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COLLABORATIVE OPEN BUILDING DESIGN

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ABSTRACT
There is a growing awareness of complexity as a result for more sustainability in building design that leads towards knowledge transfer and research between companies and the Dutch knowledge and research institutes within the building industry. New approaches towards the design of buildings are initiated. The principles of the IFD (Industrial Flexible Dismountable) concept aim at an integrated approach within the design process to reach a maximum level of integration between designers from different disciplines. A newly developed method for structuring integral design processes enables design team support during designing and further stimulates exchange of ideas and concepts. This approach is tested within a professional context of a building design project.
To support architects more effectively with their tasks the domain-independent integral design method was developed in the lines with the Open Building concept. This specific multi-disciplinary approach can help architecture and engineering in the building industry. We found that the proposed Integral Design method is a support for the design team members in the conceptual phase of building design.

Keywords: Integral design, Open Building, Case study

1 INTRODUCTION

Lately the design and the making of the built environment have become more complex. There are presently new and stricter demands connected for comfort, durability and sustainability. 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 the design itself. 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.
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.
Traditionally the building to be designed takes a central place in thinking of the design team, see fig. 1A (Hasselt et.al 1998). The focus is on the interaction between aspects and not on the main functionality: fulfilling the human and organisational needs Looking more closely we find that 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 and organizations for which the building is intended. This leads to a new approach in which the human needs are key aspects that have to be fulfilled, see fig. 1B. At this point it is good to define the differences between integrated design and integral design more explicit; within integrated design two or more disciplines are combined in order to become more effective, within integral design all disciplines necessary and important are treated as part of, or contained within the whole building design approach. So within integrated design the focus is on combining different disciplines, were as in integral design the focus is on the whole building approach and the therefore needed different disciplines. To put it in another way, within integrated design the architectural discipline and other disciplines start separately and often in different design phases and are later made to fit, were as within integral design all necessary design disciplines start

together right from the conceptual design. Integral design concepts are only possible by starting together of the different design disciplines and uniting various viewpoints of the different design disciplines involved. In order to achieve not only integration, but true synergy, between all disciplines a single designer has to 'force' him or she to consider different discipline based viewpoints while designing. Even if a designer has the ability to deploy most of these viewpoints, he or she usually does not have enough specialist knowledge to assess all of them in depth. For this reason it is assumed that a multi-discipline design team view on design is a better way of pursuing building design synergy than a mono-disciplinary individual designer view on design. The main concern in architectural management should be the conceptual design phase, since decisions made in this phase largely determine what can and cannot be done in the further building design stages. The focus should be on creating conditions in which different design disciplines within a design team will have the opportunity to, first of all, introduce their object design knowledge (Van Aken 2005), and subsequently to integrate it into design concepts. Emphasis on involvement of the various design disciplines forms the starting point for integral building design process organization.

