Agile Architecture

PROCEEDINGS

Conference of CIB W104:

Open Building Implementation

Delft University of Technology

The Netherlands 3 - 4 October 2001

Edited by Ype Cuperus

Design / Lay out:
Conny van den Broek, Corine Köhler

Printed by:
KopiePlus, Pijnacker

Published by:
OBOM, Delft University of Technology

OBOM
Open Bouwen Ontwikkelings Model

OBOM Research Group
De Vries van Heystplantsoen 2
2628 RZ Delft
The Netherlands
tel: +31.15.278 5400
fax: +31.15.278 8295
Email: y.j.cuperus@bk.tudelft.nl

Preface

Agile Architecture refers to buildings that can adjust over time with maximum grace and minimal cost and conflict, accommodating technical and organisational change while maintaining a coherent and regenerative architecture rooted in its place.

On 3 and 4 October 2001, The Faculty of Architecture, Delft University of Technology, hosted the annual meeting of the CIB W104 Working commission ‘Open Building Implementation.

This conference offered the opportunity for presentations and discussion of principles, methods and practices needed to realise agile architecture and a coherent build environment capable of regeneration for the 21st century.

The paper presentations were grouped around the following topics:

Topic 1: IFD: Industrial, Flexible and Demountable;

In the past two years the Netherlands Department of Economic Affairs has granted subsidies for more than fifty projects in order to stimulate industrial, flexible and demountable building.
In this session analyses and comparison of some of these projects will be presented in an international perspective.

Topic 2: Product and systems development;

The building process can be dissected along the line of systems and subsystems. Building node studies: emphasis has shifted a focus on modularity (E.G. from dimensional and positional co-ordination) to include a wider range of issues concerning the interface of building parts. This session focuses on interface studies, product and systems development from an open building perspective.

Topic 3: Ducts, services and building technology;

Plumbing and cabling are the carriers of the ripple effect, producing many unwanted consequences in the object (building), the process (parties) as well as in time (levels of decision making). This was recognised by Age van Randen (‘Nodes and Noodles’, 1975) and by Yositika Utida in Japan at about the same time. The confusion of terms of reference and practices between spatially oriented disciplines (architects, structural engineers) and resource system oriented disciplines (MEP = Mechanical/ Electrical/Plumbing Engineers) needs to be resolved. This session aims to find new ways to integrate the MEP systems and the spatial design.

Topic 4: Education and International exchange.

In 1963 John Habraken wrote: '...we should not try to forecast what will happen, but try to make provisions for what cannot be foreseen'. How do we teach our next generations of practitioners (designers, developers, contractors, regulators) to design/ make provisions for what cannot be foreseen? This session aims to address issues of pedagogy and includes student projects and exchange of experience in an international forum.

In these proceedings 28 papers are arranged in alphabetical order of the author's names.

I wish to thank all authors for their contributions, who have shared their insights with us. These proceedings allow you to read and reread their ideas on Agile Architecture.

Ype Cuperus

Scientific Committee

Prof. Jan Brouwer
Ype Cuperus
Prof. Dr. Stephen Kendall
Prof. Dr. Seiji Sawada
Prof. Ulpu Tiuri
Prof. Fons Verheijen
Leo Verhoef

Advisory committee

Prof. Dr. Udo Blecken
Prof. David Gann
Prof. Marton Marosszeky
Prof Dr. Seiichi Fukao

Review committee

Prof. Dr. Jia Beisi
Prof. Jan Brouwer
Ype Cuperus
Rob Geraedts
Prof. Dr. Stephen Kendall
Prof. Dr. Seiji Sawada
Prof. Ulpu Tiuri
Prof. Fons Verheijen
Leo Verhoef
Prof. Dr. Tomonari Yashiro

Organising Committee

Conny van den Broek
Ype Cuperus
Corine Köhler

An Introduction to Open Building

Ype Cuperus
Director of the OBOM Research Group
Delft University of Technology
De Vries van Heystplantsoen 2
2628 RZ Delft
The Netherlands
y.j.Cuperus@bk.tudelft.nl

An Introduction to Open Building

Ype Cuperus

The origins of the concept of Open Building is best captured by one of John Habraken's finest quotes: 'We should not to forecast what will happen, but try to make provisions for the unforeseen' (Habraken, 196I). In order to accommodate unknown future change, he suggested to introduce different levels of decision making in the building process: tissue, support and infill, respectively referring to the urban fabric, containing base buildings with their fit-outs.
The raison d'être of Open Building can also be expressed in terms of care, responsibility and technology.
People, who care about the environment they live in, will make it a better and safer place. Therefore the built environment must encourage people to take responsibility for their own territory. An environment that clearly distinguishes those spaces and parts of a building for which occupants should take responsibility, will address the user's needs to feel responsible. Therefore a building should be designed and built in such a way that both spaces and parts of the building can be clearly allocated to those parties and individuals that should take responsibility for them.
Buildings, which are designed and built with separate systems, can create conditions for responsibility and care. Therefore the subdivision of the building process needs to reflect the lines of decision-making and the definition of responsibilities between the parties. This subdivision can then be translated into specifications for connections between building parts. This in turn creates buildings that can be modified and taken apart again (Cuperus, 1996).
It offers the basis for a well-structured building process with well-defined interfaces. It allows us, to at least partially transfer the construction process from building to manufacturing. It is the key to reducing waste by coordinating dimensions and positions in stead of improvising on site by cutting to size. Applying information instead of energy.
This is an important condition to re-use building parts, thus extending the lifetime of building parts, without the waste of dumping and recycling, coinciding with degradation and the use of energy.

Open Building is a multi facetted concept, with technical, organizational and financial solutions for a built environment that can adapt to changing needs. It supports user participation, industrialization and restructuring of the building process. If change is the problem, a layered organization of the building process can provide at least a part of the solution. Positional and dimensional co-ordination of building parts and their interfaces are a tool and a condition for industrialization and probably a leaner construction process.

Levels of Decision Making

If the notion of having to make provisions for an unknown future is the intriguing problem of Open Building, the concept of levels gives directions towards the solutions. Three levels of decision-making are defined, being tissue, support and infill. They are separated, yet coordinated. The town fabric (tissue level) is of a higher level than the buildings, positioned within the town fabric. Buildings can be altered or replaced, while the town fabric remains the same. The buildings in turn can be divided in base building (support level) and fit-out (infill level).

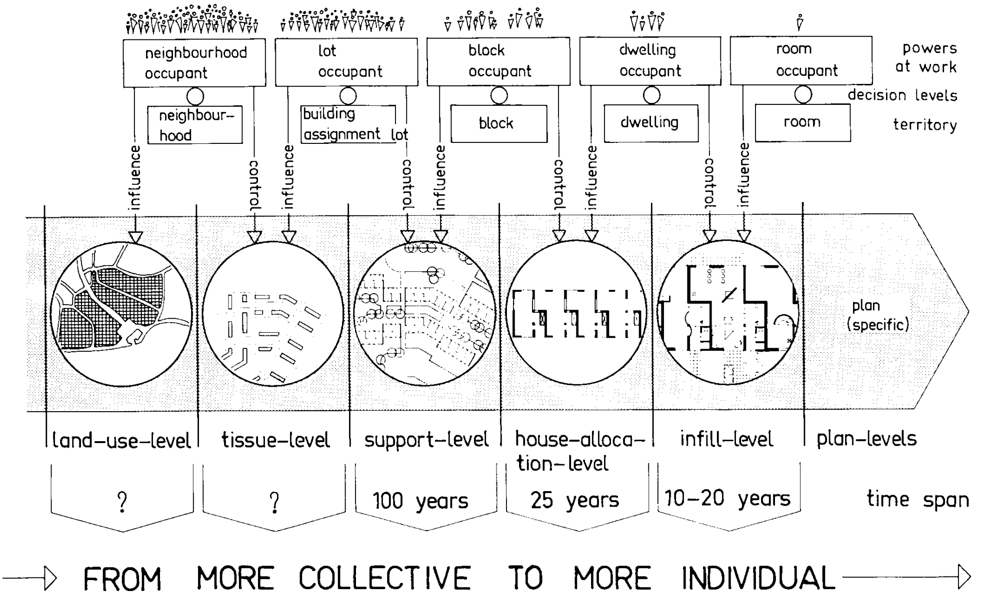


Figure 1: levels of decision making

The higher level (support) accommodates and limits the lower level (infill), which in turn determines its requirements towards the higher. On every level there is an ‘ultimate customer’: the consumer on the infill level, the housing corporation or developer on the support level, the municipality on the tissue level (Figure 1).

Open Building originates from a tradition of user participation in creating a built environment the customer is prepared to take care for, to look after, to maintain, to defend and take responsibility for. It has developed a set of tools to accommodate different levels of decision-making.

Open Building takes the customer seriously. Open Building aims to optimize the quality of the built environment, by improving the relationship between the consumer and the building industry. The Consumer will become one of the driving forces of the building industry. Open Building is a strategy to make it happen.

References

Cuperus, Y.J (1996) Housing for the Millions, The challenge ahead, conference papers, Hongkong.

Habraken, N.J. (1961) Supports an alternative to mass housing, London 1972, Amsterdam 1961 (Dutch version)

Contents

Low-income housing and cultural identity

A teaching experience of Open Building in Mexico City

Jorge Andrade
Head of the Masters Degree Program, UAM-X, Mexico.
jandrade@cueyatl.uam.mx

Andrea Martin
Head of the Housing Department, UAM-X. Mexico.
amartin@cueyatl.uam.mx

UNIVERSIDAD AUTONOMA METROPOLITANA
DIVISION DE CIENCIAS Y ARTES PARA EL DISEÑO
CALZADA DEL HUESO 1100 EDIFICIO “A” 2DO. PISO
COL. VILLA QUIETUD, COYOACAN 04960
MEXICO D.F.
MEXICO

Low-income housing and cultural identity

A teaching experience of Open Building in Mexico City

Jorge Andrade and Andrea Martin

ABSTRACT

The demographic growth in Mexico City and the insufficient land resources in the city's outskirts, give us the urgent necessity to increase the density of the actual housing areas. In order to do that we first have to understand how the families living in these areas manage to do so spontaneously. So for this particular teaching course we selected a housing complex of single houses for 150 families that have been living there for more than ten years. This case study has very unique and interesting characteristics such as:

The topography; the land has up to a 25% of slope.

The family composition; there are many extended families living in there.

The housing prototype; it is a progressive dwelling.

The course had the following objectives:

1. To observe and document the way in which low income families increase the density in their dwellings.
2. To systematize the transformation and modifications undergone by those dwellings.
3. And to apply the Open Building concepts in order to generate low income housing projects in a progressive and flexible way.

At the end the students produced projects capable of housing different families with different necessities, backgrounds and income; capable to adequate to this particular lot, with an oblique variable slope; as well as to the family's transformation within time according to their incomes.

Low-income housing and cultural identity

Jorge Andrade and Andrea Martin

Introduction:

In many Latin-American cities, demographic growth and insufficient land resources in most of its outskirts, demand urgent action to increase the density of the actual housing areas as well as to improve most of the low-income housing that slowly proliferates there. In Mexico City the process of growth and densification of the city's outskirts dwellings generally takes long periods of time and great economic effort for the families that construct them. This is a process that usually takes place without any technical or financial aid. Nevertheless these families manage to accomplish it somehow successfully although most of the time there are some functional, or structural, or sanitary or even legal problems with this dwellings. It is important though to understand how this -spontaneous incremental and densification- process takes place in this particular type of housing, in order to be able to improve it from the design, economic and timing point of view.

At the Autonomous Metropolitan University of Xochimilco (UAM-X) we perform our work with a particular pedagogic model called "modular system". This model relates the academic, research and community service work of both, the academic staff and students. We teach our students' throughout a specific problematic that help them know and solve problems from the real world. In this way students are impelled to work with the real users and to apply the theoretical and technical knowledge that they simultaneously acquire, towards the solution of particular community problems.

Since the 1985's earthquake in Mexico City, the Department of Housing of the Faculty of Architecture of our University is committed with the housing problems of the low-income families. For the last two decades most professors in this Department have been involved in working with community housing problems in the Metropolitan Area of Mexico City. Our work includes infield research, teaching students and professional assistance. So we study and analyze the ways in which the low-income families produce their dwellings in different parts of the city and of the country; the cultural identity of the different regions of Mexico; the peculiarities of the different housing types in Mexico City nowadays and throughout the different periods in our history; how family ties impact the development of the incremental housing, etc. We also relate with social and non-governmental organizations as well as with professional and governmental institutions related to housing matters. This is the case of the actual research program of our Housing Department that since 1997 is working with the Urban Popular Movement (MUP). This is a large social organization that has achieved - in only one decade- hundreds of housing units for low-income families. The idea of this research program is to document and evaluate the most relevant projects to elaborate design guidelines to continuously improve the process.

The teaching experience

This particular teaching experience derived from two different community demands: On one hand some families living in the housing complex called “People’s Emancipation” needed plans for the regularization and/or improvement and growth of their dwellings and on the other the leaders of a recently formed housing organization “Matias Romero” asked for the pre-project of an apartment building. To achieve the investigative, community service and academic aims of our pedagogic model for this one year course; first we studied and analyzed the different ways in which the low-income incremental housing of the cities’ outskirts is produced; secondly the students made the actual plans and improvement proposals for twenty participating households of the “Peoples Emancipation” community; and finally students learnt and then applied the Open Building concepts in the design of the pre-project of the apartment building for the community of “Matias Romero”
The course lasted one year and was divided it in three units with variable duration and specific but related objectives.
The three main actors in this teaching experience were: the team of twenty-five students attending the last year of the architectural program at UAM University; the community’s leaders and families of the groups we worked with; and the team of four professors that worked together the whole academic year. We (Andrea and Jorge) were the tutors in charge of the whole process, professor Enrique Ortiz was in charge of the theoretical support, and professor Everardo Carballo was in charge of the technical support.

Unit 1

Objective:

To observe and document the way in which low-income families increase the density of their dwellings in three different housing complexes so as to understand the dwelling as a process, not as finished product.

Actions:

The study took place in three different housing complexes in Mexico City. The three housing complexes were selected under the following criteria: Medium size housing complexes where people have been living for more than ten years; incremental house type of dwelling; and located in the outskirts of the city. One of the selected and documented housing prototypes was “Peoples Emancipation” where their community requested the housing improvement design.
The students made surveys and took photographs and measurements of the randomly selected dwellings in each housing complex Between 15 and 20 dwellings per complex (about the ten percent) were studied.
All the pertinent information was concentrated in two documents:
One contained the exterior and interior photographs of each house, together with a

succinct text where the family name; number of inhabitants; relation between them; ages; occupation and schooling; as well as the activities performed within the house were described.
The other contained the actual plans of the house with all the furnishings and in schematic drawings the following information: stages of incremental growth (each floor plan with the year the addition was accomplished), the members of each nuclear family with age and gender and relation (big or small squares for men and circles for women), the sleeping place for each inhabitant of the dwelling.

Some interesting findings and conclusions of the previous research were:

1. When families move into their dwellings they generally nuclear families (usually young couples with children).
2. In the short run (two to five years) families modify and add space to the original dwelling. In general sleeping and working places (dorms and workshops or shops) are added first.
3. In the long run (five to ten years), the children of the original nuclear family marry and settle down with a new nuclear family in the same dwelling. Frequently the elder son or daughter stays, but there are cases where more than one stays. At this point the process of *house duplication*[1] starts.
4. Once this process starts it takes another five to ten years to be completed. That is when the original house is divided in two or more dwellings with separate access.

This process of duplication takes place in a fairly common territorial pattern (we have been studying this territorial patterns in different types of low-income housing in Mexico for more than twenty years now).[2] At the beginning the new family has only one private space within the original dwelling and shares with their former nuclear family the public and service spaces. Usually the kitchen is the first space to be duplicated and very often while the original kitchen is shared, there are two adjacent stoves in the same space. Slowly more spaces are added until another house is completed and an independent access is achieved, with more or less success. This success usually depends on the original incremental house floor plan. If duplication is not foreseen -which it is generally not- these houses can hardly achieve an independent access. This usually depends on the location of the staircase, because this type of housing only allows vertical growth. In this process, families do not have any technical or professional help, so at the end most of these houses have a lot of different problems.

Accomplishments:

Each student documented three cases (one in each housing complex). At the end we had more than fifty cases of modifications and transformations of incremental housing. With the analysis of the fifty cases we were able to conclude some important trends going on in

1 We call house duplication to the process by which the original house becomes two or more independent dwellings. This is a fairly new phenomenon that takes place in incremental single low-income dwellings
2 Andrade, Jorge. “El territorio compartido en la vivienda popular”. DISEÑO Y SOCIEDAD, No 10. 1999/otoño. Universidad Autónoma Metropolitana, Unidad Xochimilco, México. Pag. 60-70.

incremental housing and to understand better the way in which the relation between family changes and incremental growth works.

Unit 2

Objective:

To systematize the transformation and modifications undergone by the dwellings of the participating families in “Peoples Emancipation” and to propose improvement design for those dwellings.

Actions:

The study took place in “People’s Emancipation” a housing complex of 150 single houses in the outskirts of the city, whose community is affiliated to the Urban Popular Movement. This housing complex is located to the northwest of the city, in the skirts of the surrounding mountains (the site has up to a 25% of slope). The housing prototype is an incremental house that was developed by design participation process between the future tenants and a non-profit housing agency. Families have been living here for more than ten years, so the original dwellings have undergone a lot of growth and modification.

To systematize the transformation and modifications undergone by the dwellings of the thirty participating families the students elaborated the same type of document used for synthesizing the information gathered in the other two housing complexes.

In this case they also performed detailed interviews with all family members and recollected important information. A diagnosis was made after the analysis of the information. This diagnosis included the family needs; the underlying problems; and the particular stage of development of the dwelling. Information such as: number of people living there, their relationship, ages and occupation; number of spaces of the dwelling, its use all day long, members using it and type and quantity of the furnishing; was also collected.

After the diagnosis of each dwelling was made, the design program was developed with the participation and agreement of the family or families living there. The students confronted the result of the information and diagnosis of each dwelling in order to figure out the prevailing trends of growth, so they could be able not only to solve the immediate family needs but also to foresee future problems. The design project proposal included the phases of growth for the incremental house.

Some of the most interesting findings were:

1. A high percentage (more than 30%) of the dwellings are inhabited by more than one nuclear family. Half of these dwellings had at the time of the study already subdivided their dwelling in two, with a separate access and stairway.
2. These dwellings usually grow by the addition of a large room, that is subdivided by provisional means such as furniture and within a lapse of two to five years it is finished and subdivided with permanent walls.

3. Dwelling's density still is very high. The number of children per family has decreased to two or three children but frequently there are more than one nuclear families living in the same dwelling.

Accomplishments:

Each student drew the actual plans (floor plans, sections and elevations) of one of the studied dwellings. These plans were given to the participating family members in an emotive ceremony in the housing complex gathering place. Dwellers told the students how proud they felt to be able to achieve what they actually have after many years of fighting the authorities, of hard work and social commitment and how grateful they were with them.

Dwellers of "People's Emancipation" housing complex and students in the gathering space. (April, 2001)

Not all the families needed an improvement proposal, so the students only developed fifteen proposals. The range of action was very broad: from a family only needing some partitions and finishing's for their dwelling; to a nuclear family living with two related nuclear families needing to subdivide in three their dwelling. Plans and models together with constructive and costs documents were given to the interested families at the University at the end of the second unit.

Unit 3

Objective:

To apply the Open Building[3] concepts in order to generate new low-income housing projects in an incremental and flexible way and to design the pre-project support proposal to house fifty families of "Matias Romero" community.

---

3 Habraken, NJ et al. "VARIATIONS: The systematic design of the supports". MIT Press, Cambridge, Mass. 1976.

Actions:

After learning the basic concepts to design a support following the SAR method, the students had to apply the concepts in the design of a support with the following constraints (this first exercise was just an academic one so the students could learn the support design basics) :

1. A support capable of housing the different necessities, backgrounds and income of the fifteen surveyed families.
2. A support capable of adaptation to this particular site (the same where "Peoples Emancipation" housing complex is) which has a considerable slope.
3. A support that could accommodate incremental growth.

Some students designed very interesting proposals that met the three constraints. Once the students were comfortable in applying the Open Building concepts in this site, we started our study with the second community to be attended.

Fifty families living in a lot of one thousand and three hundred square meters form this community. All dwellings are one story high and most of them have only two rooms. In general, there are serious problems of ventilation, natural light and overcrowding. Sanitary facilities are collective. The site is located in the corner of one of the biggest arteries going downtown and a residential street. Families have been renting there for more than fifteen years. Recently some legal problem appeared in which the alleged owner was in fact not the real one. The dwellers thus realized that they had rightful possession of the site. They asked for help to the City's Institute of Housing who is at the moment aiding them to buy the land to the legal owner at a good deal. But they needed also to develop a feasible pre-project of an apartment building to demonstrate that the place can house all the families living there. In order to proceed with all the paper work to get the legal and financial help, families organized themselves and came to the University looking for technical support. The students made the urban and architectonic study of the site and then sampled ten different dwellings. We organized five workshops together with the community. Not everybody in the community participated, but the workshops were very helpful to learn about their necessities and ideals as well as the individual needs to be met in the project. Different housing layouts were developed and the Open Building concepts were again applied. Structures of four to six story high were proposed.

Accomplishments:

Each student made a support proposal capable of housing the 150 families of the "Peoples Emancipation" community. They developed the support plans and models. Most of the solutions were quite imaginative and also adequate to the difficult topography of the site. The problem of incremental growth was solved in some of the projects only.

As a final exercise -in teams of three- students developed the support pre-project to house the "Matias Romero" community. In the last workshop where most of the community participated, each team of students showed plans and models of their proposals together with a ten-minute presentation. After the presentations the participants voted their first, second and third choices. Three final pre-projects were selected to be presented to the City's Housing Institute.

Conclusions:

This pedagogic model has a lot of advantages for both the faculty and the students. We, as researchers and instructors keep actualized in our knowledge of the changing trends in housing matters and are able to apply this knowledge to serve directly to the community. We also can experiment with the community new and better ways of producing housing, as in this particular case where we were able to apply the Open Building concepts.

On the other hand the students are very enthusiastic and responsive when they are dealing with real problems. They feel directly responsible for the outcome of the work to be done. They also get to know and respect different ways of life and realize that they can help and make a whole difference for these peoples' dwellings.

The links with social and professional organizations such as the MUP and the City's Housing Institute (INVI) made at the Department of Housing allows us to freely do field research, community and professional work at any time. Such is the case with the twenty-five students that just finished their architectural training with us. After this academic year of intense work with different communities they were hired by the National Institute of Architects to work in the City's Housing Improvement Program. This is a joint program between the National Institute of Architects and the Institute that is doing more than 15 000 housing improvement actions per year. The INVI provides the financial aid and bureaucratic infrastructure and the National Institute of Architects provides qualified professionals to insure the quality of the housing improvement actions.

Restructuring design

The ExamplesBox, a design decision support tool for sustainable and tenant oriented restructuring of existing residential urban areas

Geert-Jan van den Brand
Project manager building process innovation, TNO Building and Construction Research, Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands, P 0031152695283, FAX 0031152695335, G.vandenBrand@bouw.tno.nl

Maurits Dekker
Researcher building process innovation, TNO Building and Construction Research, Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands, P 0031152695291, FAX 0031152695335, M.Dekker@bouw.tno.nl

Karel Dekker
Principal advisor building and infrastructure, TNO Building and Construction Research, Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands, P 0031152695225, FAX 0031152695335, K.Dekker@bouw.tno.nl

Restructuring design

The ExamplesBox, a design decision support tool for sustainable and tenant oriented restructuring of existing residential urban areas

ABSTRACT

The SUREURO project, funded by the European Commission, deals with the sustainable and consumer oriented refurbishment of post war residential areas. SUREURO provides practical management and design tools and new flexible and sustainable technical concepts. One workgroup - called Design and Construct - concentrates on the refurbishment design process. In the project existing tools are inventoried and new tools are developed.

One of the new tools is called the 'ExamplesBox'. Dutch housing company wonenCentraal, XX architects, Heeling Krop Bekkering architects and TNO Building and Construction Research created the tool. It contains stimulating concepts, sketches and ideas for the refurbishment of residential areas on the tissue level, the support level and the infill level. It can be used in the conceptual design phase to generate alternative design solutions. The ExamplesBox can never replace the design team, for uncritical copying of concepts leads to an unwanted repetition of design solutions. The application of the ExamplesBox fits into a new design approach, called Strategic Design. This approach stimulates thinking in concepts within an interdisciplinary team before elaboration of solutions in detail. The ExamplesBox can support the communication between the participants within the team.

In the conceptual design phase the principal's demands are transformed into architectural solutions. An important feature is the exploration of the design problem definition through the examination of solutions or partial solutions. The ExamplesBox can also be used to support this process.

