural appearance. It is no longer a dream; A building that can anticipate on an unknown future consisting of building parts with different cycles of change, co-ordinated, yet uncoupled, designed by different disciplines, collaborating in a team, serving the client as well as the end user.

CONCLUSION

For the focus on the needs and drives for adaptability building comfort a process approach is needed in which the thinking of the architect designer is linked in the design-process itself with the engineer. Support both parties with information on the tasks and decisions of the other party and at the same time supplying an explanation of this information will greatly enhance understanding performance of combined efforts. The structuring of the communication of the process between architecture and consultants is based on abstraction, for instance the exchange of abstract descriptions of a design. Through the different levels of abstraction, the building model is gradually described in an increasingly more detailed manner. Thus decomposing complex design-tasks into manageable size problems.

The integrally working design team not only designs the building, it designs the design process as well. Continuous adaptation of the design and final decision making need to be balanced. Thus the design process is cyclical, spiralling up towards the final plan. The plan with its focus on internal and outside adaptability also determines the possibilities and impossibilities of construction, maintenance and management, It is therefor important to inform and hear the construction partners and the parties responsible for running the building. It is quite likely that a certain team will never operate again in the same configuration. It is
therefor advisable to report on and evaluate the process in order to gain from the accumulated experience and techniques applied.

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