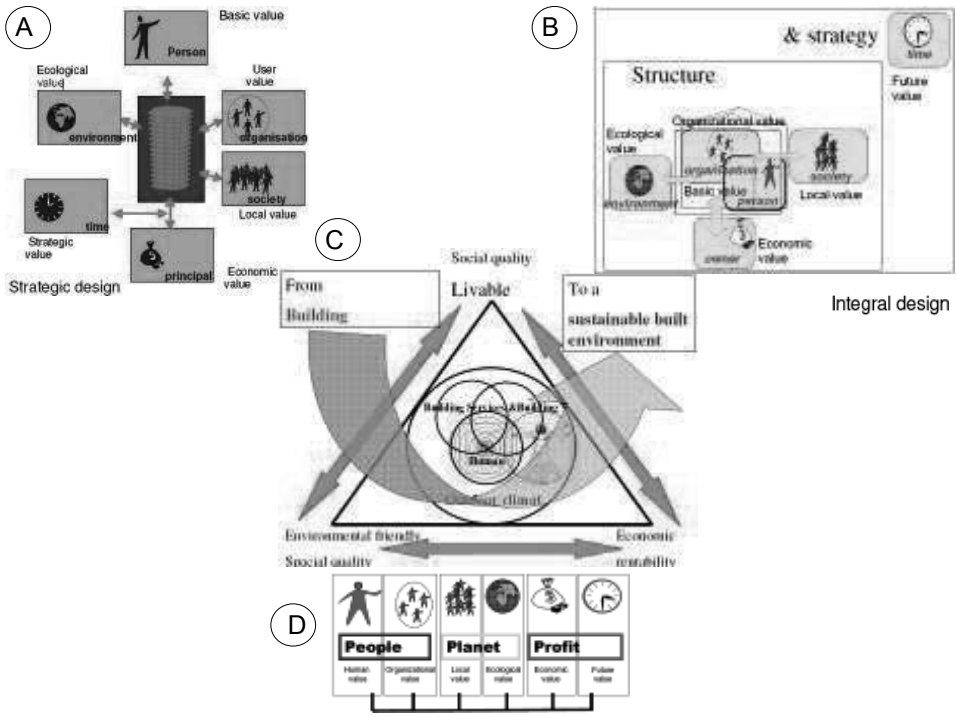

Figure 1. Strategic design (Hasselt et.al. 1998)(A), structure and strategy Integral design (B), the needed balance between different aspects/demands to fulfil within the design process (C) based on the People, Planet and Profit principle

In the design of buildings, the process of implementing the clients' but also society's needs and expectations is of great importance. During the last fifteen years attention has enormously increased to comfort in buildings and the consequences for the environment. The design process became more heterogeneous, with several diverse actors involved such as architects, engineers, contractors and clients. In the world of design and engineering, gaps between the different fields can be recognized (Lechner 1991, Cross & Roozenburg 1992, Reymen 2001, van Aken 2003). The different viewpoints imply a need for cooperation: a collaborative approach to the design process. These changes have led to a shift in the role of the architect in the building design process. The former master builder with the responsibility for the totality has been reduced to merely an actor among others in the briefing and

design phases of a complex project (Kjølle & Gustafsson 2007). Still architects have a larger influence on the crucial conceptual design decisions during the building design process and often act not as merely an actor but as conductor. Concepts as 'team-work' and 'collaboration' as collective terms for every interaction with other people are needed to deal with the complexity: collaborative design management is needed.
Problems emanate from a lack of integration between architectural design and design of indoor climate. Building Services consultants have difficulties adapting their methodical and arithmetical way of working to artistic and intuitive characteristics of architectural design. To a slightly lesser degree, the same applies to structural consultants. This notion of 'professional enmity' is not as insurmountable as it may seem (den Hartog 2003).
To make change possible, Dutch government developed a sustainable 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 (1961) first publiced in his book De Drager en de mensen: het einde van de massa woiningbouw. A slender volume subsequently translated as Support: An alternative to mass housing (Kendall and Teicher 2000).

2 METHODOLOGY

2.1 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. 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.
Open building is an attempt to integrate industrial building and user participation in housing, but the concept can also used for office buildings. It approaches the built environment as a constantly changing product engendered by human activity, with the central features of the environment resulting from decisions made at various levels. The levels which usually are distinguished are the level of city structure, urban tissue, support and infill. Open building entails the idea that the need for change at a lower level such as the dwelling, emerges faster than at upper levels, such as the support. Open building aims at a situation where decisions made on upper levels leave the contents of the decisions to be made al lower levels open.
To meet the challenges of Open building design a method has been developed by us. Not only the building to design but also the design process itself became a topic of study. The results of this new approach are called "Duurzaam Flexibele Proces Integration" – sustainable flexible process innovation. 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.
The basis of this 'level-thinking' is that of the Open Building (Habraken 1961). Habraken is still active through a very interesting web-site (Habraken 2008) and his ideas were implemented by many others. 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 2. A survey of mile stone residential projects of Open Building is given by Kendall and Teicher (2000).
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Figure 2. NEXT project interesting realisation of the ideas

Techniques are available to help further organize the complexities of environment as a subject into its component part 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 out line sequence and progression and to illustrate part-whole relationships.
At each level in the design process different decisions have to be taken. Open Building lends formal structure to traditionally and inherent levels of environmental decision making (Kendall and Teicher 2000), see fig.3.