All SUREURO participants from different countries will fill in the ExamplesBox. Thus a European state of the art view of sustainable and consumer oriented refurbishment examples is created.

KEYWORDS

Refurbishment urban areas, sustainability, consumer orientation, conceptual design, thematic solutions, open building.

Restructuring design

The ExamplesBox, a design decision support tool for sustainable and tenant oriented restructuring of existing residential urban areas

Geert-Jan van den Brand, Maurits Dekker, Karel Dekker

SUREURO [1]

In Europe 170 million people are living in approximately 80.000 post war mass housing areas containing approximately 56 million flats that were built after 1950. The SUREURO project deals with the sustainable and consumer oriented refurbishment of these areas. The main focus of the project is the strategy of the housing companies in dealing with this challenge. Further attention is paid to tenant participation in the design process and the application of sustainable technical solutions. Sustainability can be achieved only with an intensive and constructive participation of the tenants. This is a topical challenge throughout Europe. Investigating the design process concerning refurbishment of urban areas by providing stimulating concepts and creative ideas in the conceptual design phase is an effort worth making.

The SUREURO project is funded by the European Commission and develops practical tools for the sustainable and consumer oriented transformation of (big most post war) housing areas. The project is aimed at the support of housing companies and their refurbishment project partners such as local authorities, urban planners, architects, construction companies and consultants. SUREURO provides:
- The development and implementation of practical management tools for integrating sustainable development and tenant participation in their refurbishment management including training of housing companies to work with these tools.
- The development and design of monitoring and simulation tools for town planners, local decision makers, construction companies, designers and engineers and models for better planning, design and technical specifications of refurbishment projects, both at housing and neighbourhood level.
- The testing and implementation of new and flexible technical concepts for sustainable transformation of existing housing areas.

For refurbishment a general European scope exists, but the focus of each country is different. Every country has its special experiences that can be useful for other countries. In the Netherlands the increase of choice for individuals and livability of neighbourhoods are key issues. The Dutch participating housing company is specialized in defining housing corporation management strategies. In general the Scandinavian partners are more experienced in developing and applying various sustainable solutions for the decrease of water and energy use and waste reduction. This diversity on European scale produces a complete set of refurbishment tools within the project and by that an optimal exchange of experiences between the participating countries.

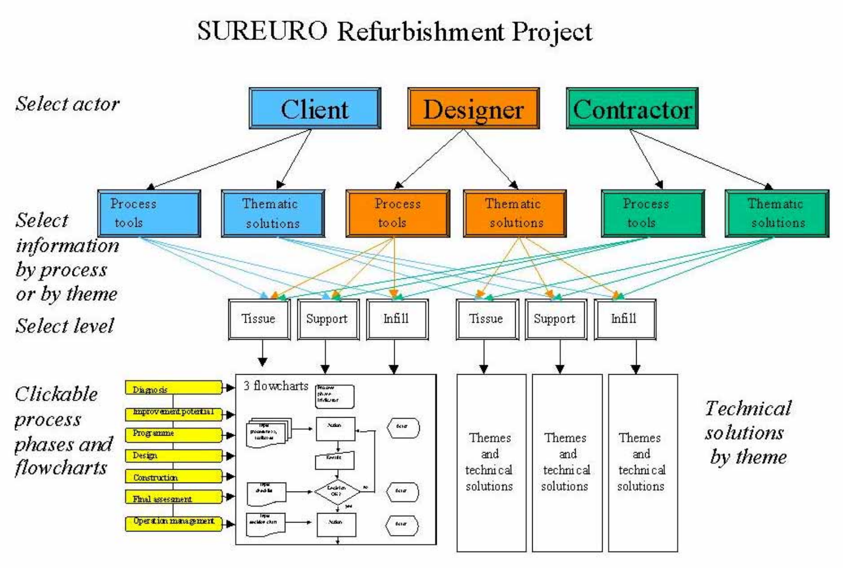


Figure 1 Model for the information about the Refurbishment project [1]

Refurbishment design process

Within the SUREURO project several workgroups are dedicated to a specific task. One workgroup - called Design and Construct - concentrates on the refurbishment design process. This workgroup has specified a process model (Figure 1) and an accompanying matrix dealing with the process phases, decision levels and (sustainability) issues (Figure 2) [2]. This structure is the backbone for the project and a way to arrange and select suitable design tools. Different countries provide tools. In the project also new tools are developed. One specific tool is situated in the early design process, the ‘ExamplesBox’. This tool supports the design team in generating alternative design solutions in the early conceptual phase of the design process. At the same time the tool is a means for the exchange of experiences between different project teams and even between countries.

Looking at the refurbishment design process we find that, traditionally, principals and contractors are strongly aimed at reducing risks within strict time and money boundaries. Designers often feel restricted by this and will try to intensify the attention for aesthetic and spatial quality. Conflicting interests of different parties lead to sub-optimal design results. In order to meet the ambitious goals of the SUREURO project substantial innovation is necessary. Better communication and collaboration of design team members can achieve this. Design team members therefor are not only selected for their specific knowledge, but also for their capacity to co-operate in a team. The ExamplesBox can also be used to stimulate the communication in the team by visualising concepts.

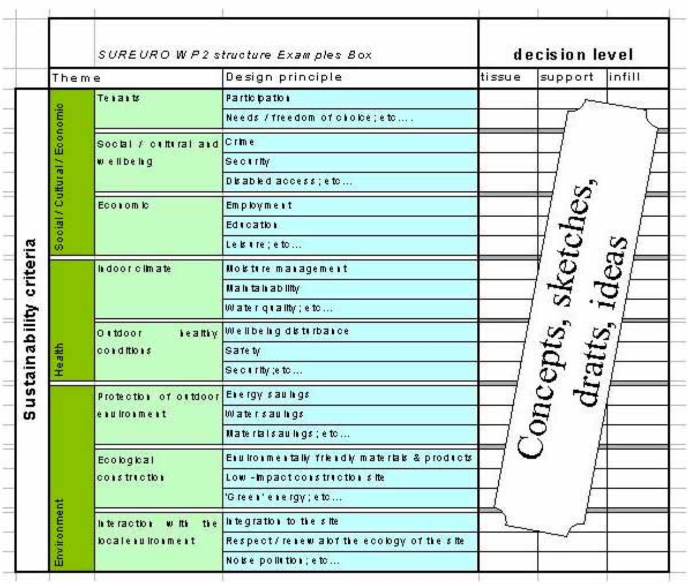


Figure 2 The SUREURO matrix

Alternative design process

Several researchers and practitioners work on alternative design processes. They respond to the disadvantages of the traditional approach. In the late 60's Habraken initiated the Open Building approach [3], primarily to improve the position of the individual citizen. He established the SAR research foundation. An essential Open Building principle is thinking in levels and a generally known SAR distinction in decision levels is: tissue, support and infill. The SAR foundation developed several design tools, such as the tissue method. These methods are demonstrated in various projects [4]. The Open Building initiative also lead to the development of a completed consumer oriented fit-out system: Matura. Rutten introduces an alternative design approach, called Strategic Design. This approach is one of the research themes at the TU/e and TNO based Knowledge Centre 'Buildings and Systems' [5]. Within this centre a group of Ääsearchers and PhD students elaborate theories and accompanying decision support tools to enable Strategic Design [6]. Another paper in this symposium deals with the blueprint of this alternative design process [7]. Strategic Design is aimed at developing buildings with a higher future value. In summary the essential features for an alternative design approach are:

- *Thinking in scenario's and design strategies:* change is essential. Starting point of the process can be not just one (linear) program, but different development scenario's that possibly shape the future of the neighbourhood. Uncertainties on future development strengthen the idea of designing flexibility.
- *Distinction of decision levels:* tissue, support and infill. Each decision level has its own

design process and a group of decision-makers. Anticipating to change within each level, with minimal impact on the other levels is essential.
- *Extending conceptual and thematic design:* executing thematic studies at the different territorial levels of neighbourhood, building and dwelling in order to generate variants on a global level and at the same time getting better understanding of the real design problem(s) without considering the complete project context. After all, too often the context passes some trivial argument to reject a good idea in an early phase.

According to Rutten design teams run to quickly to technical solutions without really understanding the design problem. Also Moughtin [8] endorses Ruttens point of view: '... an important feature of the design process is the exploration of problem definition through the examination of solutions or partial solutions.'
In these alternative design approaches *'change'* is an important issue. Enabling change in the built environment means improving individuals' participation and sustainability. Participation and discussion on issues is only possible when you have the right knowledge and information.

The conceptual design phase

A crucial phase in the design process is situated between initiative and the first design sketches and is called the 'conceptual design phase'. According to Rutten and Trum: 'During the conceptual design the "genetic code" of the building is determined. In a very short period in time more than 80 percent of the total costs and performances of the future building will be determined at design costs which are about 8%. This is therefore a very important phase in the design process and also a very difficult one as designers must think and communicate in concepts' [6].
In the conceptual design phase the principal's demands are transformed into architectural solutions. This is the transformation of 'words' to 'images'. One solution or idea captured in an image often deals with several problems at the same time. This conceptual design phase is an integral decision process strongly determining the success or failure of a project. Choosing one solution too quickly and working this out in depth can cause many risks. It is better to consider several concepts for - for example - entrances and vertical transport, and to consider them from a conceptual an integral perspective before 'jumping to solutions'. The SUREURO ExamplesBox offers a way to communicate soft issues and combining them with harder issues such as costs and time.
During the design process many ideas are developed and rejected. The reasons why certain ideas are come up with and approved or rejected are too often forgotten. In the design process it is only the end result, projected in the building, that counts. This means an almost inevitable loss of many good ideas. Every refurbishment project asks within its specific context for these ideas. The workgroup developing the ExamplesBox wanted to prevent this loss by assembling good examples by design principle and operational level. The structure of the ExamplesBox is based on the earlier mentioned SUREURO process model in combination with a first draft of XX architects. Dutch architectural companies 'Heeling Krop Bekkering' and 'XX architects' fill in the first draft of the box with their concepts. In the next phase all participating countries in the SUREURO project will do the

same. As Habraken emphasized in the 1981 published Grunsfeld Variations [4] such concepts - thematic solutions - are never prescriptive end results but ideas to stimulate the mind of principals, architects and tenants. In specific projects these concepts will be elaborated in a unique configuration attuned to the local conditions. They can not be copied without question. The ExamplesBox can never replace the design team, for this might lead to an unwanted repetition of design solutions.

The ExamplesBox - demonstration

The ExamplesBox provides two possibilities for searching for concepts. The first one is a structured search. The team has a few possible entrances for the search operation. They can either search for concepts on a certain level and / or they can indicate an issue or a design principle. When more entrances are used, the results will be more defined. The second possibility is searching for concepts by using keywords. The team can fill in a word or choose one of the possibilities in the index. Depending on the way of searching, the ExamplesBox generates a screen with results.

To show how the ExamplesBox works a small case is presented. A design team is working on the refurbishment of a residential area. The area consists of several apartment buildings, situated in a green environment and water. One of the challenges for the team is the reduction of the use of water in the neighbourhood.

The design team will look for good examples on all levels and chooses for the structured search. They select the design principle 'Water savings'. Figure 3 shows the screen with results for this search operation and gives various examples for the saving of water on the tissue, the support and the infill level.

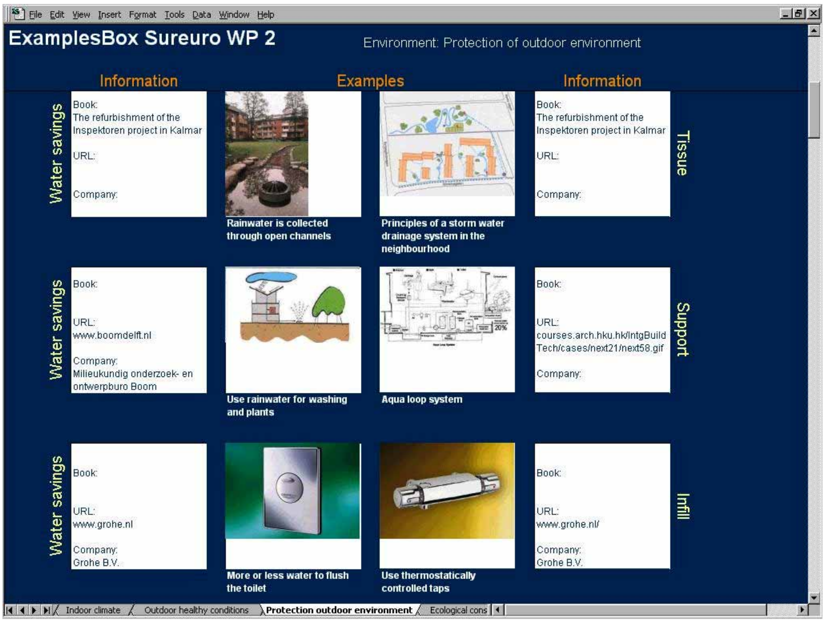


Figure 3 Screen with results for the search operation

The ExamplesBox also gives information where the team can find more specific explanation about the concept. In the near future it will be possible to associate these examples with other design principles, themes and other examples, only by clicking on the example.

Conclusions and further development

The SUREURO ExamplesBox is a design tool for the conceptual design phase for the refurbishment of residential areas on the tissue, support and infill level. A design team employs this tool for the translation of words from the brief to images and solutions. Collecting good ideas from different projects in various countries enables the re-use of these ideas. It supports the communication of soft issues and combines them with harder issues such as costs and time.

The application of the ExamplesBox fits into a new design approach, called Strategic Design. This approach stimulates ‘thinking in concepts’ before elaboration of solutions in detail. The tool supports the practical implementation of this important principle of Strategic Design. Within the strategic design approach other (open building) principles such as thinking in levels, thinking in value domains and disentangling of technical systems are applied. Integral application of these concepts will increase both sustainability and consumer friendliness (mass customization).

All SUREURO participants from different countries will fill in the ExamplesBox. Thus a European state of the art view of sustainable and consumer oriented refurbishment examples is created. This results in an effective exchange of ideas and possibly a stimulation of European wide product development. The same idea can be elaborated in other sectors of the building industry such as offices. Also extension of the ExamplesBox to other process phases is thinkable. Behind each concept detailed technical information and practical examples can be linked. Also the box can be completed with national design guidelines, for example the Dutch National package for sustainable building.

References:

[1] Dekker, K.H., 2001, ‘SUREURO: “Sustainable Refurbishment Europe”’, TNO Building and Construction Research, Delft, The Netherlands.

[2] http://www.sureuro.com

[3] Habraken, N.J., 1972, ‘Supports: an alternative to mass housing’, translated from the Dutch by B. Valkenburg, translation of ‘De dragers en de mensen’, 97 p., Praeger Publishers, New York.

[4] Habraken, N.J., et al., 1981, ‘The Grunsfeld Variations’, Massachusetts Institute of Technology.

[5] http://www.kcbs.nl

[6] Rutten, P.G.S., Trum, H.M.G.J., 2000, ‘On the innovation of buildings’, Technical University of Eindhoven, The Netherlands.

[7] Brand, G.J.W. van den, Quanjel, E.M.C.J., Zeiler, W., 2001, ‘Sustainable flexible process innovation. Practical implementation of a new building design approach’.

[8] Moughtin, C., et al., 1999, ‘Urban Design, methods and techniques’, ISBN 0 7506 4102 9, p. 8.

1 Project manager building process innovation, TNO Building and Construction Research, Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands, P 0031152695283, FAX 0031152695335, G.vandenBrand@bouw.tno.nl

2 Researcher building process innovation, TNO Building and Construction Research, Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands, P 0031152695291, FAX 0031152695335, M.Dekker@bouw.tno.nl

3 Principal advisor building and infrastructure, TNO Building and Construction Research, Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands, P 0031152695225, FAX 0031152695335, K.Dekker@bouw.tno.nl

Sustainable flexible process innovation

Practical implementation of a new building design approach

Geert-Jan van den Brand
Project manager building process innovation, TNO Building and Construction Research,
Schoemakerstraat 97, P.O. Box 49, 2600 AA Delft, The Netherlands,
P 0031152695283, FAX 0031152695335, G.vandenBrand@bouw.tno.nl.

Emile Quanjel
Project-leader research, TU Delft, Faculty of Architecture, OBOM, Architect,
De Vries van Heystplantsoen 2, P.O. Box 5043, 2600 SA Delft, The Netherlands,
P 0031152785400, FAX 0031152788295, e.quanjel@hetnet.nl.

Wim Zeiler
Researcher, TU Delft, Faculty of Architecture, Building Services, Kropman mechanical & electrical contractor,
Verrijn Stuartlaan 36, 2288 EL Rijswijk, The Netherlands,
P0031703401401, FAX 0031703999351, W.Zeiler@ry.kropman.nl.

Sustainable flexible process innovation

Practical implementation of a new building design approach

ABSTRACT

Developers and investors of residential and office buildings are facing large risks. A yearly loss of capital of approximately 50 billion EURO can be reduced by improvement of the design process. The need for more sustainable and end user oriented buildings on a background of the dynamics of ever changing needs is indisputable. This paper gives an outline of a project paying attention to the design process. The project is called 'Duflexpronovatie', which is a Dutch acronym for 'Sustainable Flexible Process Innovation'. The project, situated at Leidsche Rijn Utrecht, became a nominated project in 2000 in the long-term experimental program 'Industrial, Flexible and Demountable Building' initiated by the Dutch Department of Economic Affairs and the Department of Housing. The project demonstrates an alternative arrangement of the design process based on Rutten's outline of the Strategic Design process. Main steps of the process are: strategic briefing, total building concept and detailed design. Important design principles are: thinking in levels, fixed and flexible, thinking in value domains, thinking in concepts, interdisciplinary design and disentangling technical systems. These principles are explained and demonstrated by practical examples. Application of the Strategic Design framework and principles results into better-balanced building concepts. The integral approach on the several abstract-, scale- and building-levels is shown as necessary to close the gap between HVAC-consultants and building designers/architects in order to create consciousness about the several different aspects by the different participants during the process. Further practical application of the framework and design principles is necessary to improve this theory. Therefore it is necessary to involve more building professionals in the near future.

KEY WORDS

strategic briefing, integral design, open building, risk management

Sustainable flexible process innovation

Practical implementation of a new building design approach

Geert-Jan van den Brand, Emile Quanjel, Wim Zeiler

Managing risks by process innovation

Developers and investors of residential and office buildings are facing large risks. Annual EU construction turnover amounts 650 billion EURO. The investment in renewal and maintenance exceeds new construction. The construction industry has an unacceptably high failure cost rate of 5-10% of the total investment. This means a yearly loss of capital of approximately 50 billion EURO. This loss can be significantly reduced by improvement of the development and design process. In many building projects budgets are overrun. Early stage budgetary savings are executed to prevent this problem but this mostly results in recurring problems in the construction or exploitation phase.

Building parties are interested in innovation of products and process in order to lower their risks. Attention for life cycle management approach in building construction industry is growing. Innovations with higher initial costs are supported by life cycle cost calculations. New contract forms using performance specifications, integrating design and build activities also aim to reduce failure costs and improve construction output: buildings with a higher (future) value.

Industrial Flexible Demountable building

The need for more sustainable and end user oriented buildings on a background of the dynamics of ever changing needs is indisputable. House owners and tenants demand more attention for their individual needs. In working environments the attention for labour conditions result in increasing demands of employees. Fast changing market conditions ask for other working environments, therefore offices and production facilities must be better ‘designed for change’: *Flexible building*. At the same time the realisation of these buildings needs to take place in better climatic conditions. Construction work has to be more labour friendly. Construction labourers are scarce and building site conditions lead to a lower building quality: *Industrial Building*. There is a general awareness of materials and energy being scarce. Building material and components becoming obsolete should be easily be replaced and re-used: *Demountable Building*.

‘Industrial, Flexible and Demountable Building’ is the title of a Dutch experimental program to stimulate innovation in the building construction industry [1][2][3]. In this program, building principals are given financial support in order to apply innovative products and processes in practical projects. In turn they share their experiences and demonstrate their results to other building professionals. Most of the current projects focus on product innovation resulting in higher flexibility. Only a few projects focus on improving the design and construction process. This paper gives an outline of an IFD demonstration project paying attention to the design process: Duflexpronovatie.

Duflexpronovatie

Duflexpronovatie is a Dutch acronym for 'Sustainable Flexible Process Innovation'. Duflexpronovatie represents an alternative design process approach. Focus is on the alternative organisation of the design process to stimulate co-operation and creativity. The results are a better-balanced building concept and incentives for product innovation in the building construction industry. Duflexpronovatie project partners are Kropman B.V., Emile Quanjel Architect and TNO Building and Construction Research. Also the Technical University of Eindhoven (TU/e) is involved. From January 2001 TNO and TU/e jointly execute research and development in the knowledge centre 'Buildings and Systems' [10]. One of the research themes is called 'Strategic Design and IFD Building'.

This paper shows an alternative arrangement of the design process that offers direct opportunities for design and building partners. It results in buildings with higher future value, while developed with lower risks. Also exploitation risks of the building will decrease. There will be a better interaction between principal and design team. Collaboration between design team members and optimal use of the individual expertise is guaranteed. The alternative arrangement creates optimal process conditions for IFD Building.

Strategic Design framework

Duflexpronovatie is based on Rutten's outline of the Strategic Design process [4]. The alternative design process consists of the following main steps. For each step some main design principles are shortly described:

1. Strategic briefing:

Before generating solutions the principal's needs must be globally defined. This activity is considered a part of the design process.
Thinking in levels creates a clear distinction of decision levels. Each level comprises its own stakeholders with whom a separate design process can be executed. Thinking in value dxÔains supports the definition of strategic performance requirements of the building (Figure 1). In this phase the strategic needs of the end user are defined and a framework for balancing performance demand and supply is created.

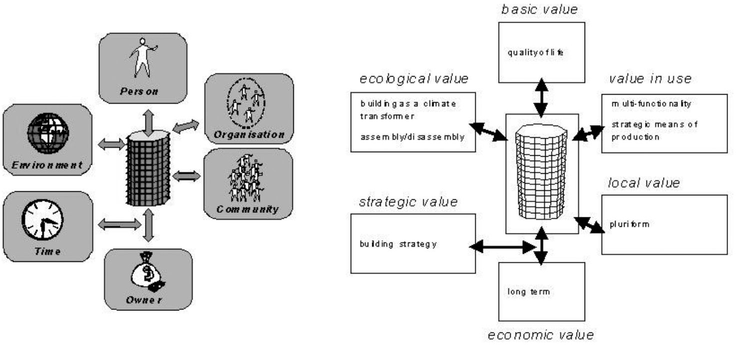


Figure 1 Value domains: stakeholders and driving forces [Source: P.G.S. Rutten]

2. Total concept:

Using the result of the first step the design team can continue the work. The team co-operation is based on *Collaborative Engineering*. For several building systems - structure, shell (envelope), services, space, 'stuff' (fit-out) - several alternative concepts are generated. Using creativity techniques, such as analogies, metaphors and Eduardo de Bono's lateral thinking, experts learn to approach the design problem from different angles. In this phase the understanding of the real design problem is still growing. These alternative concepts are discussed in the design team. In the last step concepts are combined in a *total building concept*, which is the starting point for detailed design.

3. Detailed design:

The total building concept will be elaborated more in detail. Major changes in design are not possible anymore. If the thinking in levels is worked out well there still is some flexibility between and within the different building systems. Using state of the art visualisation, simulation and communication tools the building concept can be worked out 'concurrent' by several parties.

Figure 2 represents the arrangement of the Strategic Design process. The triangle is the growing brief.

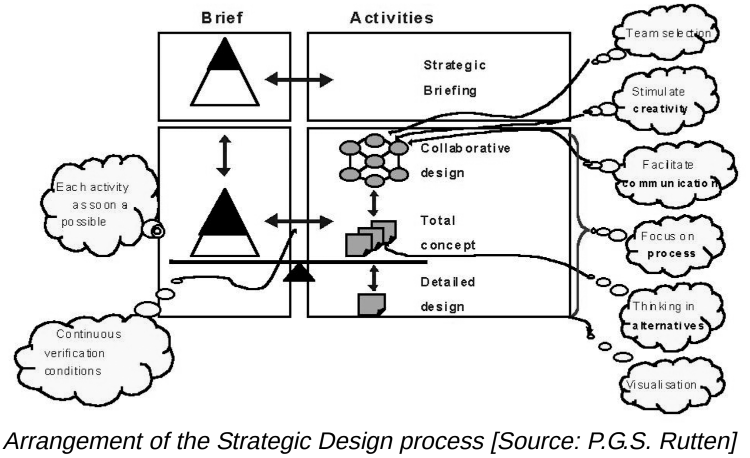


Figure 2 Arrangement of the Strategic Design process [Source: P.G.S. Rutten]

Application of strategic principles

To gain insight in the practical implications of the above mentioned design principles a practical project is executed. In the IFD demonstration project Duflexpronovatie the integral project approach in relation to the principles is demonstrated. The integral approach on the several decision and territorial levels is shown as necessary to close the gap between HVAC-consultants, building designers/architects and other building professionals in order to create consciousness about the several different aspects by the different participants during the process.