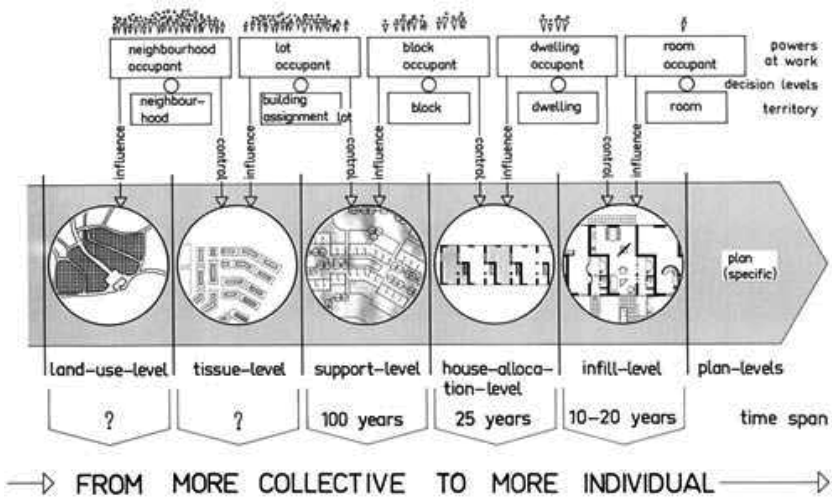

Figure 3. Decision-Making Levels in Open Building. Diagram courtesy of Age van Randen (Kendall and Teicher 2000, p.6)

One of those decisions is the application of sustainable energy systems and components. However this is rather complex to integrate in the early stages of building design as many aspects have to be taken into account. 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, see figure 1C.
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.
As the design proceeds, more information and detail will be developed. The main part of the project costs are allocated in the early conceptual phase of product development, still in this phase only few resources (manpower, money) are actually spent on the project (Buur & Andreasen 1989)see figure 4.

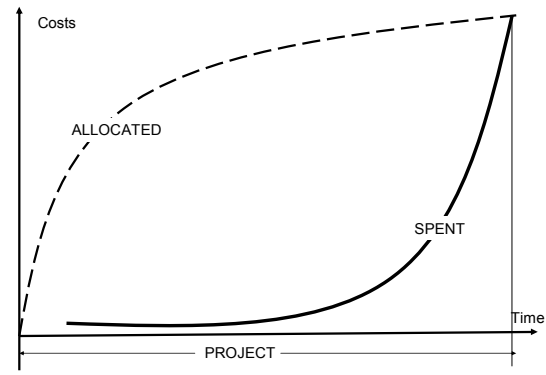

Figure 4. Relation between allocated and actual spent costs during a design project (Buur & Andreasen 1989)

The knowledge/information characteristics of the design process are described by Ullmann (2003) in two dimensions: The design freedom of the solution space and the knowledge about the problem. The dichotomy of this system is that at the early stages of design there is little information, even though nearly all the important decisions have to be made at this time, as figure 5 shows.

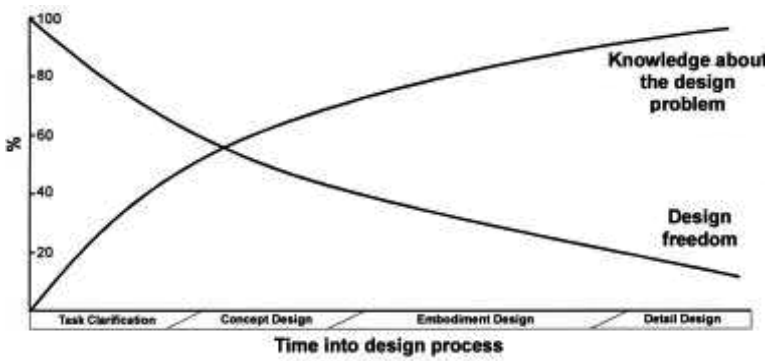

Figure 5. Influence / information contradiction at the early stages of design (Ullman 1992)

By the dichotomy of this design process at the early stages of design there is little information, even though nearly all the important decisions have to be made at this time, as figure 6 by den Hartog (2003) shows.

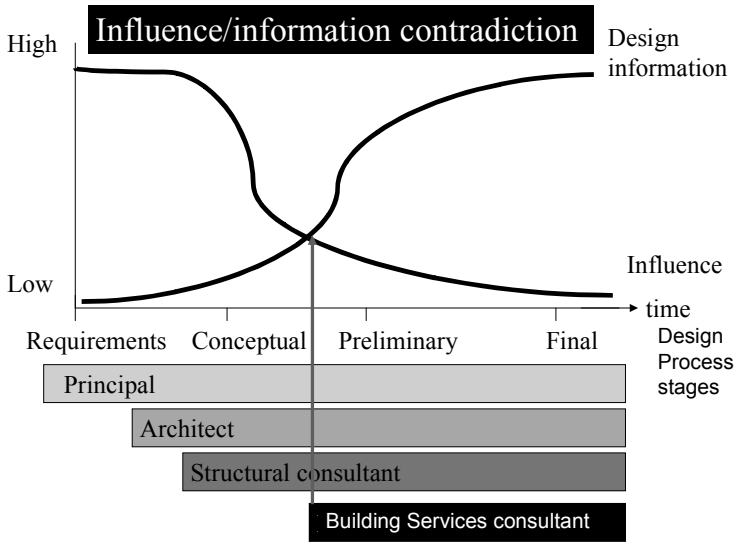

Figure 6. Influence / information contradiction at the early stages of design (den Hartog 2003)

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 figure 7.

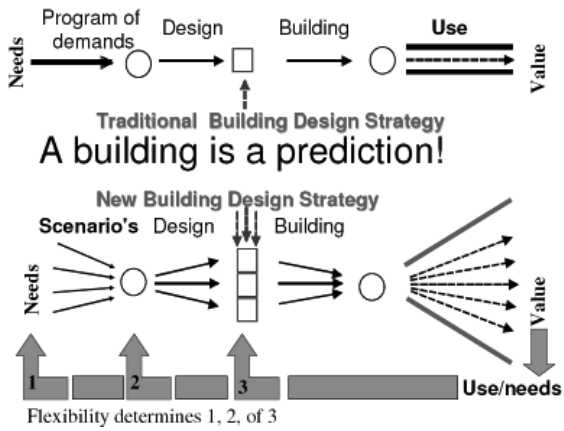

Figure 7. Flexible building design strategy versus traditional approach

In modern history, design of buildings is seen as largely an individual's creative act: "*From Palladio on, architecture has been identified with individual architects*." (Habraken 2005, p.28)
This is certainly the case for conceptual design phase, where architect is the one that lays down the vision of the whole building. Moreover, "the belief that a single designer should be in control of all levels of environmental form" (Habraken 2005, p.89) is even seen as a professional ideal. In his book 'Palladio's children', where architectural profession is portrayed as singularly obsessed with perfecting form and crafting it down to the last detail, Habraken (2005, p.111) however points how the proliferation of consultant specialists bring into play de facto co-designers due to the sheer complexity

of the contemporary built environment. “Paradoxically, while consultant design may not appear prominently in the completed project, it frequently establishes dimensions, spans, story heights, and other fundamental aspects of architectural character (2005, p.122).” The need for more rational approaches is strongly felt by the architectural profession. The development of rational methods grew into the Design Methodology movement of 1960’s (Cross 2001), culminating and effectively ending as far as architecture is concerned with the early work of Christopher Alexander.