Thinking in levels

Thinking in levels is the basic Open Building principle [5]. Defined decision levels are: tissue, support and infill. On each level a separate design process with the associated stakeholders can take place. This principle is applicable in both residential and office building and even in infrastructure works. For (rented) residential apartment buildings a housing corporation is stakeholder for the support parts, while an individual or family will be leading in the design of the infill ('boss behind their own front door').

Fixed and flexible

Directly related to the Open Building principle 'Thinking in levels', 'fixed and flexible' is a recurring principle. Speaking of different design processes on different levels implies independence between these levels. Most of the time there is a hierarchic relation: the higher level 'dominates' the lower. Ideally on the higher level minimum provisions are taken (fixed) and maximum freedom is left for elaboration on the lower level. For example the support of an apartment building only consists of the structure and shell parts, while service ducts are not yet brought into the dwelling, leaving optimal freedom of arrangement of each individual dwelling (fit-out).

> The Duflexpronovatie design team applied the principles dividing the building between structure and shell ('cupboard') and storeys ('drawers') (Figure 3). At the occurrence of changing needs, the drawers can be easily changed without affecting the higher level. Spatial configuration, lay out and the relation to the built environment are determined, while floor arrangement can be adapted easily.

Thinking in Value Domains

Traditionally starting from the brief a design team will develop solutions for assumed housing needs. In stead of rushing to technical solutions however the need of the end user must be investigated more thoroughly. A framework for definition, gathering, structuring and prioritising of housing needs is brought up by 'Value Domains'. In this framework the needs of each party involved in the design are taken into account. Different needs and different points of view are brought together to create common goals for the specific project or at least setting different points of view in the right perspective.

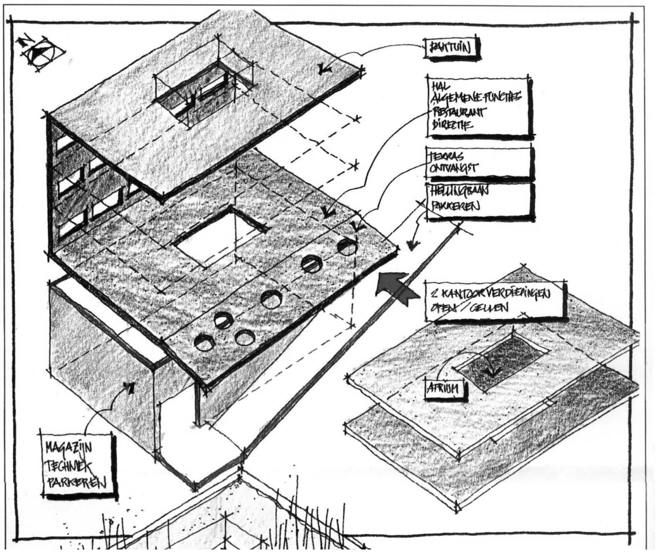


Figure 3 Duflexpronovatie, ‘Cupboard and drawers’ [Source: E.M.C.J. Quanjel]

In order to gain insight in the strategic performance criteria for the development of a new research office building for Océ-Technologies B.V. in Venlo, The Netherlands, the assigned design team applied the value domains theory. In stead of composing a detailed brief a basic set of requirements is formulated. Several concepts for building systems are developed and evaluated to this set. Along the process the set of requirements is extended as a result of progressing insight. Figure 2 demonstrates this as the triangle representing the brief as a growing document.

Thinking in concepts

As already stated Strategic Design proposes to work with concepts. But what are concepts? According to Bax and Trum ‘a concept mediates between a notion, ... and an image’ [6]. Concepts intermediate between the words in the brief and the images and examples in the minds of the designer and principal. Another paper in this congress ‘Restructuring Design’ [7] deals with this issue, demonstrating a design tool containing concepts for the refurbishment of residential areas. In stead of elaborating an entire building design and integrating all solutions in detail Strategic Design suggests to reserve more space for generating and evaluating different alternatives on a global level. Concepts for load bearing systems are combined with different concepts for heating and ventilation systems. This phase is also used to gain more insight in the real design problem. The brief can be continuously adapted and extended. After this phase the best set of concepts is integrated in a total concept for the building. In this approach more room for interaction between different disciplines is left.

In the IFD experimental project ‘Duflexpronovatie’ concepts for façade, roof and energy use are developed and evaluated. Several students were involved in this project as well as the Engineering platform of the principal company Kropman B.V. For the evaluation and selection of concepts the systematic methods of ‘Kesselring’ is applied [8].

Interdisciplinary design

The Strategic Design-approach directs extra attention to collaboration and communication. The result is less design rework and better-attuned building systems. Due to increasing complexity of buildings and the accompanying process for different building systems different designers and experts are involved. They have to interact in order to gain the best design results. Collaborative engineering is a key condition for strategic design. This approach forces designers and experts not only to bring in their specific knowledge, but also tuning in on the principal’s needs.

A vital ingredient for collaborative design is the use of creative techniques in order to generate good ideas and alternatives. Using analogy (nature, art or other), metaphor and De Bono’s lateral thinking [9] are still little known but useful for building design teams. Several researchers, for example within the Knowledge Centre ‘Buildings and Systems’ [10], explore the adaptability of these techniques. Visualisation and simulation can support the subsequent decision making process. Another aspect of collaborative engineering is utilised in the last step of strategic design, the detail design. Once the building concept is determined different teams can work concurrently on the elaboration of the building design using state of the art information and communication techniques [11].

Disentangling technical systems

A building is composed of several technical systems with each a different (technical and functional) life span. Stewart Brand distinguishes the systems: structure, shell, services, space and ‘stuff’. This distinction is based on the functional and technical life cycle of these systems. Disentangling of building systems advances flexibility of a building. The need for flexibility will be different in every project [12].

The ‘Duflexpronovatie’ project pursued an integral approach in the development of building and services. Intense collaboration between principal, architect and structural engineer resulted in the development of an innovative flexible construction and installation concept. The design concept provides disentangling of structure, shell and service. The structure consists of double wooden beams, inbetween space for service ducts is reserved (Figure 4).

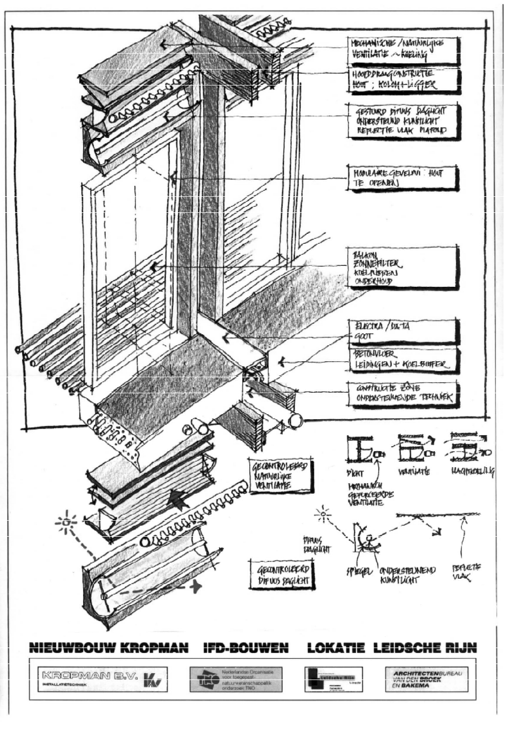


Figure 4 Duflexpronovatie, disentangling building (sub)systems [Source: E.M.C.J. Quanjel]

Conclusions and further development

Application of the Strategic Design framework and principles dealt with in this paper results into better-balanced building concepts. Interaction between different disciplines within the new organisational context is more effective. The new approach makes way for the application of state of the art visualisation and simulation techniques as well as communication tools. It also creates spin off towards project independent product development. The application will only be effective if applied integrally in the entire project.

The theoretical organisational framework for a strategic design process is worked out. Further practical application of the framework and design principles is necessary to improve this theory. Therefore it is necessary to involve building professionals in the near future. Researchers will develop design tools and design games to support building professionals in understanding and adopting the various design principles.

Many parties support the development of strategic design. In the Netherlands TNO and the Technical University of Eindhoven defined the research theme Strategic Design and IFD in the knowledge centre Buildings and Systems. An initiative at TU DELFT, TVVL and BNA called 'Integral design' is executed. For the IFD program a workshop 'Strategic Design' will be organised to involve more building professionals. The international CIB W104 workgroup Open Building Implementation can be involved for broadening the international context. At the same time fundamental research for the improvement of the theories will continue.

References

[1] Groenendijk, P., Vollaard, P., Vos, H., 2000, 'Demonstratieprojecten IFD-bouwen 1999. Zien is geloven', ISBN 90-5239-158-0, Stuurgroep Experimenten Volkshuisvesting (SEV), Rotterdam, The Netherlands.

[2] Stuurgroep Experimenten Volkshuisvesting (SEV), 2001, 'Demonstratieprojecten IFD-bouwen 2000. Een omslag in bouwen, een omslag in denken', ISBN 90-5239-171-8, Rotterdam, The Netherlands.

[3] www.sev.nl/ifd

[4] Rutten, P.G.S., Trum, H.M.G.J., 2000, 'On the innovation of buildings', Technical University Eindhoven, The Netherlands.

[5] Habraken, N.J., 1961, 'De dragers en de mensen', Haarlem, The Netherlands.

[6] Bax, M.F.Th., Trum, H.M.G.J., 1993, 'A Taxonomy of concepts in Architecture: A new tool for analysis and synthesis in architectural design processes according to Domain Theory', published in: Behesthi, M.R., Zreik, K. (eds.), 'Advanced Technologies', Proc. Fourth European International Conference on the application of Artificial Intelligence, Robotics and Image Processing to Architecture, Building Engineering, Urban Design and Urban Planning, Elsevier, Amsterdam, The Netherlands, p. 53-64.

[7] Brand, G.J.W. van den, Dekker, M., Dekker, K.H., 2001, 'Restructuring Design. The ExamplesBox, a design decision support tool for sustainable and tenant oriented restructuring of existing residential urban areas', TNO Building and Construction Research, Delft, The Netherlands.

[8] Godschalk, M., 1999, 'Gevelsystemen. Onderzoek en aanbevelingen', Technische Hogeschool Rijswijk.

[9] http://www.sixhats.com

[10] http://www.kcbs.nl

[11] Schevers, H., Rijswijk, R. van, Böhms, M., 2001, 'Product data technology as basis for a concept modeling tool', published in: 'PDT Days 2001 Proceedings', ISBN 1 901782 05 0.

[12] Brand, G.J.W. van den, Vos, H., 2000, 'Uitgangspunten van IFD Bouwen', article in: Bouwwereld, no. 22.

Building Deconstruction

Demountable building connections, a key to sustainable construction

Elma Durmisevic, Jan Brouwer
Delft University of Technology/OBOM
De Vries van Heystplantsoen 2, 2628 RZ Delft
The Netherlands
Phone: +31.15.278 5400; Fax: +31.15.278 8295
E-mail: E.Durmiseic@bk.tudelft.nl

Building Deconstruction

Demountable building connections, a key to sustainable construction

ABSTRACT

Having in mind hyper development of market economy and new technologies there can be no doubt that society is passing through the period of great shifts and that the predictions are not in favour of short-term solutions. Observers of current and future trends predict that the nature of working and living will change so drastically, and the scope expends so greatly that we will soon be faced with completely new building structures. Richard Rogers stated few years ago: Present-day concerns for static objects will be replaced by concern for relationships. Shelters will no longer be static objects but dynamic objects sheltering and enhancing human events. Accommodation will be responsive, ever changing and ever adjusting.

Besides social, political and economic shifts which are altering the way our built environment is shaped, we have witnessed in the last decades high demand for improved environmental efficiency of buildings as well.

Consequently the main question of sustainable construction is how to find the balance between consumer-oriented society, and the key principles of environmental ecology such as to: conceive natural resources, save energy, reduce waste etc.

To be able to understand and approach these significant issues, it is necessary to change our perception concerning the building, its technical composition and its life cycle.

One way to approach this problem is through the adoption of the design strategy that will support dynamic behaviour of buildings on spatial, structural and material level.

Essential component of such dynamic building structure is deconstruction with associated disassembly which seeks to maintain the highest possible value for the materials in existing buildings by dismantling buildings in a manner that will allow reuse or efficient recycling of the materials that comprises the building structures.

Ultimately this means that the buildings should be designed according to the criteria that will provide easy changes relaying strongly on the manner in which the building is assembled. This articulates the concern for assembly which determinants the interface between building components. The overall geometrical and functional relationship between independent assemblies assumes primary importance in design of adaptable building structures.

This paper will discuss design characteristics of interfaces within such dynamic structures. Further to this the focus of the discussion will be on the challenges and potential of the new design approach.

Building Deconstruction

Demountable building connections, a key to sustainable construction

Elma Durmisevic, Jan Brouwer

Deconstruction- the driving force for sustainable construction

Today's worlds greatest concern regarding built environment is how to design sustainable in a seance of: increasing spatial flexibility, extending the life span of building components and promoting the recycling of building materials and products. Accordingly the main aim of the construction industry is to contribute towards global sustainability by using energy saving processes, reducing the use of natural resources and reducing the waste production.
However buildings frequently undergo adaptations due to the degradation of more technology dependent components and frequent changes of the user's requirements.
Herewith one of crucial problems of today's building construction is that building products are usually brought together in a manner, which creates high level of dependence within building structure. Consequently every change within the building is related to the demolition of part of the building or whole building structure.
That means that most of the modern building structures today using pre-manufactured elements are designed to be mountable but not de-mountable.

While assembly may be seen today a complex sequence of connecting carefully designed components and materials, a process that may involve thousands of people and fleets of machines, disassembly, in the building industry usually involves a few bulldozers or a fist full of explosive. (Crowther99)
Ultimately the inability to remove and exchange building systems and their components results not only in significant energy inputs and large quantities of waste but into luck of spatial adaptability, and technical serviceability of the building as well.
Therefor the key issue of the sustainability is in development of the design strategy that will transform the inflexible building structures into dynamic and flexible structures whose parts could be easily disassembled and later on reused or recycled.
Consequently the main reasons for such new approach to the building construction lays in market requirements and growing environmental consciousness

Market requirements

The growing disproportion between functional and technical life cycle of the building (figure 1 left) which is caused by dynamic social and economic developments can not be solved within the framework of conventional buildings practise.

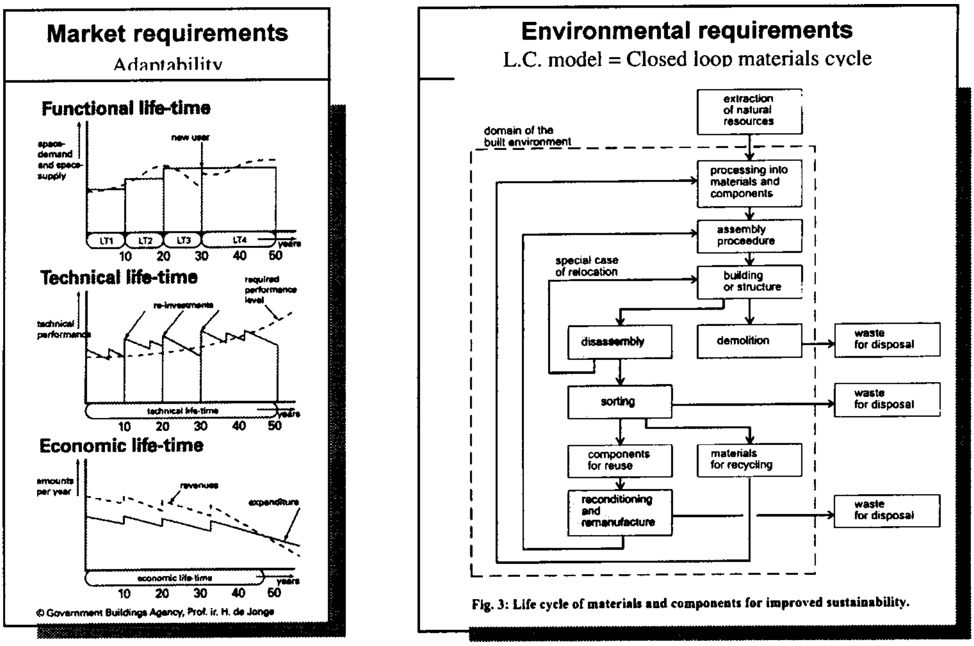


Figure 1: left- Functional, technical, economic life cycle (deJong99); right- circular system of materials and components use (Crowther99)

Generally speaking the economic duration of one phase in the use of the building is shorter than the technical life span of most of its components. Eventually the reduction of the technical life cycle is no option because this would be destruction of capital investment. That means that rather than destroying structures and systems while adopting the building to fit new requirements, it should be possible to disassemble sections back into components and to reassemble them in the new combination.

Environmental consciousness

The demolition of building structures produces enormous amounts of materials that in most countries results in a significant waste streams. In the U.S. demolition waste amounts to 92% of the total construction and demolition waste stream of 136 million tones annually. That is 125 million tones of demolition that is for the most part landfilled. (C.Kibert00)
In the Netherlands the construction and demolition waste amounts to 15 million tones per year. (Dorsthorst et al.)
Although buildings are frequently exposed to change most of them are still being built in a way that ignores the necessity for their adaptability in the future.
Eventually the changes of the built structures have negative impact on the environment which is expressed through the volumes of waste going to landfills and incineration, as well as through the energy, dust and noise which are related to the demolition activities.
Higher ecological efficiency could be achieved by prolonging the service life of the building and its components.

When considering the potential for closed loop materials cycle for the built environment it becomes clear that the main problem lays in dependent integration of components with different lifetime and functional expectances at connections. Therefore designers should design buildings for disassembly to facilitate the new steps in the life cycle and encourage the reuse and recycling of materials and components. (figure 1right)

Dimensions of deconstruction

Having in mind above mentioned the design of sustainable building runs the danger of being carried out on ad-hoc bases without disintegration aspects of building structure being an integral part of the design process. That means that we must consider how we can access and replace parts of existing building systems and components, and accordingly how we can design and integrate building systems and components in order to be able to replace them later on.

Therefore the improvement of buildings capacity to adapt to the new requirements and consequently extend the service life of the building structure and its systems can be seen as a key issue of sustainable development in the future.

The development of the design strategy, which would be focused on disassembly aspects of building structure, would steer the use of building materials in a manner that will allow their reuse or efficient recycling later on. This would drastically improve capacity of building structure to be transformed with minimal environmental stress.

If the act of demolition would be replaced by disassembly than the building would receive three extra dimensions being: spatial, structural and element /material transformation.

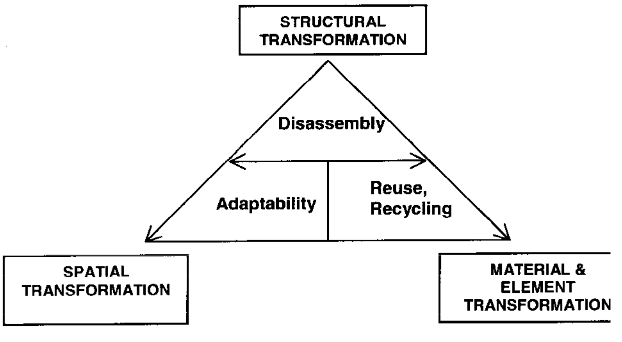


Figure 2: disassembly - the key for sustainable construction

i) *Spatial transformation* ensures continuity in the exploitation of the space through the spatial adaptability,
ii) *Structural transformation* which provides continuity in the exploitation of building components through recover and reuse of building components
iii) *Element and material transformation* providing continuity in the exploitation of the materials through the recycling of building materials.

In order to accomplish these scenarios, disassembly should take place on different levels within the building structure.

Levels of technical composition

The building structure is defined as hierarchical arrangement of elements and relations the building consist of. It represents the way parts are arranged in-group of parts (components) and the way group of parts are arranged in the whole building.
Traditional buildings were characterised by complex relational diagrams representing maximal integration of all building elements into one dependent structure.
The evolution of building structure represents the transformation from the complex relational diagram to the simplified relational diagram. The first step towards simplification of relational diagrams has to do with clustering of group of parts into independent subassemblies, which will act, independently in production and assembly/disassembly phase. One subassembly is a group of parts with a property that the parts in subassembly can be assembled independently of other parts of the building. These subassemblies exist on different levels within the building.
Elements are seen as the basic parts that form the lowest level of building subassembly, which is, called component level in this paper. In the same way that elements could be connected to form low-level sub-assembly (*component*), so this low-level assembly can be connected to form higher level assembly (*system*).

The requirements for disassembly result in the selection of construction strategies that utilize construction with independent, pre-made assemblies.

A decomposable building therefore does not necessarily exhibit one structure but hides in its structure of components and systems several different structuring principles that fit the building for construction, service and deconstruction.
Therefore the subassemblies of the building, their internal composition and the way in which they are built together to form higher-level assembly determine the behaviour of the total building structure. Having that in mind it is impossible to speak of unstructured building, but we can speak of weakly structured buildings which we may reason from the properties “difficult to assemble”, “difficult to repair”, “difficult to change” and finally “difficult to disassemble”.

Unlike the traditional building structure which is seen as hierarchy of elements the decomposable building structure can be seen as a hierarchy of subassemblies. It can be described at any level of abstraction: at the highest level (*building level*) as an overall assembly of systems, at intermediate level (*system level*) as composition of components and at the lowest level (*component level*) as assembly of elements/materials. (figure 3)

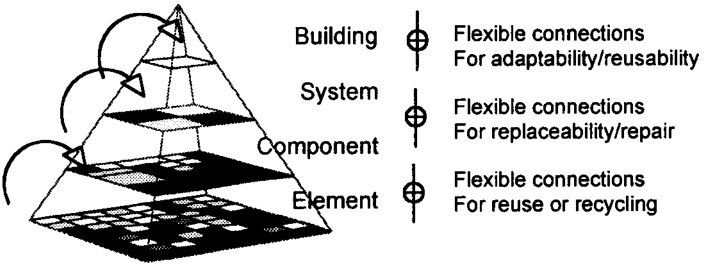


Figure 3: hierarchical composition of the building - hierarchy of subassemblies

The success of building decomposition will depend on level of decomposition of all structures within one building. As already mentioned decomposable building is a sum of structures which are captured in a form of building, system and components. Thus total disassembly D (total) is sum of the decomposition on the building, system and component level (Dbl, Dsl and Dcl)

D (total) = Dbl + Dsl + Dcl

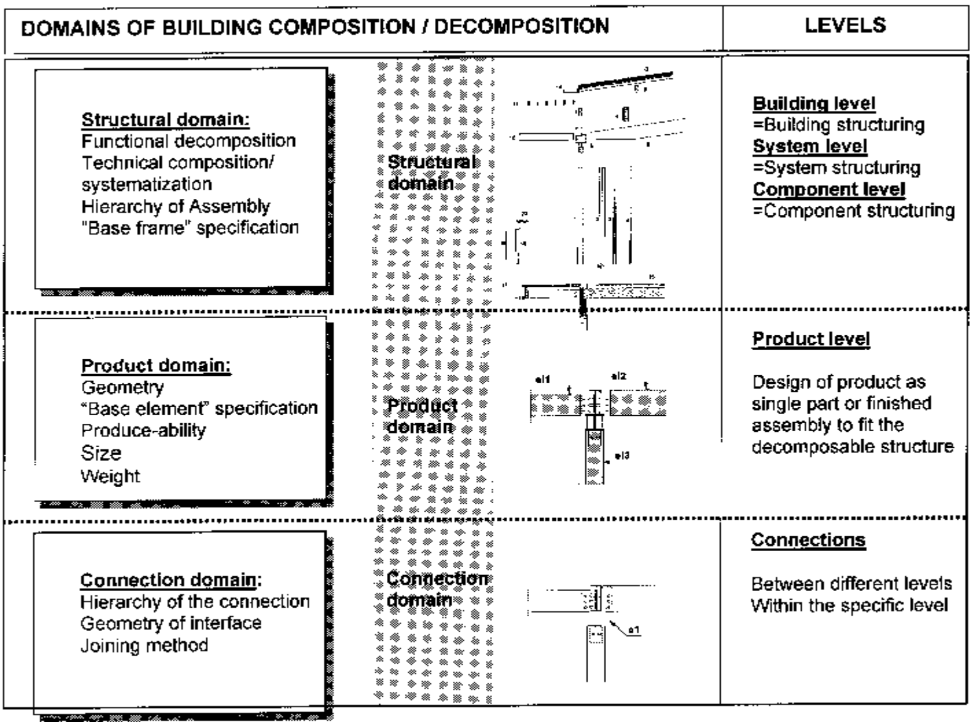
- Disassembly on building level deals with de-coupling of main building systems. The advantages herewith are reuse of systems, spatial adaptability and functional adaptability of the building.
- Disassembly on system level comprises of separation between components, which are arranged into a system. The advantages are reuse of components, adaptability of system's functionality.
- Disassembly on component level deals with separation between elements and materials and its main advantage is in adaptability of the component's functionality, reuse of the elements and recycling of the materials

Generally, it is possible to make distinction between fixed, partly decomposable and completely decomposable structures. The main difference is in the level of functional, technical and physical decomposition on each level of the building structure. For example one building function can be allocated through one independent building system. On the other hand the internal composition within the system, just as the physical relations between the components of the system could stop further disassembly. One example is composite façade panel, which can be dismantled from the main structure, but the further decomposition on system and component level is not possible. In this case the total decomposition is: D (total)= Dbl+ 0+ 0

Key aspects of building deconstruction

Two basic criteria of building deconstruction are independence and exchangeability of building products. In other words one building product can be dismantled if it is defined as an independence part of the building structure and if the interfaces with other parts are demountable. Independence of building products can be defined through the structural domain, while exchangeability can be optimized through product and connection domains.