2.2 Design Methodology

Christopher Alexander noted back in 1960’s that “the intuitive resolution of contemporary design problems simply lies beyond a single individual’s integrative grasp” (Alexander 1964). His proposal to tackle this situation was strictly rational and analytic, while still meant for an individual designer. According to Alexander, by defining requirements and interactions of requirements, a systematic decomposition of design task is achieved, which allows for practically automated fitting of different (sub) solutions. Later, Alexander adjusted his approach by using ‘semilattice’ instead of the linear ‘tree structure’ (Alexander 1965), eventually developing ‘a pattern language’ (Alexander et al 1977). His theory was that architectural design is a language consisting of patterns, which are to be used as building stones for designing. This moving away from individual analytical approach opened the path to participatory design, where besides designers the clients and users were to be involved as well.
Although Alexander was not followed by mainstream architects, his work did have big influence on especially architectural education. As one of the founding fathers of the ‘design methods movement’ (Cross 2007) Alexander’s rejection of it – “There is so little in what is called ‘design methods’ that has anything useful to say about how to design buildings that I never even read the literature anymore... I would say forget it, forget the whole thing…” (Alexander 1971) – is still seen as a ‘proof’ that intuitive and artistic approaches are to be preferred over methodical and systematic ones. Architectural practice subsequently headed by individual intuitivism “into the analogical fallacy of semiotics; and then post-modernism, deconstruction…” (Nicholson 2002).
Integral design is meant to overcome, during design team cooperation, the difficulties raised in the early conceptual phase of building design from analyzing the complexity of the design task seen from different domain depending viewpoints. 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 (den Hartog 2003).

2.3 Integral Design method

To develop our required model of design support, an existing model from the mechanical engineering domain was extended: Methodical Design by van den Kroonenberg (1978). During early 1970s a prescriptive design model was developed in the Netherlands to teach design to mechanical engineering students at the University of Twente. Called the methodical design model, 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 was extended into an integral design model by us because; “it is one of the few models that explicitly distinguishes between stages and activities, and the only model that emphasis the recurrent execution of the process on every level of complexity (Blessing 1993, p.1398)”. Especially the horizontal dimension is not strongly represented in other familiar design models and thus tend to be forgotten (Roozenburg and Cross 1991, p. 216); “not so much by its authors (see for instance Pahl and Hubka) but by its users and, above all, its critics, leading to faulty arguments and misinterpresentations of the model .”
The design activities sequence in integral design is: define/generate, analyze/synthesize, evaluate/select, and implement/shape. If compared with familiar models e.g. the basic design cycle of Roozenburg and Eekels, 1995 (analysis, synthesis, simulation, evaluation and decision) the difference is in the implementation and shaping of the design into a lower level of abstraction and as such a focus on the connection between the horizontal dimension and the vertical dimension of the design model.
The row of the integral design matrix provide the different issues, functions and aspects, to be solved in the design process, based on the process stages distinguished by methodical design (Problem definition, Working principle and Shaping phase) with a new added process stage: the selecting

phase. The original methodical design process is extended from three to four main phases, in which eight levels of functional hierarchical abstraction, stages can be distinguished. Once completed, the integral design matrix contains a description of the design process for a specific design task. The description is depending on the rationale applied and may not be chronological: the matrix structures the (intermediate) results of the process independently of the sequence in which they were generated (Blessing, 1993, p. 1398). The design is further structured by making an overview of the considered functions and aspects and their alternatives, this is called a morphological chart (Zwicky & Wilson 1967). The use of the integral design matrix is also important for the scalability of the morphological-chart based approach for large building projects with many functions/aspects which need to be considered. The morphological chart is than the result of step 1 and step 2 of the integral design method, figure 1, and is presented in figures 8 and 9.

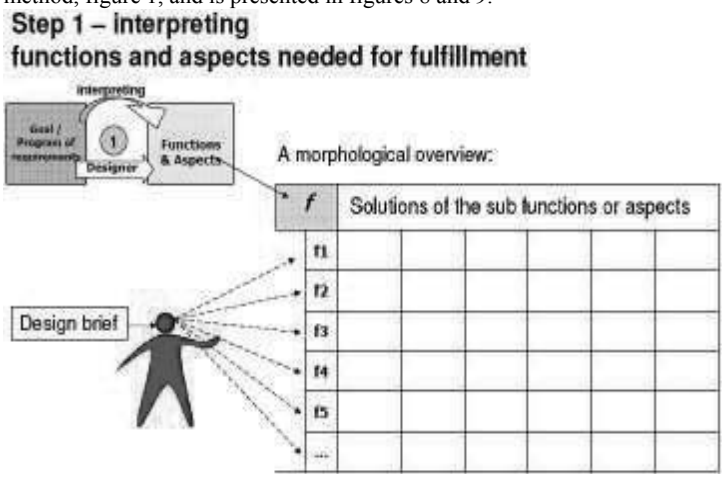

Figure 8. Step 1 of the integral design method: Programme of demands as input for the morphological chart, sub functions and aspects on the vertical axis.

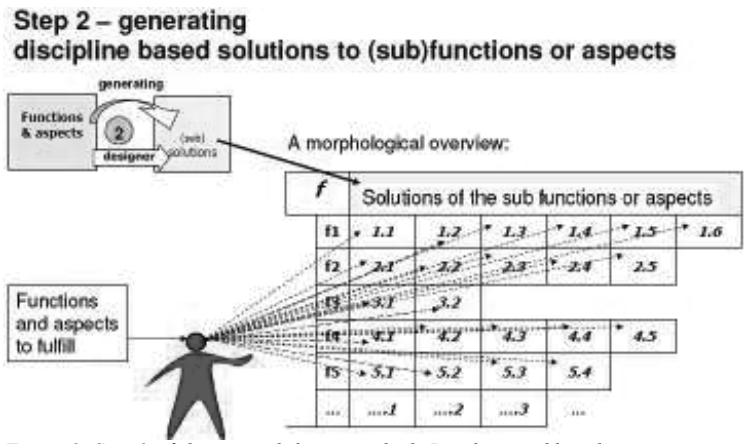

Figure 9. Step 2 of the integral design method: Put the possible solutions to a specific function or aspect as elements on the horizontal rows of the morphological chart.

This makes it possible to focus on the conceptual design phase and to integrate the opinions of others outside the design team more easily. The design process becomes more transparent and this increases the possibility to reach synergy between the different disciplines and/or designers involved in the design process.

The integral design process can be described at the conceptual level as a chain of activities which starts with an abstract problem and which results in a solution. A feature of the Integral Design model,

is the occurrence of a four-step pattern of activities in each stage. In system theory the same activities are proposed for decision processes as can be found for the design process. 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. The design process can be looked upon as working one's way through the different levels of abstraction from upper levels to lower levels the design is slowing getting shape. It is possible to connect between the principles of Open building and Integral Design is made see figure 10.