When specifying these domains for disassembly, aspects such as separation of functions, separation between different materials, separation between elements with different life cycle, separation between consumer dependent and consumer independent elements have to be considered. These aspects depend on design decisions in each domain. Therefore three design domains can be distinguished, but they can not be separated. A proposed technical composition is only valid if a feasible product features can be defined, a proposed product features are valid if feasible connection features could be defined and so on.



DOMAINS OF BUILDING COMPOSITION / DECOMPOSITION		LEVELS
Structural domain: Functional decomposition Technical composition/ systematization Hierarchy of Assembly "Base frame" specification	Structural domain	**Building level** =Building structuring **System level** =System structuring **Component level** =Component structuring
Product domain: Geometry "Base element" specification Produce-ability Size Weight	Product domain	**Product level** Design of product as single part or finished assembly to fit the decomposable structure
Connection domain: Hierarchy of the connection Geometry of interface Joining method	Connection domain	**Connections** Between different levels Within the specific level

Table 1: domains of decomposition

Structural domain

The structure can be defined through the specific views on the elements and their relations which represent the hierarchy that elements form and their composition.

The main disassembly requirement upon structuring domain is to define a building structure as an arrangement of pre-made assemblies which are assembled in a systematic order that is suitable for maintenance and replaceability of single element.
Therefore the main structuring views, which are related to design for disassembly, are:

functional decomposition, technical composition, assembly hierarchy and specification of the base frame of the structure.
Complete mach between these views with above defined requirement exist if:

- The main building functions are separated. This means that more than one building function should not be integrated into one composite building component.
- (i)The technical composition is focused on specification of independent subassemblies following above-mentioned criteria's. (The decision have to be made on, which elements will be grouped to form an subassembly on different levels of the building in order to optimise the decomposition on each level.) The first step is to subdivide the building into independent sections and subsections which have different performances and different life cycle.
  (ii)The subassembly represents arrangement of elements with a property that the elements in subassembly can be assembled independently of other elements in the building.
  (iii)The frame subassembly is specified on each level so that subassemblies are physically connected only to the "frame". In this way the bought independence between subassemblies is provided as well as the integrity of the whole structure.
- Assembly hierarchy is in favour of parallel assembly. (Hierarchy defines the order within the structure, which is related to the transfer of the load through the structure. The load can be transferred directly from one element to another creating direct dependence and resulting into sequential assembly procedure. The independence between the two components could be achieved by taking the load-bearing function out of the components and allocating it to the third component. In this way the two components do not have dependent relation any more. This means that the parallel assembly can be applied.

Product domain
Product domain is focused on decomposition aspects, which are related to the single building element or finished assembly (component). These aspects are definition of the base part produce-ability, geometry, size, weight and type of the material or product.
The design team defines product subassembly based on required performance, production flexibility, system design and geometrical or mechanical criteria's.
The main decomposition requirement on product domain is related to the (i) design of product edge so that disassembly of the product is possible, (ii) use of pre-made components in place of half pre-made elements and row material, (iii) use of lightweight material and smaller size components. If the product is finished assembly than these aspects have to be integrated with all aspects from structuring domain. On the other hand geometry of product edge, type of the product and specification of the "base frame" within the product assembly influences the aspects of connection domain.

Connection domain
Connection domain is related to the specification of the type of the connection and jointing

method. These decisions will influence directly assembly sequences, serviceability hierarchy and physical separation between distinct elements, components and systems Therefore the specification of the connections has a dominant place in the whole concept of deconstruction.

The key aspects of interface within decomposable structure is its demountability Accordingly the technical aspects that play important role in connection design are:
- separation between the elements with different functions;
- separation between the elements with different life cycle;
- of separation between different types of materials;
- accessibility to building components with shorter life cycle

For that reason the main characteristics of decomposable connections are (i) use of accessory joint types (they require additional third part to form the joint between two components), (ii) application of parallel instead of sequential assembly/disassembly, (iii) use of mechanical connections in place of chemical connections. Such connections provide the precondition for independence and exchangeability of building components and accordingly their reuse or recycling, (IV) hierarchy of assembly which is related to the component service life and expected time till obsolescence.

These conditions should be applied accordingly on all levels in a building being: building level, system level and component level. In this way all systems which are brought together to form a building would be demountable; each component, which is brought to form a system, would be replaceable and each element and material, which is brought to form a product, would be reusable and recyclable.

The domains of decomposition being structuring, product and connection domains can be distinguished but not separated from each other since they have mutual dependence in decision-making process. If one of the domains are not optimised for disassembly than the whole structure which is presented on specific level is not decomposable. For example if structuring and connection domains are optimised for disassembly the disassembly can be stopped by inappropriate geometry of product edge which is part of product domain. On the other hand we can have pre-made component with carefully specified aspects in the product domain but if the connections with other components are not designed for disassembly than the disassembly of the whole component will again not be possible and so on. That is why the decomposition on every level within the building can be presented through the dependent function of three variables (Sd-structural decomposition; Pd-product decomposition; Cd- Connection decomposition. Decomposition function on one level is than:

$Dl = Sd \times Pd \times Cd$

Conclusions

As the problem of environmental degradation increases designers will come under increasing pressure to provide solutions to reduce energy and material consumption. Design for disassembly is one possible solution in which a building can be truly deconstructed in a reversal of construction sequences.

Main criteria for design for disassembly are:

- The building should be specified as the hierarchical composition of sub-assemblies. One subassembly is a group of elements with a property that the elements in the subassembly can be assembled independently from other elements of the product.
- More than one function should not be integrated into one composite building component
- Internal structure of the building component should be focused on specification of one "base frame" which will keep the integrity of the component and at the same time act as an intermediary between surrounding components (this should be the case on all building levels).
- The geometry of the component edge should be designed in a way that will provide parallel disassembly
- The connections between the two components should form accessory joining type which will keep one component independent from other during disassembly of one of the two.
- Mechanical connections should replace chemical connections at all levels
- Components with shorter life cycle and user related components should never be the first in the assembly process, unless clear scenario is developed for their replaceability.

Reference

(CC GIL 00): Sustainable building research group, The impact of the facilities/maintenance management on the long term sustainability of the built environment, performance indicators at post-construction stage of building life cycle, Conference proceedings SB2000, Maastricht 2000

(Mitchell 94): Artifact grammars and architectural invention; Automation Based Creative Design, 1994, Elsevier Science B.V.

(Crowther99): P.Crowther, Conference proceedings Proceedings of the 8th International Conference on Durability of Building Materials and Components, May 30 - June 3, Vancouver, Canada. Volume 3, Vancouver, Canada (1999)

(Kibert00): C.Kibert, Construction ecology and metabolism. Conference Proceedings "Integrated life cycle design" Helsinki 2000

(Durmisevic01): "From massive construction to decomposition of housing -a way to support further industrialization and customization of housing-" Conference Proceedings IAHS Slovenia, May 2001

(Dorsthorst et al.) Bart J.H.Dorsthorst et al. "From grave to cradle: reincarnation of building materials " Conference proceedings Sustainable building 2000, Maastricht 2000 The Netherlands

The success or failure of a building system

Assessing the success or failure of standard housing building systems by means of the SUFA score

Rob P. Geraedts

Associate professor of Project Management
Delft University of Technology, Faculty of Architecture
r.p.geraedts@bk.tudelft.nl

The success or failure of a building system

Assessing the success or failure of standard housing building systems by means of the SUFA score

SUMMARY

Research by the Department of Real Estate and Project Management of the Faculty of Architecture of the Delft University of Technology[1] has shown that there are ten important factors leading to the success of failure of a standard building system: competitive prices, flexibility, design, project or series size, local building practice, systematic development and evaluation, prototypes, marketing, obligatory use and internal property development. On the basis of these ten factors what is called the SU(cess)FA(ilure) score of a building system can be ascertained. This method can be used to compare different existing building systems; it can be also done graphically with the aid of a SUFA profile. The SUFA score is particularly useful for firms who need to test the feasibility of a new building system. In this way supply and demand can be effectively linked. Particular attention is given to one of the success or failure factors, namely the marketing of building systems, with four aspects being considered[2]: product policy, promotion policy, prices policy and distribution policy.

KEYWORDS: Open Building, Standard housing building system; SUFA score; Success factor; Failure factor; Cheap; Flexible; Prototype; Product development; Marketing; Policy.

The success or failure of a building system

Assessing the success or failure of standard housing building systems by means of the SUFA score

Rob P. Geraedts

Introduction

In the development of a new standard housing building system it appears that there is widespread uncertainty about how to achieve success in practice. This means that firms are exposed to considerable risks, as a short historical analysis will show. In the period from 1980 to 1996 a good half of the systems either used or newly developed in Holland either for complete dwellings or for infill systems have since disappeared from the market. The risk for firms can be kept within reasonable proportions if it is clear in advance which factors generally determine the success or failure of a building system. What factors should a firm take into account in developing a new building or infill system?

Success and failure

Success and failure are intimately related, and the same goes for the factors that determine success or failure. When a particular building system gets a very low score for a particular success factor this may mean that its chance of failure is quite high (see fig. 1). The reverse is also the case that the chance of success is very high when the chance of failure is small. This argument is applicable in every aspect where one can speak of a relation between success and failure.

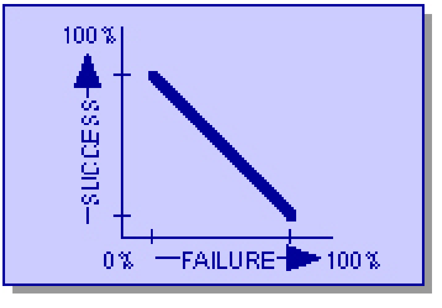
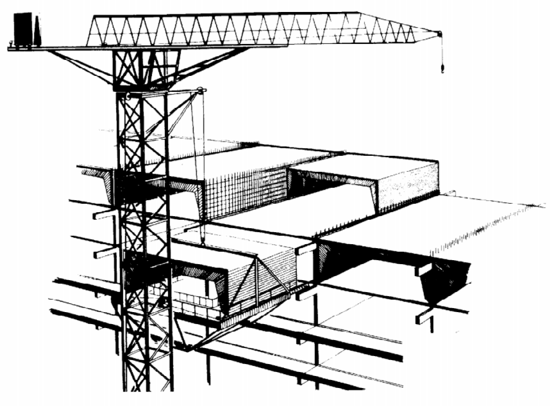
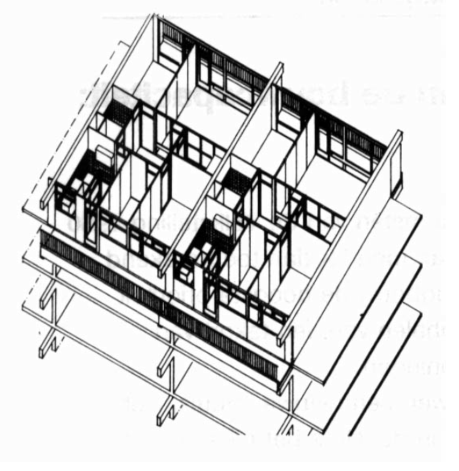


Fig. 1: The relation between the success and failure of a specific factor

Purpose

The most important purpose of the research was to get a better understanding of the reasons why the development and use of building systems of this sort is successful or not. The question was whether an instrument could be devised for comparing housing building systems and assessing them with a score for their success or failure chances. In this connection a standard housing building system is defined as follows: a method of building by which a systematic collection of products, materials and transactions results in either a building component or a complete building. It concerns building systems for both complete dwellings and for just the structural components or the infill components of a dwelling.





Method of research

The research consisted of a detailed look at 26 Dutch housing building systems[3] with the aid of a written enquiry and oral interviews. The basic principle of all the building systems is described, as is the reason why it was developed, the result, the technical description and above all the success and failure factors of the system. By presenting the success and failure factors of each building system together with the other systems in a single matrix, one obtains a total overview of all the relevant factors. The factors most frequently mentioned by the interviewees as decisive factors were then subject to further research.

Success and failure factors

What follows is a brief description of the ten most common and important factors that influence the eventual success or failure of a building system.

Price Competitiveness

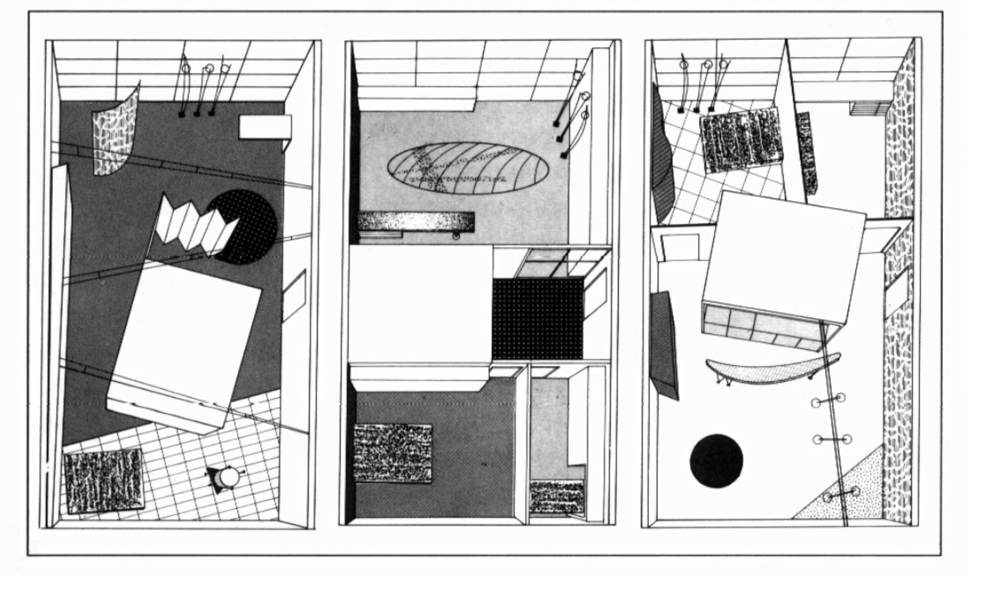
The most important success factor of a standard domestic building system is whether it is price competitive compared with other building systems or traditional building methods and products. Research has shown that in most cases people decide to go for the lowest offer. The costs of the end product usually form a more important decision factor than the quality - that may well remain the same.

Building time

A related success factor is the profit gained in the preparatory phase and the building time when the work is done faster and more efficiently. In general one can conclude that if a building system is offered that is not price competitive, the success of such a system is limited. The most successful housing building systems are mainly those that deliver the same quality at a cheaper rate than traditional projects, or better quality (for example a larger house) for the same costs.

Flexibility

Most standard building systems where there is little or no allowance made for any variation in facades or floor plans have eventually disappeared from the market. Given the demand for flexibility in the market both during development and afterwards when the product is used, building systems with a rigid appearance are not longer accepted by either clients or users. Successful building systems have to be flexible in order to fit in with the changing demands of the market. Some account must also be taken of the fact that creating flexibility is accompanied by cost-increasing factors. When this leads to an offer that is not price competitive (see aspect 1: Price competitive), then the means no longer conform to the end. This is certainly the case when it is unclear during the development period whether the potential for flexibility will actually be made use of in future. For many contractors or suppliers at present flexibility of infill systems in housing is still not a decisive success factor. This is due to the prevailing housing shortage. Demand exceeds supply and the need to provide a flexible infill system is therefore also less great. In a few years time a reversal of this situation is expected. In the housing sector the supply market will turn into one where demand dominates. That means that suppliers of homes will to an increasing extent have to take customers' wishes into account. Offers that are tailor-made for the consumer will mean that flexible building systems will become more and more necessary.



Design

The potential for project-linked alterations, particularly for the exteriors of houses appears to be an important success factor for building systems. Both from the point of view of planning requirements and that of the specific needs of the client such systems should be capable of producing an individual "architecture" per project. The absence of an industrial, factory-like or standard product appearance is of the utmost importance. The possibility of architectural variation is essential to the survival chances of a building system. The same goes to a lesser degree for the use of materials. From the consumer's point of view the materials and detailing of building systems should not be distinguishable from those of traditional products. With hardly any exceptions, those building systems that in the past presented themselves, as products of technological and industrial innovation have not survived.

Project and Series size

Many building systems of the 60s and 70s were developed in the certain knowledge that the average series size of housing developments would vary from 50 to 400. In most cases it was a case of large building sites in new development areas in urban neighbourhoods. During the 80s a change took place. A denser exploitation of urban areas became a basic policy aim. The result was the creation of a large number of small building sites within the city limits. The great number of small series of 5 to 30 homes formed a new success factor for the development of building systems. Building systems that couldn't adapt to the new situation went under. A successful building system was one that rejected the notion of a minimal cost-effective series size.

Local building practice

Complying with the national or regional building practice is a decisive factor in the success of a housing building system. Particularly important here is the use of materials and the accompanying detailing (see also point 3: Design). The materials used in Dutch housing building practice in 1997 are as follows: the structural walls are either of sand-lime bricks or concrete; the floors are generally concrete plate floors or poured concrete floors; the exterior facades consist of insulated cavity walls with a brickwork outer cavity leaf; interior walls consist of plaster blocks; walls and ceilings are finished with a spray. This choice of materials remains extremely important. A home should not look like an office. Materials and products with an industrial and technical image such as profiled steel sheets and sandwich panels cannot be used for the exterior wall cladding of homes. The same is true of a plastic facing instead of tiles in kitchens, bathrooms and toilets. Home dwellers will not put up with this.

Systematic development

A systematic approach and assessment of the projects development is an important factor for the successful application of a building system. This enables the preparatory phase of the projects to be made full use of, so that no steps are overlooked that might lead to cost-increasing alterations during the building phase; it also means that there is a control of the number of alterations in the design and that improvisation on the site is avoided. A systematic approach also implies an evaluation of the development process and the resulting product. This enables one to identify the hiatuses. Reduction of improvisation during the work on the site is primarily reinforced by building systems that involve prefabrication. The logistics of the execution is easier to control due to it not being dependent on weather conditions and because assemblers can be employed instead of expensive professionals.

Although the building time is much shorter, prefabrication has the disadvantage of a longer preparatory period in comparison with building blocks or on-site poured concrete.

Prototypes

For the eventual success of housing building systems it is highly recommended that a prototype, trial home or trial project be carried out. This ensures that imperfections are detected that are not apparent in the theoretical development stage. After the prototype is made, an evaluation takes place about whether the building system meets with the different aims and expectations. Through this method risks during the later stages of the process can be avoided.

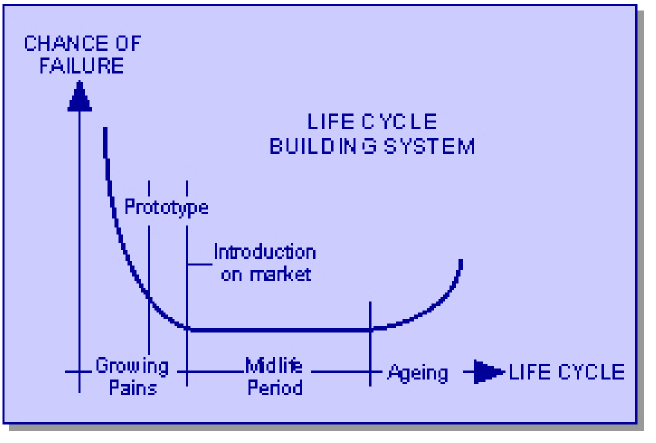


Fig. 4: The life cycle of a building system, the chance of success or failure and the place of the prototype

After a prototype a model dwelling is also an excellent means of persuading clients of the advantages of a building system. In figure 4 the average life cycle of a building is shown in relation to the chances of success and failure. The life cycle consists of three main phases: an initial development stage characterised by growing pains and ending with one or more prototypes and the introduction of the system on the market. During this period the chances of failure decline sharply. The second period can best be described as the effective life of the system. The chances of success or failure remain more or less the same. Finally at the end of the cycle a period begins the main features of which are symptoms of ageing and deterioration. The chances of failure then increase considerably.

Marketing

An important condition for the success of a building system is that there has to be a market for it, or else the demand has to be created. Market research usually shows who the potential clients will be and what their general and particular wishes and requirements are. Without market analysis the chance is great that supply and demand will not relate adequately to each other. Analysis[4] shows that new products and services are especially vulnerable when there has been insufficient market analysis (see figure 5).

CAUSE OF FAILURE	
1 Insufficient marketing analysis	45 %
2 Deficiency or failure of product	29 %
3 Lack of effective marketing	25 %
4 Higher costs than expected	19 %
5 Response by competitors	17 %
6 Bad timing of introduction	14%

Fig. 5: Main causes of the failure of new products or services (Hopkins) based on the percentage of answers given

With insufficient market analysis, the second main cause of failure is problems with the product, especially technical ones. In this connection too it is advisable to carry out a trial project in order to identify and eliminate imperfections. The basis for a balanced and effective marketing policy is formed by the following four factors: product policy, promotion policy, price policy and distribution policy (see figure 6).

MARKETING ASPECTS		
1 PRODUCT POLICY	Product Application	New buildings Renovation
	Product Types	Hire Buy
	Product Features	Flexibility Appliance Appearance
2 PROMOTION POLICY	Advertising Sales Promotions Public Relations Information	
3 PRICE POLICY	Price - quality ratio Price competitors Price objective	
4 DISTRIBUTION POLICY	Relation with/spread of retailers Logistics	

Fig. 6: The main marketing aspects for new building systems

Product policy

The policy for the product offered, namely the building system, should comply with the wishes and requirements of the consumer. The aim should be to achieve a high degree of flexibility, with system components produced in different styles or finishes and with a wide assortment of interchangeable products.

Price policy
Apart from the fact that prices should be related to those of other building systems on the market, the quality of the system should be at least as good as that of one's competitors.
Promotion policy
Promotion policy means in practice making different forms of publicity, maintaining public relations and supplying adequate information about the product and nurturing good relations with the different media. An important part of marketing policy is to recognise the right moment for making use of the different promotion instruments. The aim of promotional activities is to make the building system attractive to the consumer.
Distribution policy
Distribution policy has to do with the relation with and the spread of retailers and the logistics of actual distribution. It is important to come to a quick consensus with the retail trade and distributors so as to be able to offer the consumer a high-quality well-organised network.

Obligatory use
This success factor is mentioned mainly by the larger building contractors who have various regional branches or subsidiaries. It concerns the obligatory use of particular building systems in projects where one's own firms are involved. If this is not insisted on the chance is great that the internal market will be too small for any successful development. Supervision of possible adaptations is also of great importance. A great advantage of having an internal market for a building system is the potential for maximum improvement of both the process and the end products. Through a better mutual rapport and supervision it is possible to build in a more efficient, fast and cheap manner.

Internal project development
As mentioned in point 9 (Obligatory use), being able to supervise the development and realisation of one's own projects is a success factor for the development of a building system. In addition to the above-mentioned advantages, the firm is then able to exercise considerable supervision over any alterations and adaptations during the process of development. The result is an improved rapport between supply and demand, a more efficient process and more effective costs- management.

The SUFA score of a building system

Weighting success and failure factors

After this description of the most important success and failure factors, their mutual relation needs to be ascertained. A weighting factor indicates the degree of importance of the different success and failure factors with regard to each other. In order to come to a definitive assessment of the total success or total SUFA score of a building system, each factor has to be assessed separately in relation to the other factors. The chance of success is greater when one factor is present than another. That is why the different factors need to be weighted in relation to each other. To determine the SUFA score the following grades are assigned: 5=very high influence (on the success or failure of a building system), 4=high degree of influence, 3=moderate influence, 2=little influence, 1=very little influence (on the success or failure of building systems).

Scores dependent on weighting

In theory the users of the method just mentioned can apply the different weighting factors for their own ends. One should however bear in mind that the different minimum and maximum scores change and so does the order of diminishing importance of the different success factors. The currently presented values of the weighting factors are the result of interviews with the suppliers of the building systems concerned.

SUFA Score

After the ten most important factors for the success or failure of a building system have been ascertained in diminishing order of importance by means of the weighting factors in the manner described above, the total SUFA score can be determined. The SUFA score is the weighted total score of the different mutual success and failure factors. To arrive at a SUFA score it is first necessary to establish assessment norms for the different factors. During research the following assessment norms or ratings were established: 5=very good, 4=good, 3=moderate, 2=hardly adequate, 1=poor. With the aid of these ratings a total SUFA score for the building system in question can be determined (see figure 7).

ASSESSMENT OF SUFA SCORE			
SUCCESS FAILURE FACTORS	RATING 1 - 5	DEFAULT WEIGHTING 1 - 5	SUBTOTAL SCORE
1 Price competitive	2	5	10
2 Flexibilty	4	5	20
3 Design	1	5	5
4 Project size	3	4	12
5 Building culture	5	4	20
6 Systematic development	5	4	20
7 Prototypes	4	4	16
8 Marketing	2	3	6
9 Obligatory use	3	3	9
10 Internal project development	5	3	15
		TOTAL SUFA SCORE:	133

Fig. 7: An example of an assessment of the SUFA score for a building system on the basis of a rating per aspect, weighting factors and a total score (133); the ten factors are placed under each other in diminishing order of importance.

In figure 7 a fictitious example is given for assessing the SUFA score of a particular building component. The different success and failure factors have been already described above. The result is a weighted SUFA score of 133. What does this score mean in practice however? To decide the maximum and minimum scores need to be determined. These limits or minimum or maximum attainable scores are assessed as follows (see figure 8).

MINIMUM AND MAXIMUM SUFA SCORES					
SUCCESS FAILURE FACTORS	MINIMUM RATING	MAXIMUM RATING	DEFAULT WEIGHTING 1 - 5	SUBTOTAL MINIMUM SCORE	SUBTOTAL MAXIMUM SCORE
1 Price competitive	1	5	5	5	25
2 Flexibilty	1	5	5	5	25
3 Design	1	5	5	5	25
4 Project size	1	5	4	4	20
5 Building culture	1	5	4	4	20
6 Systematic development	1	5	4	4	20
7 Prototypes	1	5	4	4	20
8 Marketing	1	5	3	3	15
9 Obligatory use	1	5	3	3	15
10 Internal project development	1	5	3	3	15
MINIMUM AND MAXIMUM SUFA SCORE:				40	190

Fig. 8: The minimum or maximum attainable scores arrived at on the basis of 10 different success and failure factors

In figure 8 the 10 success determining factors, their individual minimum (1) and maximum (5) ratings, the default weighting factor (varying from 5 to 3), the weighted minimum and maximum scores per factor and finally the total weighted minimum (40) and maximum (190) SUFA score are given respectively.

SUFA Classes

In the same way as we did for the different underlying success factors, we can now present the total SUFA class for the building systems concerned (see figure 9). This consists of the weighted score that falls within a certain range. The table below shows the five SUFA classes with their score ranges. They vary from Class 1=Not successful, with a score between 40 and 70 to Class 5=Highly successful, with a score between 160 and 190.

SUFA CLASS TABLE WITH SCORES	
CLASS 1, Not successful	40 - 69
CLASS 2, Hardly successful	70 - 99
CLASS 3, Fairly successful	100 - 129
CLASS 4, Successful	130 - 159
CLASS 5, Highly successful	160 - 190

Fig. 9: Table with the score range of the 5 different SUFA classes

SUFA Profiles

One can use these SUFA classes to arrive at an immediate assessment of a building system and to compare different building systems. We are still not clear however what the reasons are for success or failure. With one system it may lie in the degree of flexibility in the facades or floor plans of the homes, in the other it may have to do with good marketing. In order to display this at a glance a so-called SUFA profile can be used (see figure 10).

An example

The upper diagram in the SUFA profile in figure 10 shows the scores of the different success and failure factors. Score 5 is the minimum and score 20 the maximum. The lower diagram of figure 10 shows the total weighted SUFA score with the pertaining SUFA class. In the example shown here the score is 133. The corresponding SUFA class is 4 (the building system is successful). In this way different building systems can also be effectively compared with each other graphically. The reasons for the success factors of one building system may for instance be found in the profile, with more emphasis on the success factors 1 to 5; with another building system they may be found in the lower regions in factors 5 to 10.

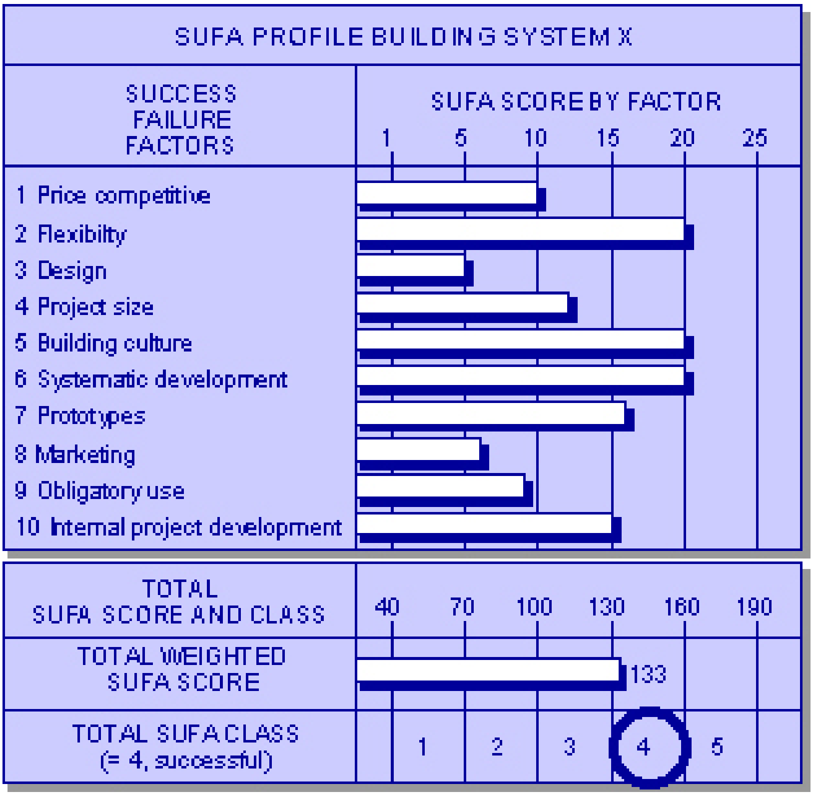


Fig. 10: An example of a SUFA profile of a building system; the diagram above shows the scores of the different success and failure factors; the diagram underneath shows the total weighted score and the class pertaining to it

Conclusions and recommendations

There are 10 important factors involved in the success or failure of a standard housing building system. On the basis of these factors the SU(cess)FA(ilure) score and the SUFA class of a building system can be determined. Various existing building systems can in this way be compared, also graphically, with the aid of the so-called SUFA profile. With the aid of the SUFA score a firm that wants to develop a new building system can ascertain what risks are involved in its development and what factors are important in order to ensure that the new building system will be a success. The assessment of the different success and failure factors is of course very much related to the individual or firm involved. In this research a default value is given for the mutual weighting of the ten most important factors. In theory users of the method described can apply the different weighting factors for their own ends. The values of the weighting factors presented here are the result of interviews with the suppliers of the building systems concerned. The actual criteria used for these norms and ratings are at present only arrived at empirically. Further research is necessary to give them a more solid scientific basis.

Another important success factor that was not considered in this research project concerns the human factor[5]. It concerns the owner of an enterprise, a person or project manager who is looking ahead to the future, capable of translating changes in new chances and convinced of the success of his own project. A person who is not afraid to change a project during development when new information is coming in. Such a dynamic person is of great importance for the success of failure of a building system.

References

1 Lok J., Succes- en faalfactoren van standaard woningbouwsystemen, afstudeerrapport, BMVB, end exam report 1996.

2 Kleuver H., Marketing van inbouwsystemen, BMVB, end exam report 1996.

3 The following 26 housing building systems have been researched: MAX-60 (De Meeuw), Kombifort 2000 (Fort Bouw), Kroonwoning (Sanders), Pre Choice System (DURA), Geelen Variant Systeem (Geelen Bouw), Flexi Moduul (Grootel), Meerkeuzewoning (Intervam), Zie-zo woning (Koopmans), Petit Prix (Nijhuis), EnergieZuinige woning (Sanders), Spaarhuis (Slokker), Woonplan 2000 (Slokker), Trendwoning (Trebbe), Facet-Garantwoning (Van Wijnen), Basiswoning (Wilma), Casco-systeem (Elementum), Bouwsysteem (Heembeton), ISB-project (TUE), Droogstapelbouwsysteem (Tatsta), MAGU (Vertical HO), Inbouwpakket (Bruynzeel), Interlevel (Prowon), 2DEE- Inbouwsysteem (Nijhuis), Matura Inbouwsysteem, Espritwoning (Van Dijk/Eger), Unitwoning (Archipel Ontwerpers).

4 Hopkins D., New Product Pressures, The Conference Board Record, 1971.

5 SBR, Product Development, Stichting Bouwresearch.

Project Flexible Breakthrough: Methodology and Design

Nico A. Hendriks
professor in Building Materials and Sustainable Construction
Eindhoven University of Technology

Haico van Nunen
PhD student
Eindhoven University of Technology

Paul G.S. Rutten
professor in the Design of the Interior Climate
Eindhoven University of Technology

Project Flexible Breakthrough: Methodology and Design

ABSTRACT

In the Netherlands housing corporations hold 1,3 million houses, of which almost 600.000 are realised in buildings with three- and four-room apartments in the low cost renting sector. They were built between 1945 and 1975. The market position of these houses has been deteriorating substantially, although they are located in very pleasant quarters of the large and medium-sized cities. After renovation the houses remain too small, poorly equipped and noisy. For this reason a research program was started. The objective of this program is to - more or less - reconstruct the apartment buildings, at the same time using, as much as possible, IFD-technology. IFD stands for: Industrial, Flexible and Demountable. This resulted in the concept 'Flexible Breakthrough'. The basic principle of the project is to completely remove (demolish) one of the four bearing walls in each apartment and replace this wall by a steel supporting frame. The resulting much larger space is to be redesigned with IFD-technology.

The paper describes the systematic methodology to analyse the possible solutions and the design of the Flexible Breakthrough concept. This concept provides maximal industrialisation, flexibility and demountability within the given constraint of remaining the major part of the existing apartment building.

KEY WORDS

IFD-technology, apartments, existing buildings, partial demolition

Project Flexible Breakthrough: Methodology and Design

Nico A. Hendriks, Haico van Nunen, Paul G.S. Rutten

Introduction

Between 1945 and 1975 more than 2,5 million houses have been built in the Netherlands. Housing corporations hold 1,3 million of these, with almost 600.000 realised in apartment buildings. Most of these houses are three- and four-room apartments in the cheap renting sector.

Despite the efforts of many housing corporations in the 80's and 90's the market position of these houses has decreased substantially. The most important reason for this is that the quality of these houses hardly can be improved and if so, only by high, uneconomic investments. The houses remain too small, poorly equipped and noisy. On the other hand, many of these apartment buildings are located in very pleasant quarters of the large and medium-sized cities, which makes them attractive for rehabilitation.

For this reason, Stichting Bouwresearch (foundation Building Research) in co-operation with housing corporation 'het Oosten', one of the largest of Amsterdam and the Eindhoven University of Technology, initiated a research program. The objective of this program is to - more or less - reconstruct the apartment buildings, at the same time using, as much as possible, IFD-technology. IFD stands for: Industrial, Flexible and Demountable. This resulted in the project 'Flexible Breakthrough'. The basic principle of the project is to completely remove (demolish) one of the four bearing walls in each apartment and replace this wall by a steel supporting frame. The resulting much larger space is to be redesigned with IFD-technology.

IFD technology

Important aspects of IFD technology are (Hendriks & Jacobs 1999):

- industrial construction: prefabrication, which means also less waste with the actual production, often production recycling is feasible;
- no waste on the building site, which is a boundary condition;
- construction becomes assembling: completely dry building method, which is also a boundary condition;
- flexible also means "changeable" during the course of life of the building, so there is also less waste;
- flexible in the design phase means for example that the developer of the building can wait until the last moment with final decisions about the lay-out of floors;
- demountable also means that reuse or at least recycling is possible;
- perhaps IFD technology can mean: less construction (in general).

Design criteria

For the design on changeability the following criteria could be used (Hendriks & Vingerling 2000):

Integration and independence of disciplines:

- supporting structure
- installations
- building envelope
- interior finishing

Completely dry construction method, which means:

- no in situ concrete
- no mortar joints
- no screed floors
- no plaster
- no sealant
- no in situ polyurethane

Perfect modular measuring, which means:

- extreme attention to drawing work
- prototype testing on:
  - mountability
  - functionality
  - demountability
- quality system drawing work
- assembly instructions

Changeability on all aspects:

- supporting structure (limited)
- installation (practically unlimited)
- building envelope (limited and modular)
- interior finishing (practically unlimited and modular)

Because one of the four bearing walls has to be demolished it was not possible to apply all the principles of IFD-technology in every detail. The consequence of the removal of such a wall is that the floor slabs also partly must be demolished. After the installation of the new steel supporting frame the floor slabs have to be reconnected, which must be done with in situ concrete. But for the remaining part IFD-technology can be applied.

Methodology

The methodology that has been used by the design team is based on the approach that has been introduced by Rutten (1997). First so-called system development areas have been selected. Evaluation points relate to critical details and other aspects of the design that need to be analysed. For every evaluation point a maximum of three alternatives has been determined. The evaluation of these alternatives is a balanced multi-criteria selection process to not only attain a high degree of industrialisation during construction, extreme flexibility during use of the building and demountability at the demolishing stage of the building project, but also a high degree of sustainability and personal comfort. This will be demonstrated by an example.

System development areas

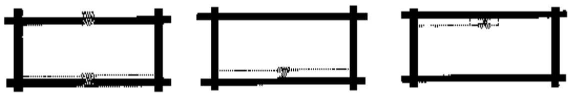
The following system development areas have been selected:

1. Foundation
2. Position of supporting beam
3. Sound proofing
4. Demolition
5. Construction and stability
6. Façade
7. Building services
8. Execution

For every evaluation point also the relation with other points have been given.

Example

As an example the analysis of the position of the supporting beam is given. This is done because this position is crucial in the whole concept. Table 1 illustrates the alternatives as well as the considerations for the final selection, which is alternative A.



	A	B	C
Alternative	Beam in the floor slab, with raised floor and finishing ceiling	Beam on top of the floor, with raised floor	Beam under the floor, with either a locally or completely lowered ceiling
Advantage	Minimal loss in height of room (2,43 m free). Floor is also flexible space for pipes and ducts Optimal flexibility Demolition is possible through the roof Acoustical improvement of the floor Electrical wiring in floor, but also in ceiling	Floor is also flexible space for pipes and ducts Optimal flexibility Acoustical improvement of the floor	Extra floor is not necessary With locally lowered ceiling remaining height of room is 2,59 m
Disadvantage	Thresholds and doors must be adapted	Free height of room is not more than 2,27 m Thresholds and doors must be adapted	With completely lowered ceiling free height of room is 2,28 m Sewers of upstairs neighbours through apartment No acoustical improvement of the floor In case of locally lowered ceiling connection of toilets etc. only near beam Limited flexibility
Observations	Lowest loss in roomheight, with acoustical improvement and finishing possibilities Piping and ducting for building services can be integrated in the supporting frame	A beam is also required on the roof	

*Table 1. Analysis of supporting beam position**

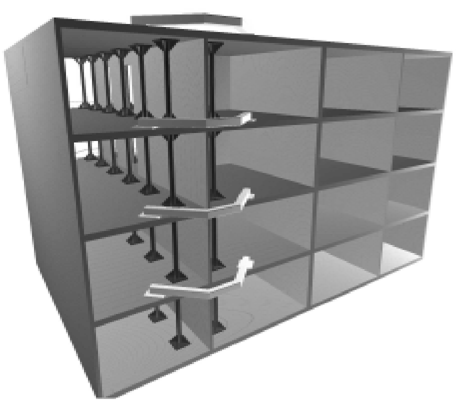


Figure 1. Positioning of temporary supports.

* Relations with demolition and building services

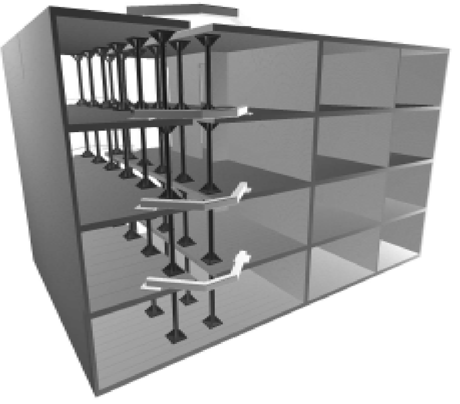


Figure 2. Removal of the bearing walls.

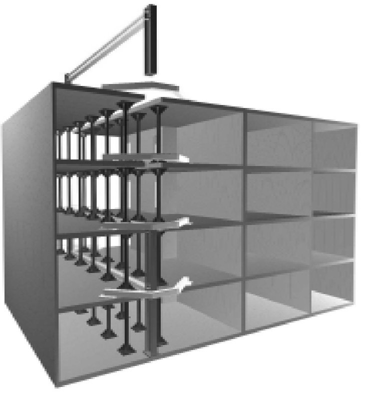


Figure 3. Installation of the integrated supporting frames.

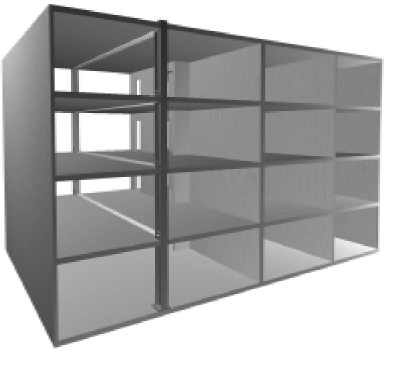


Figure 4. Completed structure.

Further research

During the progress of the study two more housing corporations joined the meetings: Far West in Amsterdam and HaagWonen in The Hague. They have contributed substantially in the evaluations. The positive conclusions of the feasibility study have resulted in a consecutive study in which they participate together with housing corporation 'het Oosten' and Stichting Bouwresearch (Foundation Building Research). The essential element of this study is the prototype testing on a real project. First part of the testing is the execution of the demolition and installation part of the 'Flexible Breakthrough' concept. This will be done on an apartment building that already has been designated for demolition. After evaluation of the results the concept will be tested on complex where the inhabitants will return. The results of this study will be reported in due course.

Results and conclusions

From the research in the first phase of the project can be concluded that the 'Flexible Breakthrough' concept is very feasible. The balanced multi-criteria selection process not only attains a high degree of industrialisation during construction, extreme flexibility during use of the building and demountability at the demolishing stage of the building project, but also a high degree of sustainability and personal comfort.

References

Hendriks, N.A. & Jacobs, G.P., 'Industrieel, Flexibel en Demontabel Bouwen (IFD): Ontwerpen op veranderbaarheid', Eindhoven University, February 1999, in Dutch.

Hendriks, N.A. & Vingerling, J.J., 'Industrial, flexible and demountable (IFD) building technology: a key to sustainable construction', paper presented at the ILCDES 2000 Conference, Helsinki, Finland, May 2000.

Rutten, P.G.S., 'Een model voor het ontwerpen op veranderbaarheid', chapter in 'Bouwwijs', Delwel uitgeverij, The Hague, 1997, pp. 41-44, in Dutch.

Hendriks. N.A. & Gassel, F.J.M. van, 'Construction of a prototype of an industrial, flexible and demountable (IFD) apartment building system', International Status Report on Aspects of FutureSite, CIB Publication nr 265, presented at the CIB World Congress, TG 27, Wellington, New Zealand, 31st March, 2001.

SATO - PlusHome

Esko Kahri
SATO-company (leader, investor), ARK Kahri&Co (architect) and ToCoMan (cost-data consultant).
Involved engineering offices: Finnmap (constr.), Enertek (HVAC), Majurinen (electr.)
Involved key-producers: Two bearing structures and fa(ade systems and HVAC integrating company.

SATO - PlusHome

ABSTRACT

SATO - PlusHome - the winning project April 2001: Multi-storey OB-housing system with SATO-company, the largest housing organisation in Finland. New stage of development and solution for PlusHome work started 1998. The pilot contains 80 apartments situated 10km from Helsinki centre. Preparing R&D is based on 4 themes with industry.

General goals & facts:

The main aim is the service and data-system for multi-storey housing with integrated building structure, installations and resident-service, both personal and internet version. The long term goal is to cover the majority of SATO-housing. The concept is based on "mass-tailor" production with large amount of pre-priced alternatives and automatic production data.

Building solution and constructions

The basis is staircase-house with free dwelling-sizes. Various shapes of house-units are available for different sites. The structure is based on bearing outside-walls with a max. span of 12m and a free adjustment of the floor area. Two bearing structure alternatives are introduced: one based on concrete and the other on steel. The structure gives a clear division of support and in-fill. The fenestration system makes possible many choices in the façade.

Open Building method and choices:

Apartment sizes and lay-outs can vary from studio to family apartments and be different on top of each other - this quality stays for future renovation. Also spatially interesting solutions are available, even a 11/2 floors high living rooms. The designs will be carried out with a studied empathy, themes like "children care" - "pleasure of life" - "elderly secure" etc. In addition there will be architect's tailor-service.

SATO - PlusHome

Esko Kahri

The title is the name of winning project April 2001 in a Open Building competition arranged by Helsinki City and the Finnish Technology Agency: The main goal of this project is a wide OB-housing activity by means of new PlusHome enterprise in partnership with the SATO-company, which is the largest housing organisation in Finland. The winning “Arabia-shore” project contains 80 apartments in two 5 storey blocks of flats situated 10km from Helsinki centre in a new urban area near the sea. The construction work will start autumn 2002. Authors: SATO-company (leader, investor), ARK Kahri&Co (architect) and ToCoMan (cost-data consultant). Involved engineering offices: Finnmap (constr.), Enertek (HVAC), Majurinen (electr.) Involved key-producers: Two bearing structures and façade systems and HVAC integrating company.

General goals & organisation

The aim is the service and data-system mainly for multi-storey housing with integrated building structure, installations and resident-service, both personal and internet version. The new stage of development after several OB-pilots started 1998, when Kahri&Co and ToCoMan decided to start partnership and collected team in order to conclude best housing solutions and find business concept to carry out OB-projects. The long term goal is (1) to start partnership with SATO (option offered) to serve their housing about 3000 flats / houses / year in Finland and (2) widen consulting for all investors and builders. The concept is based on “mass-tailor” production: large amount of pre-priced alternatives and automatic production data. The investor sees important the image improvement and marketing benefits, but there is also other business changes. The system of choices and data control allows different levels of service: Owned flats may have a full range service and variations (e.g. plans / windows / balcony / materials / equipment), partly owned some less and rented last mentioned choices with individual rents. PlusHousing has the benefit of long time renovation agility. The organisation of the Open Building procedure is following:

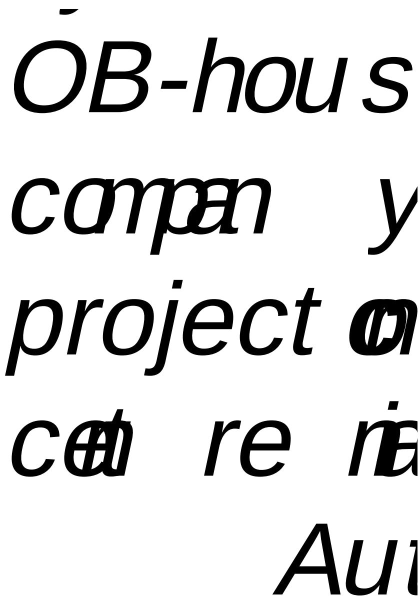


Fig. 1 The SATO company is the main partner which buys new kind of service from OB-specialised PlusHome-company. It is concentrating in developing the concept and system services for (1) Resident Service System such as data and procedure for residents´ choices and internet info; (contents of choices may vary by projects)
(2) Cost-Data Services for project management, residents choices and data for product ordering and logistics.