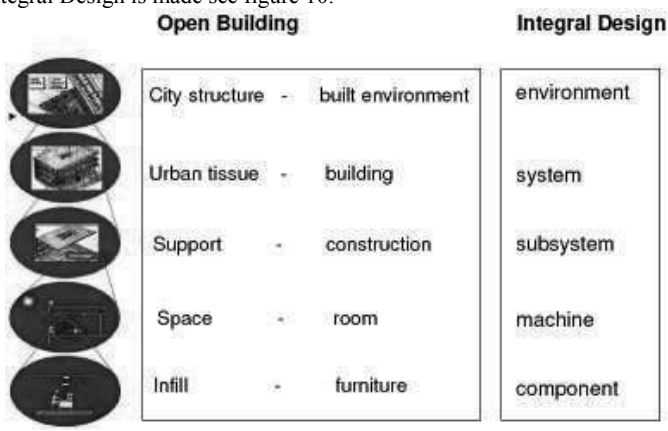

Figure 10. Abstraction levels of Open building and Integral Design

3 APPLICATION

In the planning of their own new office Kropman, one of the major Dutch building service contractors, wanted to show their design and engineering capabilities. It had to be innovative and so they decided to design an office building with a flexible construction and notable use of sustainable energy.
Designing their own office gave them the opportunity to approach the design process at a different stage, see figure 11. As principal of their own office, they used the design process to investigate the influence of introducing knowledge of building services consultants into the early conceptual stages of the design process. Furthermore, even at the requirements stage of the design process the influence of the building services consultant could be effective. Kropman, is normally only confronted with the resulting end quality of a design process. When compared with an Integral Design process setting where all design team members cooperate from the very beginning of the project, this unique project participation as principal and building service consultant becomes clear. On because of this it was possible to test the new design approach with the Integral Design method in practice.

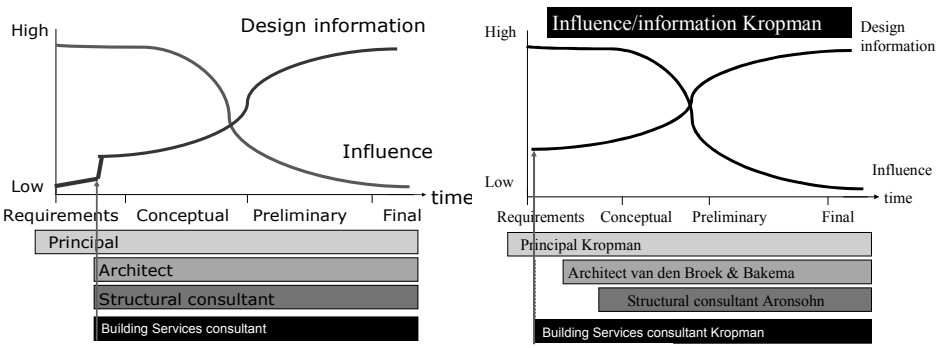

Figure 11. Influence/ information within an Integral Design project setting and the Kropman project setting

During the process there was a strict focus on implementing sustainable energy solution and their optimal integration with the construction of the building. To make this possible, they developed a sustainable IFD (Industrial Flexible Dismountable) building concept. An IFD-building is seen as an expedient for an optimal useable and efficient building process. The IFD-programme was an joined initiative of the Netherlands Ministry of Housing, Spatial Planning and the Environment and the Netherlands Ministery of Economoc Affairs. IFD-building is strongly related to 'Open Building', based on the ideas of N.J. Habraken (1998). The application of new innovative construction products and methods in this project demonstrated their potential; and the project reached the status of a demonstration project within the IFD programme of SEV (Stichting Experimentele Volkshuisvesting (Groenedijk etal. 1999). The conceptual design and the final realization are shown in figure 12.