Preparing Reseach&Development:

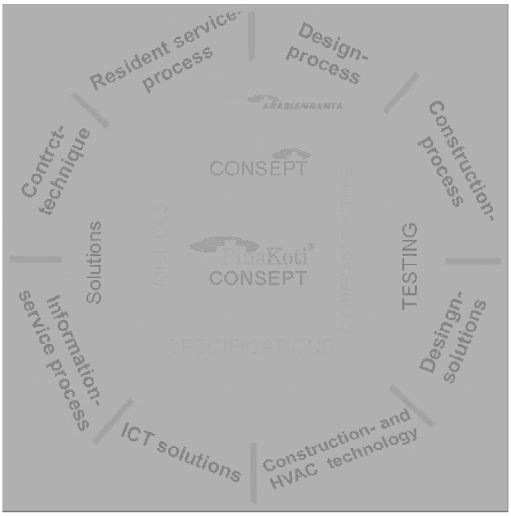
In order to reach the goals the preparing R&D work will be carried out in four main parts.

(1) PlusHome- and (2) SATO-companies both make concept & business studies (for long-term business plans) in order to start constant OB co-operation (in case the pilot project is successful)

(3) “Arabia-shore” building solution of multi-storey housing based on 90s pilots (floor plans / facade & balcony system / resident service / cost-production data systems) and feed back for concepts (1&2) and further projects

(4) Technical development with industry based on two bearing structure alternatives (design - build projects with industry for steel / concrete structure & installations).

The development will be financed partly by Finnish Technology Agency. Project subjects are worked on three main levels (rough contents in following diagram).



- **Resident service**
  alternatives / floor plan game presentations, service descriptions
- **Design process**
  building permission system design coord. / cost-integration
- **Construction process**
  support-infill boundaries investor / design-builder boundaries
- **Design solution**
  building lay-out / basic economy elevation & balconies / variations
- **Constr&HVAC-technology**
  investor demands to industry alternative lay-outs for production
- **ICT-solutions**
  info / communication process computer program applications
- **Information service**
  project cost management internet application for residents
- **Contract technique**
  legal contracts with parties

Fig.2 The developing work is based in this case mostly on previous experiences / systems / programs. This project is collecting full-range instructions and business plans. PlusHome core is the general frame for SATO-plus procedure, but the emphasis will be in "Arabia-shore" project. Feed back to inner levels will be done in the end of project. Technical development takes place by industry / producers programs.

Building solution and constructions

The basis is the staircase-house with free dwelling-sizes. Various shapes of house-units are available for different sites, two are introduced in pilot blocks of flats. The structure is based on bearing outside-walls with a max. span of 12m and a free adjustment of the floor area. This principle allows good fit to many sites - if the framework is not very deep. Two bearing structure alternatives are introduced: one based on concrete and the other on steel. This is based on experiences in former projects: in monopoly situation the price has tendency to rise in comparison with quality. The structure gives a clear division of support and infill. Installations serving different floor plans above each other have more limitations with concrete hollow-core-slab structure. The new steel structure allows free piping in the floor, but experiences are limited. Demands for sound isolation have been raised in Finland 1999, and it will be the critical aspect specially concerning bathrooms. For good OB-solution the wall between flats must have varying placement in different floors. We are lucky, that a favourable and good sound isolating light wall has been developed by a Finnish company, based on special steel frame and sheets. Walls inside the apartment have the major demand relating to electric cables (easy installation, removing and adding). But only reasonable wall moving and removing possibility is needed. Our earlier pilot shows, that easy movable walls have much over capacity in housing. The fenestration system is based on large frames, where inside will be alternatives for residents (e.g. glass heights: normal / low / reaching floor). Balconies also have some choices and the steel system allows free arrangement of sizes lengthways the building. They also have a range of railing and outside wall alternatives of glass and wood.

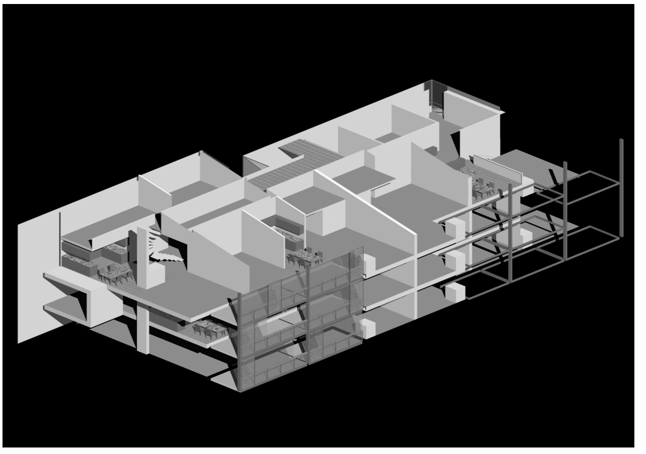


Fig.3 An opened section view shows the block in the "Arabia-shore" project. There is two more floors below the picture. Essential is the possibility to vary sizes of flats length-ways the building in every floor independently. The picture shows, how apartment walls can have different placements also to direction of other staircase unit (in the picture to the front direction)

Open Building solution and choices:

The design is based on staircase house, which is in our cold climate the dominant and wished solution. Apartment sizes and lay-outs can vary from studio to family apartments. They also can be different on top of each other - this quality stays for future renovation. The main staircase arrangement of floor plans is based on four apartments: in the middle two smaller and besides family types. The sizes of flats can vary lengthways the building in every floor separately. Every move of wall between apartments makes a functional plan both sides: this quality makes possible to carry out the residents floor plan game. Inside different sizes are further choices: more open plans or separated traditional rooms, but even dynamic wall moving possibility in some special apartments. Spatially interesting solutions are available to serve very sophisticated clients: Topmost apartments have a loft floor and high living rooms with sloping ceiling. In the end of building there is some apartments with optional 11/2 floors high living rooms, which is a very special system quality. The designs will be carried out with a studied empathy, themes like "children care" - "pleasure of life" - "elderly secure" etc. In addition there will be material and equipment choices, but according the "mass tailor"-principle they are limited to 3...4 pre-priced and fixed choices. In some extend there is available the architect's tailor-service both in floor plans and materials, but the price is much higher. The division of support and infill allows schedule, where residents can make their choices much later than usual. There is available internet and personal version of service: Internet is showing outlines of the project, floor plans and choices with prices. For closer look there will be a small exhibition and personal advise mostly by estate agent, but architect is available for info-events and special advise.

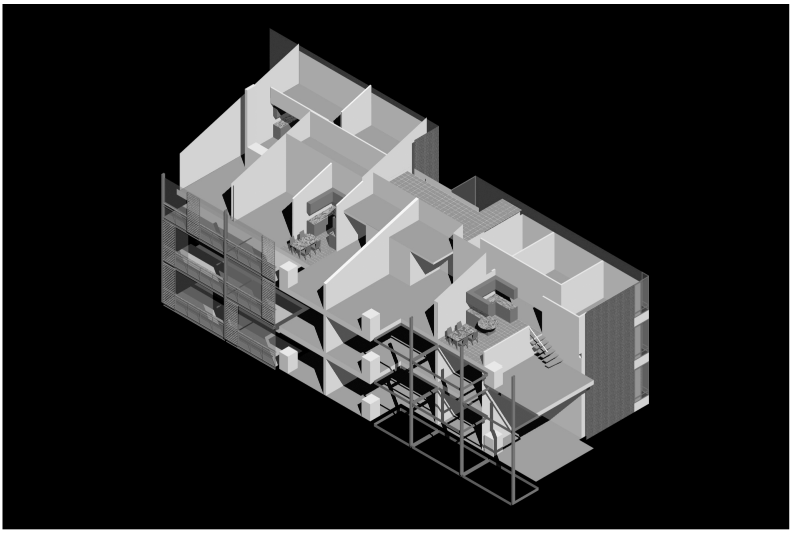


Fig.4 Second opened view of the staircase unit shows the end of building; there are apartments with optional 11/2 floors high living rooms. Topmost apartments have a loft floor and high living rooms with sloping ceiling. Special types are a clear minority, but important to satisfy also sophisticated demand.

The Inter-Relation between Openings in Facades and Locations of Movable Partitions and its Effect on User Flexibility in Residential Buildings

Dr. Eyal Karni
Faculty of Architecture & Town Planning
Technion - Israel Institute of Technology
Technion City, Haifa 32000, Israel
Voice: 972-4-8294063
Fax: 972-4-8241197
e-mail: arkarni@tx.technion.ac.il

The Inter-Relation between Openings in Facades and Locations of Movable Partitions and its Effect on User Flexibility in Residential Buildings

ABSTRACT

User flexibility in residential buildings is a need of modern times. It can be achieved by implying various strategies, one of which is by using light-weight partitions which can be re-located in the dwelling space in order to form a variety of required sub-spaces. The performance of this strategy depends on the inter-relation between the partitioning sub-system and related building sub-systems as well as a variety of design parameters.
This paper addresses one such aspect: the inter-relation between openings in facades and possible locations of adjacent partitions. An analysis of two cases is brought forward demonstrating an approach which can be used sometimes, but not always, to realise zones in facades in which openings may support several alternatives of interior space sub-division. However, this procedure may assist regarding this relation only while concerning specific cases, and similar analysis should be carried out in view of all existing inter-relations related to the partitioning sub-system which suggests conducting a comprehensive research.

KEY WORDS

User Flexibility; Partitions; Facades; Residential Buildings.

The Inter-Relation between Openings in Facades and Locations of Movable Partitions and its Effect on User Flexibility in Residential Buildings

Dr. Eyal Karni

Introduction

User flexibility in residential buildings is a primary design objective derived from modern living needs. Such needs vary among dwellers over time. Present familial life cycle involves change in the number of family members dwelling in apartments, as well as in conducting work from home and enjoying user friendly world-wide communication. Interior space sub-division is, therefore, called for in order to provide the necessary conditions for such demands. It may also prove to be valuable in small or medium size apartments where dwelling space may sometimes be limited.

Over the years a number of strategies have been designed to address this goal. One strategy is to provide dwellers with modular light-weight movable partitioning systems which can be re-located in a given space in a number of configurations, creating sub-spaces for dwelling needs. However, in order to obtain reasonable solutions based on the qualities of such partitions, apartments built for user flexibility need to be designed, among other design goals and considerations, in view of two issues:

- The inter-relation of building sub-systems (for example facades and technical supplies) and the partitioning sub-system.
- Various architectural considerations (such as the overall geometry of floor plan and location of entrance).

All these aspects need to be examined carefully and a relevant research is needed in order to evaluate the inter-dependency of these issues and their effect on possible geometrical solutions for interior space sub-division.

The following example illustrates one such aspect.

An Example: The Inter-Relation between Openings in Facades and Movable Partitions

Openings in facades are usually fixed elements which normally remain in size and location. When adjacent partitions are transferred to new locations, some limitations may occur. Should a partition approach a façade within the opening span problems may be created concerning, for example, opening windows or acoustical insulation between adjacent dwelling spaces. As a result, the design of openings in relevant facades is preferred to be carried out in accordance with anticipated locations of partitions, enabling a reasonable number of solutions.

Figure 1 illustrates seven theoretical locations of partitions which approach a planar façade as derived from seven theoretical interior space sub-division alternatives. Along the façade several combinations of bedrooms or combinations of bedrooms and a living room or a study may be created. Partitions of these combinations are drawn respectively and their superposition provide zones in which openings need not be located in view of the above mentioned considerations.

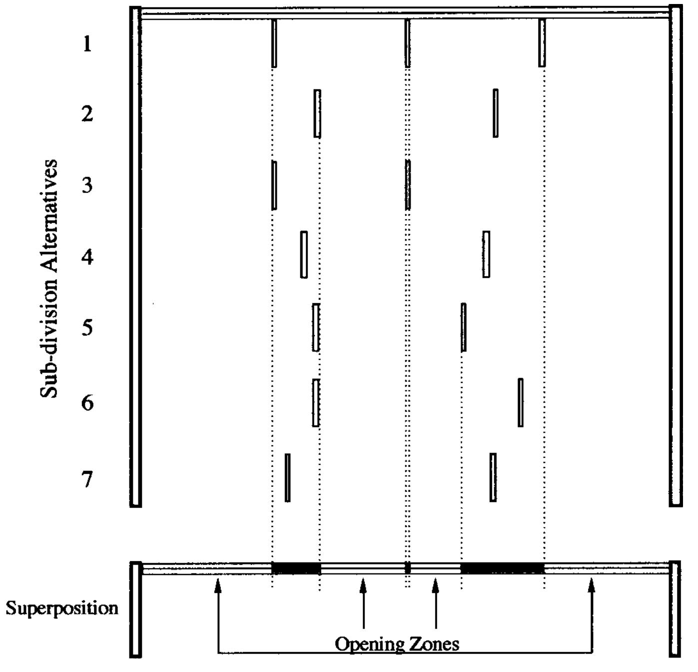


Figure 1: Case a: Superposition of theoretical sub-division alternatives along a façade.

The result shows that, in this specific case, if openings are located in the suggested zones, the described seven theoretical options are possible. This idea suggests that a relative small number of openings placed in appropriate locations may be quite sufficient in providing a reasonable number of interior spaces along such a facade. Of course, not each and every possible solution may be obtained in this manner, however, if adequate solutions are realised and openings are located accordingly, user flexibility concerning this aspect may be achieved to a satisfied level. Such an analysis, should be carried out in accordance with each specific case since each plan has its specific characteristics and the described procedure may not work for each and every case.

There may be conditions in which not all the desired sub-division alternatives may be optional using the described procedure. This may be a result of a smaller façade dimension or a specific combination of spaces or a particular floor plan.

Figure 2 illustrates such a case in which all seven theoretical options can not be met in one arrangement of openings. Alternatives 1-4 incorporate three spaces along the façade while alternatives 5-7 have only two spaces. The various locations of partitions concerning alternatives 5-7 as well as their left-right possible locations (mirror effect) or various combinations of the two - do not provide reasonable space for placing the needed openings for the middle spaces of alternatives 1-4. Therefore, these two sets of alternatives can not be achieved, in this specific case, together while maintaining a fixed design of openings in the facade. Still, such analysis may provide valuable knowledge concerning user flexibility in regard to possible sub- division alternatives of specific apartments.

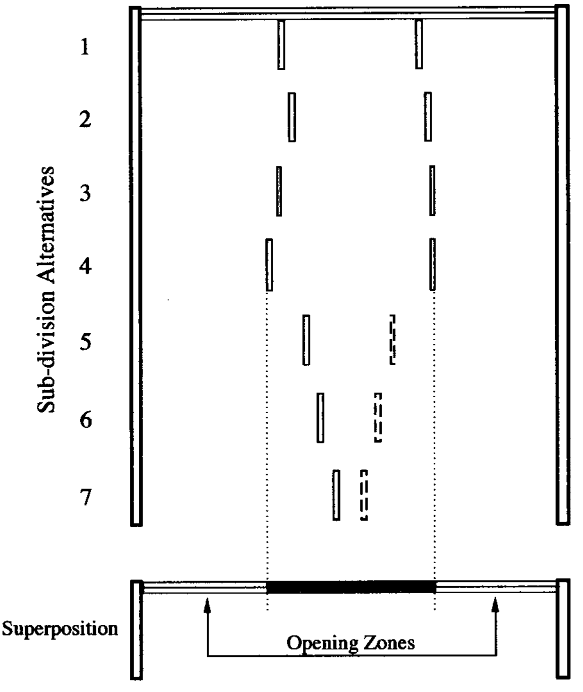


Figure 2: Case b: Superposition of theoretical sub-division alternatives along a façade.

It is important to note that this paper deals with only one aspect concerning re-location of partitions along facades in view of their pre-designed openings. However, a variety of constraints and considerations should also be addressed when such design is carried out, bearing their implications and effects on the final design.

Conclusions

Openings in facades determine possible locations of adjacent movable partitions creating interior dwelling spaces. In other cases they may also rule out some alternatives in which a conflict may be created between the approaching partition and specific openings in facades. Analysis of optional locations of partitions resulting from future sub-division of dwelling space may assist in realising possible options and in ruling out others and, therefore, may support decision making concerning size and location of such openings. This aspect is only one of a number of issues which need to be further investigated in a comprehensive research in order to enjoy the performance of movable partitioning sub-systems and their contribution to user flexibility in residential buildings, especially in small or medium size apartments.

Survey of the Open Building Methods in Japan providing for Flexibility

Kozo Kadowaki
Research Associate, Dept. of Architecture, Tokyo Metropolitan Univ., Japan

Seiichi Fukao
Professor, Dept. of Architecture, Tokyo Metropolitan Univ., Japan

1-1, Minami-osawa, Hachioji-shi, Tokyo 192-0397, Japan
Tel. +81.426.77.1111 ext. 4762
Fax. +81.426.77.2793
E-mail: kkad@ecomp.metro-u.ac.jp

Survey of the Open Building Methods in Japan providing for Flexibility

ABSTRACT:
Open Building concept had been introduced into Japan before 1972, and there are not a few multi-unit projects which actually constructed based on this concept. It was set as one of the goals to increase building flexibility in most of these multi-unit residential buildings, and the aims and design strategies to increase flexibility had a great variety.
This research makes a survey of such open building projects from the aspect of the aims and design strategies to increase flexibility of multi-unit residential building. Furthermore, capacity analyses of skeleton (or support, base building) of some of these projects are conducted.
Literature survey and drawing analysis based on Japanese existing multi-unit residential buildings revealed the aims for flexibility, and the aims were classified. The design strategies to increase flexibility were picked out. The principal 41 open building projects in Japan were selected, and hearing investigation for the persons who concerned with project development was conducted. These investigations revealed the relations between the aims and design strategies to increase flexibility.
Moreover, capacity analyses of the above 41 open building projects were conducted from the aspects as follows: ability of moving facilities, and ability of floor plan alteration. And capacity of skeletons of above 41 projects was evaluated.
Lastly, some suggestions from these investigations would be addressed for the future design strategies to increase building flexibility in this paper.

Survey of the Open Building Methods in Japan providing for Flexibility

Kozo Kadowaki and Seiichi Fukao

Introduction

The housing system which is called “S/I house” in Japan, is based on a number of research projects and technological developments which have been conducted from various approaches. There were already some researches and developments discussing the concepts or technologies underlying which of present S/I house in early 1970s in Japan. In addition, the Open Building concept pioneered by SAR was introduced into Japan before 1972. From then, there are not a few multi-unit projects which actually constructed.

It was set as one of the goals to increase building flexibility in most of these multi-unit residential buildings, and the aims and design strategies to increase flexibility had a great variety.

The purposes of this paper are to classify such design strategies to increase flexibility from the aspect of their aims by literature survey, and to grasp what is effective to increase building flexibility by drawing analysis.

Design Strategies to Increase Building Flexibility

Trials in Past Projects

There are a number of ambitious multi-unit residential projects towards flexibility in Japan, as mentioned in the preceding chapter. The design strategies to increase building flexibility shall be illustrated according to their aim taking examples. Indeed it is important not only the building system but also management system, for example its supply system, to provide for flexibility, but here we limit the discussion to the building system or design strategies. Added to this, we are mainly concerned with the design strategies in “Support Level”.

a. Unit Size or Dwelling Layouts

Let us start with the strategies to change unit size or dwelling layouts freely.

“Tsukuba-Sakura Housing Estate”, the Century Housing System or CHS multi-unit completed in 1985, prepares flexibility for dwelling unit size, conversion, and interior layout. Flexibility for dwelling unit size was achieved by combining or separating the dwelling units ranging in size from 35-115m2 in this CHS project. An opening in the bearing party wall combines the dwelling units, and installed drywall separates a dwelling unit. Tsukuba-Sakura succeeded in realizing various units because of such slight devices.

“Iidadashi Building, Residential Section” (2000) also prepare flexibility for dwelling unit size, by eliminating a span of bearing party wall in the transverse direction. “Iidabashi Building” is a 14-story re-development project of Iidabashi district in Tokyo; 1-9th floor is used as

offices and 10-14th is as landowners' houses. Flexibility of dwelling size was prepared to answer landowners' diverse needs. This design was adopted to determine the size of units freely, but not for "to change". There are many projects which enabled to change the size of units by moving party walls, but there were almost never examples which actually changed unit size, because it is difficult to make an agreement with a neighbor.
"Hyogo 100 year Housing Project" (1997) was developed by Hyogo Prefecture to realize longer multi-unit lifetime comes up to 100 years. Moment-resisting frame structural system on the 5.4m*5.4m structural grid is used, and the bearing wall was all eliminated in this ambitious project. It produced slab as "Artificial Ground" for dwellings, and enabled dwelling layouts completely freely. In addition, "NEXT21 Experimental Housing Project" (1993), "KSI Experimental Housing Project" (1999), "Flexsus House 22" (2000) etc. also do away with most of bearing walls to determine or change dwelling layouts freely. Added to the structural system, plumbing system is distinguishing characteristic in these projects for free dwelling layouts. We shall have more to say about this later on.

b. Partition Layout

Next, we are concerned with the trials not to restrict partition layouts, to determine interior layout or to allow their easy reconfiguration.

i). Elimination of Restriction Caused by Pillars or Beams

Frame structure is major structural system of multi-unit residential building in Japan. Use of frame structure makes projections of pillars or beams inside interior space. And such projections restrict partition layouts.
In "Hikariga-oka Park Town Housing Estate" (1985), a project of which interior layout and finish decision of dwellings was done freely by each occupant applying the system as known as "Free-Plan Rent System", wall structure was used in order to eliminate restricts of partition layout caused by pillars. But use of wall structure produced long walls in the mid of the dwelling unit. They reduce the capacity of the support as a result.
"Verde Akibadai Corporative Housing Project" (1990) is a coop project conceived by Tokyo Metropolitan Housing Corporation. It used frame structure, and the pillars and beams in the both opening sides of the dwelling unit were set outside. Indeed it made partitions layout easier, but there are any more objections of pillars and beams in the mid of the dwelling unit.
In "Toka-ichiba Housing Estate" (1998), the "Wall-Flat Beam Structure" developed by HUDC (Housing and Urban Development Corporation; now Urban Development Corporation or UDC) was used to solve such problems. This structural system was developed on the basis of the conventional bearing wall box frame structure. Bearing wall breadth and beam heights were minimized through a structural study; just 410mm height beam was materialized.
"Makuhari Patios Housing District M1-2 Block" (1995) constructed by Shimizu Co., used a flat slab concrete construction system. The beams were built in the slab, and the interior space is completely free of beams. Yet the slab thickness was set at 350mm because of the built-in beams, the capacity of the support in the vertical direction was a little reduced.

In “Flexsus House 22” (2000) conceived by Takenaka Co. in the House Japan project of MITI, use of the prestressed hollow-core slab succeeded to reduce the slab thickness to 250mm. Use of a flat slab also makes interior fit-out easier to install, and eliminates the barriers of piping or ducting running.
Some projects also materialized a flat concrete ceiling using the inverted slab.

ii). Elimination of Restriction Caused by Openings in Exterior Walls
The fenestration, namely the arrangement of windows or entry door(s), sometimes restricts partition layouts.
In “Senboku-Momoyamadai Housing Estate” (1982), the first project applied “Two Step Housing Supply System”, possible configurations or interior layouts were studied when the building was designed, and the fenestration was determined allowing the expected partition layouts. Modular design of interior fit-out helped the expectations of interior layouts and the coordination for positing various elements.
In “Matsubara Apartment” (1998), which is the third project built in “Tsukuba Method”, bearing walls were eliminated from partly of the dwelling’s exterior façade, allowing each occupants’ freely determination. “Green Village Utsugidai” (1992), a coop project built by HUDC, is the first three generation household type multi-unit residential in Japan. In this project, not only exterior façade could be determined by each occupant, but also could have one or two entry doors. In these projects, non-structural drywall is used as the exterior wall. It also makes changing the fenestration adapting to reconfiguration easier.

c. Wiring, Plumbing and Installation
i). Wiring and Cabling
Sometimes it is necessary to modify the route of wiring or cabling with the alteration of interior layout. They should be modified easily allowing easy reconfiguration.
In “Eifuku-cho Apartment” (1985), one of the earliest CHS project, spaces were left between all of skeleton and fit-out where wiring and cabling can run. One may say that it is already a conventional construction at present.
In “Minami-senju Housing Project” (1989), also a CHS project, IDS (Intelligent Distributor Station) was installed as a space to accommodate the distribution panel and the information panel of each dwelling unit, and reconnecting of the cables with newly installing of equipments shall be done inside IDS, in order to adapt to the equipments upgrading or appearance of new media without replacing partitions or exposed cabling.
ii). Ducting, Piping and Plumbing
There are number of projects that explored to make the maintenance and replacement of installations easy or to make the “wet areas” (bath units, lavatory, Toilet and Kitchen) location or relocation free. To take the advantage of the support for such needs, the design of ducting, piping and plumbing is very important issue. Here the design strategies for installations flexibility shall be illustrated.
“Green Maison Tsurumaki-3” (1983) is constructed by HUDC applying “Menu System”. The support of each dwelling unit named “Free-Space” is composed of three structural bays lined with north to south. North bay and south bay are for living spaces, and occu-

pants can select the interior layouts of living spaces from several prepared plans. The slab of mid structural bay is employed as "wet zone trench"; 200mm lower than both side slabs, and the finish floor level is 300mm above the "trench" floor. It makes installations relocation easier in the mid bay. The mid bay faces a light well. The wet areas are well lighted and well ventilated facing this light well. Exposed stacks were located on the balcony jutting out into the light well from the mid bay allowing their easy maintenance.

There are many projects that the building employed a "wet zone trench" like "Green Maison Tsurumaki-3". Most of the CHS projects used this design strategy, clearly dividing "Living Areas" as "Flexible Areas" and "Wet Areas" as "Fixed Areas". It can be explained as due to one of the principal objectives of CHS; to divide each component group related to their durable years, allowing their easy maintenance or replacement.

Dividing "Flexible Areas" and "Fixed Areas" clearly is sometimes effective to reduce the wastefulness initial cost. Relevant to this point is following remark in CHS rulebook: "It is important that building adapt to the change of household type and of occupants' lifestyle. But it is not always necessary to prepare adaptability or flexibility of all building elements. It is rather important to design "Flexible Areas" and "Fixed Areas" assuming occupants' lifecycle." (Ministry of Construction: Design Manual of Century Housing System V, 1983, in Japanese) CHS aimed for that building stay in good condition through its lifetime, namely flexibility was only of secondary importance to avoid deteriorations in its function. Dividing "Flexible Areas" and "Fixed Areas" clearly is effective on the assumption that standard household types live in, but it cannot necessarily allow diversified needs concerning housing; for conversion, SOHO, adaptability for aged, and so on. There are trials towards further flexibility in recent years.

"Tsukuba Method Housing Project II" (1996) used an inverted slab and beam structural system. The finish floor level is 530mm above the concrete floor, and the wet areas would be freely located. Main beam in the longitudinal direction usually has three sleeves per a span (5.4m) where ducts and piping can pass over the beam. It makes wet areas relocation also freely. As dusts are located under the finish floor, modification of the rout of ducting with the wet areas relocation would not affect room height. "Hyogo 100 year Housing Project" we have seen earlier also used an inverted slab, and a variety of floor coverings for example the step at the entry vestibule, storages, sunken bathtubs, and other features were built utilizing under-floor spaces.

"NEXT21 Experimental Housing Project", "Hyogo 100 year Housing Project", "KSI Experimental Housing Project" and "Flexsus House 22" allow free dwelling layouts or relocation, and the plumbing systems are distinguishing characteristic for free dwelling layouts as mentioned before. In these projects, the vertical shafts are not always located by each dwelling unit. Plumbing from each dwelling unit runs inside a dropped ceiling or raised floor built in common space of the building, to a vertical shaft utilized by some dwellings together.

Classification of Design Strategies

We have taken a general view of design strategies and their aims used in multi-unit residential buildings in Japan. Next, the existing 34 Open Building projects in Japan were selected, and literature survey about a certain dwelling unit of each project revealed the design strategies providing for flexibility used in each project. Extracted design strategies were classified from the aspect of for what it was used; what flexibility was planned using that design strategy.

Classification of design strategies providing for flexibility is shown below.

A. Flexibility for Changing Unit Size or Dwelling Layouts

A-1. Building Structure

A-1-1. Make an opening in bearing party wall to exchange a space with the next dwelling.

A-1-2. Use a non-structural drywall as party wall to install or remove combining with the next dwelling or dividing a unit in two.

A-1-3. Use a non-structural drywall as exterior wall to determine or change its layout.

A-2. Plumbing

A-2. Run the piping from each dwelling unit above a dropped ceiling or under a raised floor in common space of building, for example in open access corridor, to a common vertical shaft not to be restricted dwelling layouts by separate shafts.

B. Flexibility for Partition Layouts

B-1. Provide Large Interior Space(s) without Concrete Objection Allowing a Variety of Floor Plan

B-1-1. In the Horizontal Section

B-1-1-1. Eliminate obstacle to partition layouts such as pilaster or bearing wall.

B-1-1-2. Not use a concrete wall as partition

B-1-1-3. Not divide living areas by concrete wall or wet areas. Or wet areas are removal unifying separate living areas.

B-1-2. In the Vertical Section

B-1-2-1. Design the structure that no beams cross living spaces.

B-1-2-2. Minimize height of beams crossing living spaces.

B-1-2-3. Conceal the beams completely above dropped ceiling.

B-1-2-4. Flat the concrete ceiling completely using inverted slab or no-beam structure.

B-2. Elimination of Partitions Restriction Caused by Openings in Exterior Walls

B-1. Use non-structural drywalls in façade to determine or change the fenestration.

B-2. Use non-structural drywalls in façade to determine or change the entry door(s) position.

C. Adaptability for Installations

C-1. Divide support and wiring leaving a space between support and fit-out.

C-2. Divide support and piping leaving a space between support and fit-out.

C-3. Install drains out of interior space.

D. Flexibility for Locations of Wet Areas (Kitchen, Lavatory, Toilet and Bath Unit)

D-1. Established Wet Areas Locations Rule

D-1-1. Free-located in a certain range in a dwelling unit.

D-1-2. Free-located anywhere in a dwelling unit.
D-2. Eliminate Obstacles to Ducting or Piping
D-2-1 Eliminate Obstacles to Ducting or Piping Above the Ceilings
D-2-1-1. Provide spare sleeves where ducts and piping can pass over the beams.
D-2-1-2. Reduce height of beams where ducts and piping can pass over the beams.
D-2-1-2. Use an inverted slab or no-beam structure in order to ducts and piping would be run freely.
D-3. Eliminate Obstacles to Ducting or Piping Under the Raised Floor
D-2-2-1. Provide spare sleeves where ducts and piping can pass over the beams (only in case of inverted slab).

And the results of the survey of existing projects are presented in Table 1. In addition, labels in Table 1 correspond with them above. It revealed provided flexibility in each housing project.

Flexibility and Capacity Analyses

Analysis Methodology

It was revealed that what design strategies were used and for what flexibility was provided in 34 Open Building projects constructed in Japan in preceding chapter. In this chapter, capacity analysis of a certain dwelling units of each project is conducted, and the effectiveness of the design strategies increasing building flexibility shall be discussed. In addition, flexibility for interior layouts is mainly discussed. We are not concerned here with it in case of reconfiguration with combining dwelling units or separating a unit.
We will explain the methodology of this analysis.
First, possible interior plans of each dwelling unit were picked out referring pamphlets or drawings. Further more, possible interior plans which were not in the pamphlets or drawings were designed within the limits of dwelling flexibility revealed in preceding chapter. For example, the wet areas location was not changed if it had been determined to be fixed. Only right-angled lines to the base building were used when we designed it. Length of a side of habitable rooms (the rooms except Toilet, Lavatory and Bath Unit) was determined more than 2.4m on center. A private room to which cannot access from public room or hall way was not designed.
Each room forming the picked out interior plans were divided into “Public Room” (Dining Room, Drawing Room, Living Room and other communal rooms and kitchen, except Toilet, Lavatory and Bath Unit) and “Private Room” (habitable rooms except “Public Room”).
Public rooms were moreover classified into three types based on their floor space:
Type 1 - Too small room as a habitable room (less than 10m2)
Type 2 - A room that is enough for one but too small for two (10-14m2)
Type 3 - A room that is enough for two (14-20m2)
Type 4 - A room that can use in more various ways

No.	Project Name	Year of Com-pletion	System
1	Pilot House, Shimizu Co.	1971	Pilot House
2	Shimo-Hosoi H. E.	1977	New Planning System
3	Senboku-Momoyamadai H. E.	1982	2 Step Housing Supply
4	Green Maison Tsurumaki-3	1983	Free-Space Structure
5	Cherry Heitz Kengun	1984	2 Step Housing Supply + CHS
6	CI Heitz Machida	1984	CHS
7	Matsugaya Corporative H.	1984	Corporative Housing
8	Hikariga-oka Park Town H. E.	1985	Free-Plan Rent System
9	Eifuku-cho Apt.	1985	CHS
10	Urayasu AMC Project	1985	CHS
11	Tsukuba-Sakura H. E.	1985	CHS
12	Terada-cho H. P.	1986	CHS
13	Senri-Inokodani H. E.	1987	2 Step Housing Supply + CHS
14	Yao-minami H. P.	1987	CHS
15	Hiroshima H. P.	1987	CHS
16	Rune Koiwa	1988	CHS
17	Villa Nova Kengun	1988	CHS
18	Minami-senju H. P.	1989	CHS
19	Verde Akibadai	1990	Corporative Housing
20	Green Village Utsugidai	1992	Grouping Free-Planning System
21	NEXT21 E. H. P.	1993	NEXT21
22	Nagamachi Apt.	1995	RC Special Wall Structure
23	Makuhari Patios H. D. M1-2 BL	1995	Thick Slab Built in Beams
24	Tsukuba Method H. P. I	1996	Tsukuba Method
25	Tsukuba Method H. P. II	1996	Tsukuba Method
26	Hyogo 100 year H. P.	1997	Hyogo 100 year House
27	Takenaka Matsuyama Apt.	1997	CFT Frame Structure
28	Toka-ichiba H. E.	1998	Wall-Flat Beam Structure
29	KSI E. H. P.	1998	KSI
30	Matsubara Apt.	1998	Tsukuba Method
31	Flex Court Yoshida	1999	2 Step Housing Supply
32	Tsurumi-Chuo Apt.	1999	Renace System
33	Flexsus House 22	2000	New Housing Structure
34	Iidabashi Bld. Residental Section	2000	Redevelopment/Replotting

* The projects are set in chronological order in this table.
**Read the abbreviations in Project Name as follows; H.E. = Housing Estate, H.P. = Housing Project, E.H.P. = Experimental Housing Project, Apt. = Apartment, BL = Block, Bld. = Building.
***Shaded cell in Table 1 means the item which cannot be used, because of preceding characteristic of the project. For example, D-3 is a design strategy in case of support an inverted slab was used, so this item cannot be used in case of use of other structural system.

The total public rooms size was also obtained.
Figure 1 indicates the result of this analysis. The total public room size is illustrated as a polygonal line in this figure. The projects in which the result of analysis was shown are: “Pilot House, Shimizu Co.” (1971), “Terada-cho Housing Project” (1986), “Tsurumi-Chuo Apartment” (1999) and “Tsukuba Housing Project II” (1996).

Result of Analysis

We explain about result of analysis in detail.

In “Pilot House, Shimizu Co.”, a project reflects the concept of open industrialization, it was aimed increasing the range of element choices by constructing the whole building with prefabricated parts, in order to satisfy customers. Installations were prefabricated using the unit construction. This installations unit was located in the center of the dwelling unit, and it is hard to relocate it.

Use of precast wall structure eliminates objection inside the dwelling unit, and two large spaces for living space are provided. It creates a variety of interior layout. However, this support cannot include four private rooms in spite of this large size dwelling unit. It is because that the fenestration and the fixed kitchen restrict partition layouts.

“Terada-cho Housing Project” was constructed by Osaka City Housing Corporation in 1986. This CHS project prepares a large square living space without beams locating the wet areas aside, to take advantage of interior layouts. However, no-window room come into existence when adding to rooms, because the dwelling frontage is narrow and the unit expands far deep. According to Japanese low, no-window room need to be designed as it can be widely opened to obtain lightning combining with next room. So no-window room cannot guard privacy, and the use of no-window room tends to be limited.

When providing four private rooms in a unit, the public areas become too small to be used by such a large family. One can safely state that it is not a desirable way.

“Tsurumi-Chuo Apartment” used the “Renace System”. In Renace System, an inverted slab is used and the floor is supported by lightweight steel beam without legs. It creates flexible under-floor space and reduces a noise of above dwelling unit. It also makes the wet areas location free. In Tsurumi-Chuo, the finish floor level is 730mm above the concrete slab, and wet areas would be located freely. However, small unit size restricts a variety of interior layouts. Fixed entry vestibule also obstructs it and limits the floor space of north private rooms facing exterior access-corridor. But under-floor storages make up this loss a little.

Because the dwelling frontage is also narrow and the unit expands far deep, wet areas, which does not need lighting in the low, tends to be located in the center of the dwelling unit in order to add rooms. This support cannot use the merit of free wet are location enough because of its form and size (But it is not a major objective of Renace System in the first place).

“Tsukuba Housing Project II” also used an inverted slab and wet areas would be freely located. The unit size is about 103m2, and it is well lighted because all sides of the unit are facing exterior. It creates high capacity for free planning and remodeling.

Use of under-floor space also offers a capacity for a large variety of floor plans.

In these project and other project analyzed its capacity and flexibility, the design strategies to increasing building flexibility were effective in almost cases. To make free-located wet areas offers a remarkable capacity for a large variety of interior layouts in particular. In addition, it is also important to provide a large unit size, enough story height, well lighting and so on, in order to truly create a variety of residential units. As for lighting, it gets hard to obtain as dwelling unit size become larger, so the whole building design get more important to solve this problem.

Conclusions

In this paper, design strategies providing for building flexibility used in Open Building projects constructed in Japan were put in order, and the effectiveness of them were discussed. And flexibility and capacity analysis showed that form of dwelling unit is important to make use of these design strategies effectively.

There is considerable validity to the concept that Multi-unit residential building is a way to make human living efficiently. However, increasing building flexibility almost runs counter to promotion of efficiency. For example, the narrow-frontage and long-expanded dwelling unit was come into existence purchasing how many dwelling units can be stuffed.

Further discussion about the proper balance concerning this problem is expected.

References

Public Housing Corporation Liaison and Conference Committee: Design Methodology and Examples of New Planning System Part I, Prefabricated Housing Development Center, Apr. 1983 (in Japanese)

Fukao, S.: A Study on Building Systems of Support and Infill for Housing in Japan, Proc. of International Symposium on Open Building; Taiwan, pp.100-102, Nov. 1998

Kendall, S., Teicher, J.: Residential Open Building, E & FN Spon, 2000

Kadowaki, K., Fukao, S. et al.: Quantitative Evaluation Method of the Capacity of Skeletons used in SI Housing, Proc. of CIB W104 Open Building Implementation; OBT2000, pp. 133-140, Oct. 2000

Improving the renovation of existing multi-family housing in Japan by Open Building

Kazuo Kamata
Technical coordinator Tokyo Gas Co.,Ltd.
7-1 Nishishinjyuku 3 Chome, Shinjyuku-ku Tokyo 163-1059, Japan
Tel 81-3-5322-8992 Fax 81-3-53227633
E-mail : kazuok@tokyo-gas.co.jp

Improving the regeneration of existing houses by Open Building

ABSTRACT

1. While Japan is notorious for its demolition and rebuilding development, with regard to RC multi-family housing built from the 1940's on a mass scale, the number of rebuilt houses has not been very large. In addition, the recent economic depression has made demolition and rebuilding development difficult. On the other hand, the renovation of existing houses remains mainly at the level of repair work. However, in addition to extensions that have been made in the past, the installation of EV, improving common space and remodeling of interiors have been undertaken recently. I will survey these new activities in the regeneration of existing houses in Japan.

2. In housing renovation, the distinction between the "3 levels" might be more definite than in newly built housing because "SUPPORT" exists already. I will classify the above-mentioned activities according to the "3 levels" and identify the problems that need to be solved.

For example, in INFILL, there is the problem of construction while people are living in the building, a shortening of the period of construction, the reduction of construction noise and an increase in the number of special sub-constructors. In SUPPORT, there is the problem of changing the common drainage that exists in the units and the effective and low cost installation of EV in apartments with narrow staircases. In URBAN TISSUE, there is the problem of the construction of car parks and the mutual agreement on open space between different generations.

Improving the renovation of existing multi-family housing in Japan by Open Building

Kazuo Kamata

The situation of multi-family housing and their renovation in Japan

Multi-family housing in Japan

Historically, Japan had terrace houses but not multi-story houses. Even in the 20th century before World War II, RC multi-family housing was uncommon. However, there was so-called “Dohjun-kai housing”, which consisted of 16 housing estates, each with 2,500 units which had been built by the foundation for victims of the Great Kanto Earthquake disaster of 1923. After the war, the Ministry of Construction and the Japan Housing Corporation (forerunner of the Urban Development Corporation) actively built RC multi-family housing. Especially from the 1960’s, in order to accommodate the population influx into major cities, many big housing estates were built and prefabricated construction was promoted. These technologies spread to the private housing sector and multi-family housing has become the main form of urban housing. According to housing research done in 1998, multi-family housing comprises 38% of all Japan’s housing, and an impressive 53% in Tokyo.

The characteristics of each kind of multi- family housing

Owner-occupied housing:

This type of housing makes up 18% of the total multi-family housing and most of it was built using RC construction. Ten percent of this housing was built before 1970.

As the maintenance of this type depends on each co-occupant cooperative, maintenance levels are very different. Some old housing in good locations and with remaining floor area ratio has been rebuilt, and a few middle-rise-housing units in the suburbs have been extended. On the other hand, there are many housing estates that may be declared decrepit in the near future.

Publicly operated housing:

prefectural governments and municipalities build this housing with governmental subsidies for low-income bracket families. This makes up 11% of the whole, and 23% of this was built prior to 1970.

In this type, wooden terrace houses that were quickly built after World War II were rebuilt as RC multi-story housing. Some middle-rise housing has been extended by the addition of a single room with a bathroom. Recently, the renovation of individual buildings has started.

UDC and other public housing:
This housing makes up 5% of the whole and most has been built using RC construction in major metropolitan areas. Forty percent of this housing was built before 1970.

While in the past, UDC extended the structure of terrace houses and middle-rise housing, from the 1980s UDC activities have shifted to the rebuilding of old housing estates built prior to 1965. Moreover, the remodeling of vacant housing has also started.

Rented private housing:
This housing makes up 55% of the whole. Of this, 35% are wooden structures and 65% are made of other materials. About 10% of this housing was built before 1970. The floor area of these units is generally small and a portion of these units incorporate shared facilities. There are as yet no renovations planned for this type of housing.

Company supplied employee housing:
While recently the amount of this housing being built has been decreasing, it occupies 8% of the whole stock.

Renovation implementation methods

While Japan is notorious for its demolition and rebuilding development, with regard to RC multi-family housing, the number of rebuilt houses has not been very large. As mentioned above in the section on publicly operated housing, mainly wooden terrace houses have been rebuilt as RC multi-family housing. UDC has rebuilt RC housing at the highest rate of all housing and the proportion of the rebuilt houses to all UDC housing stock is 20%. In owner-occupied housing, the rebuilt houses make up only 0.2% of the whole. In addition, the recent economic depression has made demolition and rebuilding development difficult.

On the other hand, the renovation of existing houses remains mainly at the level of repair work. However, some types of renovation have been undertaken, such as the following, and many people in Japan are now recognizing the importance of renovation.

Extension of housing units:
This was implemented first in publicly operated housing as a result of residents' movement. One room with a bath has been added in front of each housing unit in a large number of 4 and 5 story housing. In some UDC housing and a few owner-occupied housing this method has been undertaken in almost the same manner of construction way.

Restructuring of housing units:
In order to make lager housing, two housing units have been combined into one, either horizontally or vertically. This method has been implemented in publicly operated housing in the case of occupied housing and before occupation in UDC housing.

Remodeling of owner-occupied housing units:
In owner-occupied housing the remodeling of each housing unit has been done in large numbers at the residents' request and cost. Therefore the extent of remodeling is very wide.

" Super reform" (Renewal of Support and Infill):
the Tokyo metropolitan government instead of rebuilding a few years ago undertook this method. This includes the installation of elevators, the renewal of common service devices and the remodeling of individual housing units.

"Renewal" (Remodeling of Infill):
In order to meet current needs, UDC remodels vacant houses when former residents move out.

Improvement of residential environments:
UDC have improved the external environment by building car and bicycle parking space, renewal of play lots and common gardens.

3. Improving the renovation methods by OB

We can characterize these renovation methods by a three-level concept, which is proposed by Open Building in the table, and point out problems of renovation in Japan. The area of multi-housing units is smaller than the area of detached houses. Especially in publicly operated housing and UDC housing, the floor space per person was very small, and therefore the object of renovation mainly has been to make larger housing units and shifted to Infill with Support (See table).

Renovation Implementation Method	Three Levels		
	Urban Tissue	Support	Infill
Demolition and rebuilding developmen	-	-	-
Extension of housing units		-	-
Restructuring of housing units		-	-
Remodeling of owner-occupied housing			-
"Super reform"		-	-
"Renewal"			-
Improvement of residential environments	-		

Renovation methods characterized by three-level concept

It should be noted that the structure of Japanese households has changed with the aging society coupled with the decreased birth rate in addition to the breakdown of household members into smaller units, so the expansion of floor space is no longer the biggest objective. On the other hand, as it is predicted that the number of households will decrease in the near future, it is not necessary to increase the number of housing stock. The demolition and rebuilding development intended to raise the land use ratio and the density of residential areas no longer have social importance.
Therefore, I have attempted to reconsider multi-family housing in Japan in terms of the three levels given above, in order to improve the renovation to meet current housing situation.

Urban Tissue Level
A large amount of multi-family housing is built as housing complexes. These housing complexes are on large sites with much open space, which is lacking in the ordinary residential areas around the housing complexes. Therefore, in the Urban Tissue level, the renovation of multi- family housing should include the role of revitalizing the surrounding area. For example, building social facilities or reserving some areas for temporary place of refuge (important in Japan because of the constant threat of earthquakes), which is implemented in cooperation with local governments. These activities improve the quality of the housing complex itself.

Support Level
In the Support level, there are problems that require resolution, especially in housing built before the 1970s, but the structure itself is not yet excessively old and can be safely occupied for at least another 30 years. The problems include aged common service equipment, the lack of elevators, etc, and these can be renovated within the exiting structure. In consideration of the Earth's resources, rebuilding development should only be done when the structure becomes unsafe.
One issue to be solved is that the cost of renovation is often too heavy a load for residents. Subsidies from the national and local governments should be invested in renovation at the Support level, as in redevelopment projects designated by law.

Infill level
While a large amount of remodeling in Infill level has been undertaken and is fairly common, there are also some problems that require solutions. The first problem is how to increase rental housing remodeling based on individual residents' needs. The range in which residents themselves can remodel their rental housing is limited because of problems when they vacate the unit. Therefore, DIY renovation is not common in Japan. The second is how to establish practical rules that allow the resident to conduct partial Support repair at the time of remodeling the Infill. While structural safety is all-important, the present rules are too tight to allow efficient Infill remodeling. The third problem is how to improve the skills of contractors who conduct the Infill work. In owner-occupied housing the

remodeling is undertaken by just the resident and the contractor, so the quality of the work cannot be professionally judged. A third party should be involved, as the occasion demands.

4. Synthesizing

To meet current housing needs, renovation methods synthesizing the above-mentioned three levels is necessary and attempts to implement the synthesized renovation method have recently been started by several sectors in Japan.

Notes on Teaching Open or Agile Architecture

Dr. Stephen Kendall, AIA, CIB
Assistant Chairperson, Department of Architecture
Director, Architecture Futures Institute
College of Architecture and Planning, Ball State University, USA
skendall@bsu.edu

Notes on Teaching Open or Agile Architecture

ABSTRACT

This paper discusses problems of open or agile architecture pedagogy in two design studios in a professional architecture program. One studio focused on residential mixed-use architecture; the other on office architecture.

Agile or open architecture assumes that buildings adjust over time to remain valuable and attractive. Further, control over such adjustments is distributed at a variety of decision levels. Every intervention sets out a context for another party to follow: one party makes form and space that is later occupied and then altered by another party.

For students learning new skills and knowledge - and for their teachers - this reality of an “open architecture” is important because it matches reality. Yet the full force of this picture seems to elude much of our teaching in many areas of professional design education. This is particularly so in the architecture studio, at least in schools of architecture in the US. It is there that the idea of the changelessness of buildings is planted. It is also there that other problematic attitudes are planted and cultivated - the primacy of the “program”; the exclusive importance of the designers’ self-expression; the assumption of unified control; and the search for the unique and singular, among others.

The paper describes in some detail the way two agile or open building studios were organized. From these experiences I outline several general problems and several principles that may assist teachers in releasing students of architecture from a trap of narcissistic self-expression and schizophrenia before they enter practice.

KEY WORDS: agile, open architecture; design studio; design pedagogy; architectural education.

Notes on Teaching Open or Agile Architecture

Dr. Stephen Kendall

Agile or Open Architecture

Two recent experiences teaching open or agile architecture studios have reacquainted me with predicaments that are probably faced by all teachers of open building. The predicaments concern an issue at the center of architectural practice, and therefore properly at the center of discussion about the future of architectural, interior design and engineering education. The issue is the following:

How do we design buildings to support both longevity - in respect to more enduring community or shared interests - and change - in respect to more dynamic and varied individual preferences?

This question has appeared on the doorstep of architects worldwide as part of our adoption of "sustainability". It is certainly one of the critical issues professionals must address when designing new buildings or adjusting and improving the building stock we have inherited.