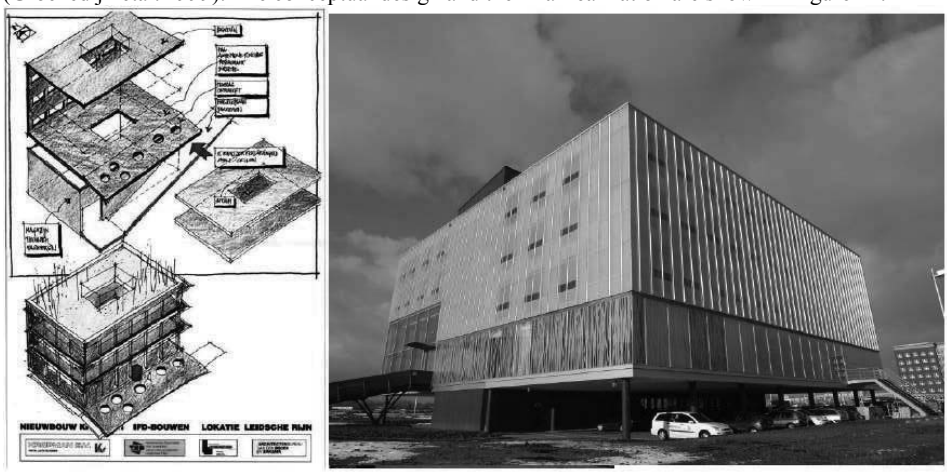

Figure 12. Conceptual design and the final Kropman office

5 DICUSSION

Open Building seems the same thinking as is seen in all kind of design processes, particularly in the automotive industry, the so called "platform design". The potential advantages with platform-based approaches are described by different researchers in par example Gedell et al. (2008). Also nowadays product development in the automotive industry is characterised by cross-functional teamwork. Still the organisation and development culture are in many ways component-oriented (Almefelt 2005) where as the organization and development culture in the building industry is more designer-centred focussed on the building as a whole. Lately there is also in automotive industry a change away from the "Old Masters" (Pahl & Beitz, Hubka, Tjalve and Roth) way of working towards a more designer-centred approach. This also means to regard the tacit frames of an individual in context with practice, cultural circumstance, methodology, etc (Abidin et al. 2008). As such automotive industry and building industry are developing both in a direction of either more cross-functional or more cross-cultural approach. As architects tends to be more verbose and engineers more functional this can lead to a good future development of design. Isolating design as a discrete discipline during the Renaissance opened the path to innovation (Habraken 2005); " *throughout history, architecture and building (innovation) had always been systematic, in the sense that ways of building rested on shared elements brought together in fixed and familiar ways. Alexander refers to this as 'timeless way of building'. Nowadays however, within the building as a composition of systems, the architect is neither the designer of all systems, nor does he or she design with all systems. The most important role of architect is to orchestrate and coordinate the team of co-designers, which is assembled ad hoc for each project*".

So maybe we are at the point of a new path to innovation: true collaborative design, in which the different designers each with their own cultural and domain specific knowledge, reach the synergy as a basis for innovation.

Besides designing the Kropman project, one of the design team members was chairman of the steering committee Climate technology of the TVVL (Dutch Society for Building Services). During this period he was asked questions about the investigation of problems concerning comfort and health in buildings. Instead of treating them with an 'end of pipe solution' approach, where only the effect is treated and not the cause, the real source of the problems was investigated. These problems resulted from mistakes made during the design process, so it was logical to investigate the design process itself. The parallel between the activities within the Kropman design process and the TVVL activities led to a combined effort. The architect and building services consultant of the Kropman project took the initiative to get in touch with the Royal Institute of Dutch Architects (BNA) and Delft University of Technology (TUD). In year 2000, BNA, TVVL and TUD participated in the research project Integral Design. This project primarily aimed at the reduction of failure costs.
Since 2001 we have been propagating 'integral open building design methodology' within Dutch building design practice, through continuously developing learning-by-doing workshops. Integral approach represents a broad view on the world around us that continuously needs to be adapted and developed from sound and documented experiences that emerge out of interaction between practice, research and education. This integral approach can eventually lead to integral process, team and method – all the required conditions for design of the end product. Implicit to this broad view is that integral design solutions are only possible through unification of different viewpoints on the same aspects. This is the reason we assume that a multi-discipline design team view on design is an effective way to pursue building design integration. The aim is to improve conceptual design (process level) by defining an 'integral open building design method' that would increase potential for creation of integral building designs (product level). Positive results on these two levels are assumed to eventually trigger and support culture change within (Dutch) building design practice.

6 CONCLUSION

To support architects more effectively with their tasks, integral design method for conceptual design is needed. Transforming a design methodology such as the domain-independent design theory of Open building to a specific multi-disciplinary approach helped to construct a bridge between architecture and building services. We think that the proposed Integral Design method is a possible solution to bridge the gap between design theory and daily practice.

Acknowledgement

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