It happens that agile or open building provides useful insights and practices in regard to this question. There is ample evidence of this in practice, if we look closely. Certainly, buildings have always been adapted, adjusted, and rehabilitated. (3)

The issue I highlight is especially problematic in the academy. It is difficult in part because it makes us reexamine the knowledge and skills - and the ideology - inherited from the Modern Movement. The discussion that follows concerns the distance open or agile architecture takes us from the tenets of modernism. It may also explain in part why the sustainability agenda has been taken up with only limited enthusiasm in schools of architecture outside the mechanical systems and building materials arenas of study

Limits of Modernism

One of the main pillars of modernism is programmatic functionalism, or "listing". (13) Programmatic functionalism refers to the practice of listing and then fixing a detailed and well ordered "program" (or "brief") of functions or human activities, and assembling building forms around it while knitting the ensemble into a whole with complex strands of columns, beams, slabs, wires, pipes and ducts. This picture is drastically oversimplified, but is nevertheless accurate in its main points. The "program" is usually considered as the "starting point" for conceptualizing the design and guiding technical solutions. It is the first thing given to students in a design studio, and the first thing that a practitioner seeks from

the client.
Despite the apparent reasonableness of the “program” as starting point, a given “program” does not lead in a direct way to a certain “form”. The same “program” given to a number of architects - or students - will result in an equal number of “designs”. As Habraken has pointed out, “the form must be there first. Once we have a form, we can assess what functions it can hold...the idea that program makes form is a vestige of the functionalist approach of Modernism.” (7)

Of course, this begs the question of where forms come from to begin with, a subject that deserves attention elsewhere.

Rooted in the strangely attractive formula “form follows function”, reliance on “program” and “function” emerged in the late nineteenth century during a period of increased adherence to a kind of false scientific rationality in all professional fields. This attempt to align designing with science and rationality accompanied an upheaval in society to which the design and planning professions were not immune. In adopting “scientific rationality”, much conventional knowledge about form types, spatial and territorial order and systems was discarded. These conventions were replaced by a kind of pseudo-science that masked a new ideology of style, formal determinism, professional control and deep mistrust of conventions and non-professionals.

New ideas about design education accompanied the movement to ground designing on scientific theory and theories of functional optimization. The Bauhaus course, which still dominated US schools of architecture into the 1960’s and in which I was educated, assumed that knowledge and experience about architecture gained before entering the academy was suspect and polluted. Just as today we clean our computer hard drives and install new memory and operating systems, the Bauhaus course advocated mental house cleaning. It offered a broad new start - preferably from a clean slate. This indoctrination - adopted internationally - aimed to sever aspiring designers from conventions, from their own experiences, and from the public at large.

The Bauhaus, with all that it offered of importance, was a way of establishing a distinct and separate professional class and ideology. It also begged the question of the value of precedent, type, conventions and the social construction of systems and occupation of space. A great deal of later work reinforced the premise that designing had a scientific basis. (1) (12)

There is ample empirical evidence that social and organizational dynamics, and developments in building technology - particularly new systems for indoor climate, electrical and plumbing services and communication - have rendered the old notions of programming to be radically flawed. Today, buildings undergo constant reuse and internal reconfiguration with the result that the idea of a fixed “program of functions” has lost its meaning as a starting point for building design. It should be clear that a more nimble, robust, and historically grounded understanding of the relation of form and function is needed. (6)(9)

New Developments in Practice

Despite the baggage of modernism, the failings of the natural and social science models applied to designing, and the difficult challenges in making a sustainable built environment, certain developments in practice give reason for cautious optimism. (5) We see the end of ways of thinking and practice that have dominated architecture and planning discourse among the professions and in the general public for generations. Programmatic functionalism in the built environment has infected both urban planning and architecture. But it is finally being put to rest, although few will admit it, and even fewer know what can replace the now obsolete avant-garde.

Advanced practices in industry, in architecture and interior design practices show new ways of working. Meanwhile, not unexpectedly, much theorizing remains “much ado about nothing”, or, paraphrasing Buckminster Fuller - more concerned with “garmentation” than with what happens in the built field in any fundamental way. (2)

But if reliance on stale modernist beliefs is coming to an end, overthrowing or replacing a dominant convention in architectural theory and education is no small project. If a change is to happen - if a new avant-garde is to appear at the forefront of education - it will help if we take time to learn from the built legacy of the past hundred years, and at the same time, take stock of new developments in the real world.

The principle lesson, in my view, is that the increased complexity of the built field has led to the emergence of new ways of organizing the built field suited to the new realities. These new ways of working relate not strictly to technical criteria but also to levels of control (6), because buildings are about people (exercising power) and things (the parts people control). However, because the built field is complex and dynamic, it’s actors and their habits many and varied, and its condition often confusing, the lessons offered by careful observation of reality may be missed at first. So - as any teacher knows - the message needs to be offered repeatedly by many people, in many ways.

I ask that you see the studios described in what follows against this backdrop.

The Housing Studio

The housing studio had two phases. In the first seven-week phase, students were each asked to rehabilitate an older twentieth century building that had been a furniture store. Three stories in height and occupying a corner site in the downtown of a mid-sized town, it had been abandoned but recently re-made into an apartment building with professional offices on the street level. It had a steel frame and limestone cladding with large windows. Parking was offsite.

The task was to make it into an agile or open building: residential units on the upper two floors and commercial spaces on the street level. The students were expected to “edit” the building back to a “base building”, and to explore a variety of interior layouts before settling on a final scheme.

Students were also allowed to alter the facade, but were asked to retain its basic historic character. I encouraged students to consider that the exterior facade - or part of it - of each individual occupant’s space could be determined on an individual basis by either the base building designer or by the occupant’s designer, following certain design rules. Students were asked to take a position on this and design accordingly.

I had previously taught a studio in this way (10) and had some idea of the process of “editing” an existing building back to its base architecture. I also showed them a number of examples of residential agile or open architecture. (11)

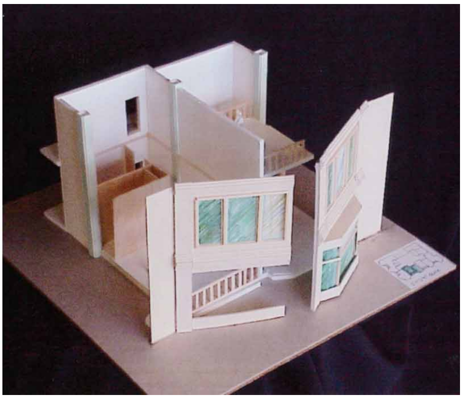
The idea of starting with a rehabilitation project was to
- Manage complexity by limiting the number of form and context variables
- Learn to design on levels related to distribution of control
- Learn to “edit” an existing building to make way for new forms and uses, and
- Bring out the idea of facade variety within constraints.

In the second seven-week phase, students had an opportunity to design a completely new building on an immediately adjacent site. The new site was almost an exact mirror image of the first: same gross floor area; a downtown site of the same character and size; the same hierarchy of facades (two facing major streets, one facing an alley, and one on a property line); the same story height; and the same mixed use functions.

Students were asked to assume that the design process would occur in two stages: a base building and a fit-out stage. They were also allowed to select a strategy for the facade as before. I pointed out with examples - both contemporary, historical and international - that the question of distributed control of facade design was not new - that all shopping centers and all downtown building facades were ‘living” facades in this sense.

Each student was to select one of their fellow classmates’ schemes as the “neighbor” for their new building, and to relate to it in some direct and positive way. This was part of an effort to enliven the idea of “designing in context”.

In this phase, I expected that some of the knowledge gained in the first phase would easily transfer into the new building, allowing much more focus on the study of variable dwelling units and adaptable facades and increased technical “depth”, concerning structure, mechanical systems and façade systems design.



Images of original building + student model of the proposed renovation)

The Office Building Studio

This studio was announced as "The Agile Office Studio". These students had just returned from 6 months working in architect's offices as part of their "internship" requirement. I explained at the first meeting of the studio group that the studio was organized in three parts:

Phase One: research
Phase Two: base building and site design
Phase Three: tenant programming and interior fit-out design

All of the schemes were to be variations on an "enclosed atrium building". The research would be teamwork, the base building work was to be individual, the tenant programming was to teamwork, and the interior fit-out was to be individual work. The fit-out design work was to be done by each student in a base building designed by another student, and the design responsibility for the enclosed atrium facades would be distributed between the base building and the tenant designers.

The work began with a series of lectures on the modern office building. We discussed the phenomenon of "churn" or constant tenant turn-over, and the problem that architects faced when making a base building design with no fixed program of functions. The research phase and readings addressed:

- Building economics
- Building energy utilization
- Trends in the office environment
- Worker productivity
- Case studies of exemplary contemporary office architecture

We took a field trip to a Workstage building developed by a new company formed from an alliance of a large furniture manufacturer (Steelcase); a national real estate, development and construction company (Gale and Wentworth) and a large national financial lender and investment broker (Morgan Stanley Dean Witter). Workstage delivers, for lease, customized high quality office buildings using a standard "kit-of-parts" whose footprint and facade can be customized. Office interiors are furnished by the Steelcase "Pathways" interior fit-out system. (www.workstage.com). We also visited the corporate offices of Haworth, another very large office furnishings manufacturer.

At the same time we examined a number of alternative downtown and suburban sites for the agile officer building. All sites required new buildings in the range of 3000m2, on two or three floors. Students were required to select as starting points one of several choices of structural, mechanical, and facade systems.

I assigned an in-class exercise to acquaint students with the problem of "bay size" relative to office interior layouts. Each student was given an A4 sheet of paper showing a pattern of piers, offering two spatial opportunities - one large and one small - the larger being twice the smaller. Students spent several hours experimenting with arranging normal office furnishings in a variety of configurations with the piers as constants. I also introduced a variety of technical solutions to horizontal distribution of air-conditioning, plumbing and cable management systems.

At the conclusion of the site studies and research presentations, students began their base building designs. I imposed two basic architectural constraints. First, all schemes must have an interior "atrium", shared by all tenants. Second, each student must take a position relative to the treatment of the exterior facades. The choice was either that the base building architect would determine the exterior facade in its entirety, or the facade could be determined in part by the tenant architects. I had already said that the design decisions for the interior atrium facades were to be distributed.

The base building designs were completed and presented.

We then began the second design phase, starting with a programming exercise. I had arranged with several local corporations who were willing to be "surrogate" clients preparing to move to new offices. Pairs of students visited their current offices, photographed them, conducted interviews and obtained floor plans.

This information was the basis for the selection by each student of the base building in which their "surrogate" company would be relocated. Each student selected one of the base building schemes designed by a fellow student in the previous phase of the studio work. Drawings were obtained from their fellow students, and interior design and atrium facade work completed. Students were required to show drawings, interior perspectives, physical models and samples of materials and catalogue illustrations of furniture, ceiling, and lighting selections for each scheme.

The “surrogate” clients attended the final project reviews along with visiting practicing professionals.

Images of Base Building and fit-out

Pedagogical Problems

These experiences revealed several problems.

Recognizing Levels

First, students are unfamiliar and uncomfortable designing with the concept of levels. Levels suggest that built form is hierarchical and not seamless and unitary. Levels suggest that under certain normal circumstances, decisions may not all be made by one party, but can be - and usually are - distributed among a number of parties and designers. Levels make us face the inevitability of change. Levels also make us recognize that change is not uniform but occurs in an organized way, also under distributed control. Students who have worked in offices come to recognize this intuitively, but in the safety of the academy they return to the more comfortable assumption of unified control. Some students complain that the studios in which levels are used do not allow them to express themselves enough. The distribution of control of floor plans was difficult, but the distribution of control of facades completely baffled the students.

Designing with Constraints

The second problem I find is that open building teaching places a strong emphasis on constraints, of various kinds, and evaluation of alternatives generated by constraints. Some constraints can be selected by us (design concepts), while some - as in the real world - are given. Open building design demonstrates the importance of a good grasp of how to conduct evaluations in an explicit way. This makes students pay attention to rules. These points makes many students very uncomfortable, because they often operate with the false premise that creativity has to do with being unconstrained and implicit.

Designing without Program

One of the constraints typical to studios - a program of uses as a starting point- is not a governing one in open building teaching. In open building teaching, functions meet form, but form comes first. Form can be evaluated for the range of uses it will support. Not surprisingly, many students find themselves without any basis for designing when no program is given or when multiple programs must be accommodated. This makes the students realize that they have weak form knowledge, an uncomfortable feeling and one that gives rise to difficulties.

Using Research

The third problem is that open building teaching cannot and does not hinge on questions of the designer's personal preferences alone. Open building teaching does not ignore such issues, because no designing can be done without the designer's personal preferences. Open building designing is a kind of designing that - in addition to such personal issues - emphasizes a set of skills and methods needed for effective communication in reaching agreements. This includes studying variants on a given theme, exploring capacities across levels, and so on. Most studio experiences are not focused on reaching agreements but on forcing the designer's personal opinion. Given the focus on personal expression, many students feel that too much time is spent on research, on "warming up" exercises, and on making decisions explicit and verifiable.

The Studio Tradition

These problems are endemic to the studio tradition. I have yet to find an exception. Bringing students face-to-face with them, and altering expectations, is problematic, uncomfortable, is against the grain and often fails. Students often complain loudly. Faculty colleagues are uncomfortable since their assumptions are also questioned.

This is because studios are a "sacred cow" in schools of architecture. Studios are a vital part of design education but their importance is threatened by excessive expectations.. They are a "black hole" into which much is lost. (8) They are dominated by self- expression, criticism and synthesis, all of which are valuable if overstressed. Studios are a competitive race to the finish in which little is shared among the students. Studios are about "one-off" projects, personality, and the studio master's values. There is little patience for substantive attention to methods, skills or capturing knowledge for future use. Studios take too much time, too much of which is wasted.

A Design Workshop Sequence

My conclusion is that architecture curricula need another kind of course sequence called *design workshops*. These are needed to avoid forcing the studio to provide everything concerned with the development of design skills and knowledge. Workshops are needed to teach fundamental principles of designing in a developmentally sound way. Just as there are parallel course streams in building systems, building structures, history, computers, and sometimes-social factors - all focused on certain kinds of knowledge and skills in a developmental way independent of the studios but with reference to them - there also needs to be a course stream that teaches how to design, independent of the specifics of program.

Such courses would help everyone teaching studios. Design workshops would build the skills and knowledge needed to operate with form complexity, change and distributed control, central to all designing. Without such skills, students will inevitably find the reality of open or agile architecture to be a force fit in the studio environment and will reject it.

There is a pressing need for this discussion to occur in academic circles. Certainly my experiences cannot be unique. These issues go to the core of professional education. A future international conference of CIB W104 should focus on teaching agile or open building and examine experiments in the idea of design workshops.

Footnotes

(1) Alexander, Christopher. Notes on the Synthesis of Form. Harvard University Press, Cambridge, 1964.

(2) Banham, Reyner. Theory and Design in the First Machine Age. Praeger, New York, 1960

(3) Brand, Stewart. How Buildings Learn. Viking, New York, 1994.

(4) Elliott, Cecil D. Technics and Architecture, The Development of Materials and Systems in Buildings, MIT Press, Cambridge, 1992.

(5) Fassbinder, H., and Proveniers, A. New Wave in Building: A Flexible way of design, construction and real estate management. Van Gorcum, Maastricht, (ND)

(6) Habraken, N. John. The Structure of the Ordinary: Control and Form in the Built Environment. MIT Press, Cambridge, 1998.

(7)Habraken, N. John, Tools of the Trade, unpublished lecture at the MIT Department of Architecture, 1996.

(8) Habraken, N. John. “Around the Black Hole”, Plan, MIT Department of Architecture, 1980.

(9) Kendall, Stephen, “Base Building and Fit-out: Principles for 21st Century Building Maintenance and Management”. RE - Building Maintenance and Management. Tokyo (in Japanese), October 1999.

(10) Kendall, Stephen. “A Base Building Pedagogy”, Journal of Architectural Education, vol. 43, no.2, 1990; pp 29-41.

(11) Kendall, Stephen and Teicher, Jonathan. Residential Open Building. Spon, London,

1999.
(12) Simon, Herbert. The Sciences of the Artificial. MIT Press, Cambridge, 1969.

(13) Zevi, Bruno. The Modern Language of Architecture. Van Nostrand, New York, 1981.

Living Façades

Elena Kobets-Singh, Student
Stephen H. Kendall, Professor
Singhelena8@hotmail.com

Department of Architecture, College of Architecture and Planning,
Ball State University, Muncie, Indiana, 47306, USA

Living Façades

ABSTRACT

Contemporary buildings can be classified in the concept of “open building” as being composed of a serviced skeleton, fit-out and envelope.

This paper report on a study that concentrated on the building envelopes or (facades) and their qualities to transform under distributed control over time. Façades are defined in relation to control. This study revealed that the Façade is an arrangement of elements, identifying boundaries between territories operating on different levels.

Elements forming boundaries between territories on the same level display different qualities and are called demising elements. Specific qualities of the facade that can allow “growth” as any form of transformation, including addition, reduction or simply relocation of the elements, and therefore can make façades into living configurations.

The presence of “margins” has been identified as one of these qualities, where a Margin is a specific part of a territory, located adjacent to the boundary, which displays characteristics of both neighboring territories. These characteristics are illustrated by case studies of traditional settlements and newer housing developments and show a variety of ways “living” façade can manifest.

Examination of relations between property boundaries and positions of the margins are opening an experimental field for architectural development. At the same time, lessons drawn from these studies are very surprising at first, because problems identified as preventive for the development of living facades are commonly not “technical”. Most of the case studies bring us to the point where territorial control, if incorporated in the design scheme, can provide all necessary opportunities for “living” façade growth. Architectural decisions, informed by knowledge of territorial control, can facilitate built environment with facades capable to a natural regeneration over time.

KEYWORDS: Open building, facades, territory, control, and margin.

Living Façades

Elena Kobets-Singh

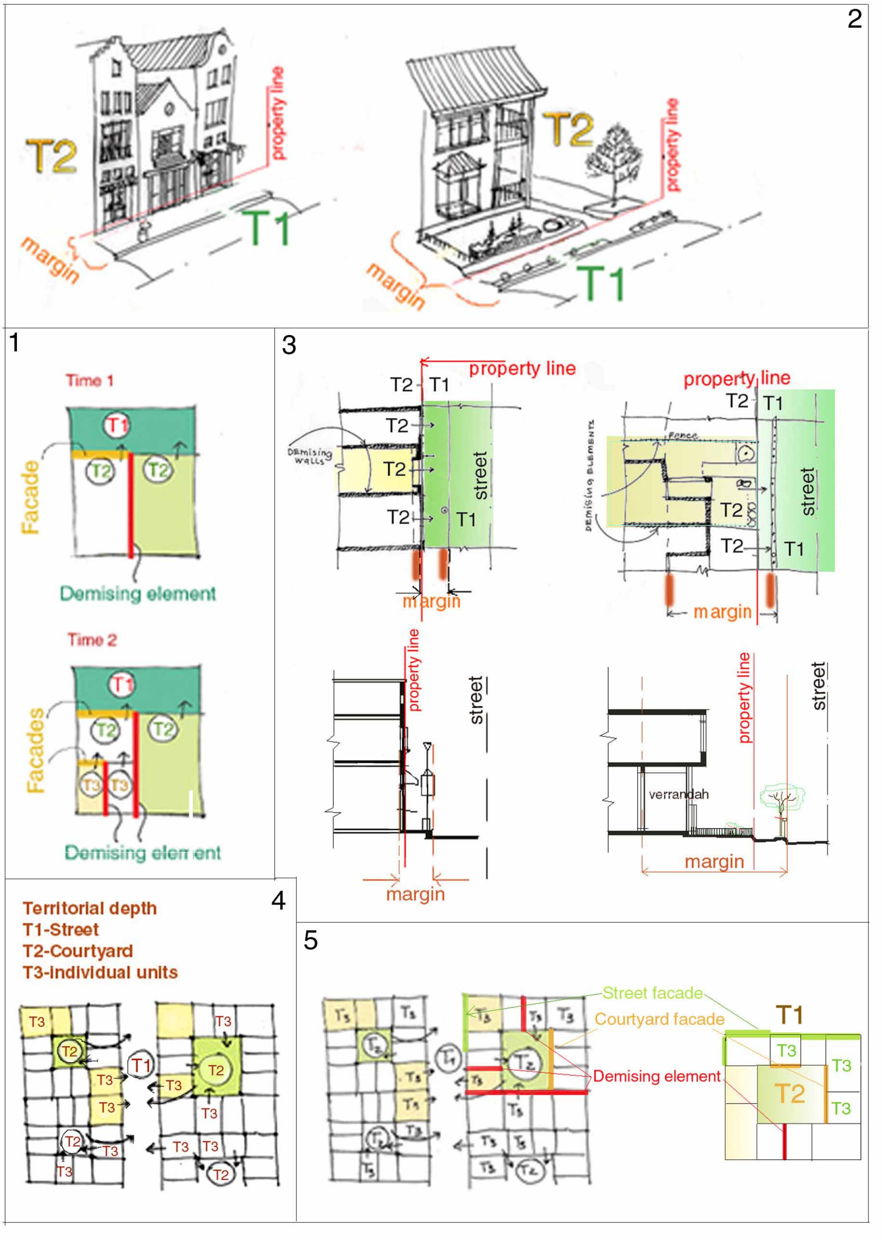
The purpose of this study is to *clearly observe and describe qualities of façades under distributed control and to identify qualities allowing façades to become living.*
Contemporary buildings are sometimes described as being composed of three major systems:
1) Serviced skeleton;
2) Fit-out;
3) Envelope.
Our study was about the building *envelope's* behavior under distributed control over time. The field of our study covers issues of territorial control, hierarchical relations of territories, boundaries and transformations of physical elements acting as facades.
We started by examining numerous situations in which these issues were evident. For example, apartment buildings have many independent powers acting together in different situations. Often, they face difficulties in transforming their environment when the whole building is divided into smaller territories, and where control over building elements and spaces in it are distributed. We realized that, while some theoretical and applied understanding has developed around the idea of delegated responsibilities for planning of the interior spaces and "infill" of "opens buildings", there are difficult questions still to be asked about flexibility and changeability of building facades.

Defining terms of reference.

Several key terms need to be defined.
Power is the "ability to change physical reality" by " individuals, groups, organizations and institutions, who are *in control* of parts of the site and therefore can change it". (1) Any change of the environment implies action of the power on the site.
Control is the ability to transform or relocate physical elements; control of space is the ability to regulate admittance.
Live configurations are arrangements of form under control of a power.
Territory is a space, or an arrangement of connected spaces, under control of one power.

Façades

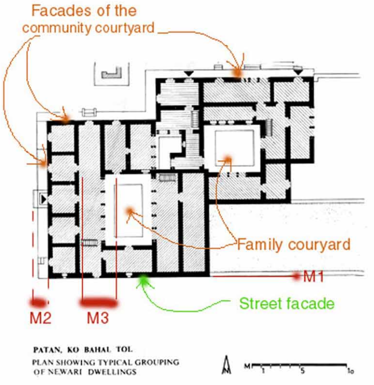
- *What is a Façade? How can we recognize one, when we see it?*
It may help to look at this question from the point of view of territorial control.
Boundaries of spaces are very important in defining the façade, because one of the clearly visible characteristics of territory, a bedroom, for example, is to have walls protecting it and separating it from adjacent spaces. In architectural terms we can recognize the wall between the room and the outside space as a façade.
- *Can we name all elements of the enclosure, defining boundaries between spaces, as facades?*


2
T2
property line
margin
T1
T2
property line
margin
T1
1
Time 1
T1
T2
T2
Facade
Demising element
Time 2
T1
T2
T2
Facades
T3
T3
3
property line
T2
T1
T2
Demising walls
T2
street
T2
T1
margin
property line
T2
T1
street
T2
T2
T1
margin
property line
street
margin
property line
street
verrandah
margin
4
Territorial depth
T1-Street
T2-Courtyard
T3-Individual units
5
Street facade
Courtyard facade
Demising element
T1
T3
T3
T2
T3

Walls are examples of boundaries, with fascinating richness of meaning attached to this simple word. We recognize that walls separate and protect, while representing the character and values of the power controlling the wall. " Wall is one of the most incontrovertible statements a ruler (for us power) can make, yet is often signifies a certain weakness or vulnerability."(5) We also can use this meaning to describe how people can create "space" for themselves in relations to others, thus reflecting psychological boundaries.
The case studies in this paper, and discussions with colleagues, revealed some essential differences in qualities of boundaries, depending on the hierarchical relations between the territories sharing these boundaries.

Definition 1.
The façade is a physical configuration that identifies the transition from one territory to another, where one of them is on a higher level in the site hierarchy. That is, a *façade is an arrangement of elements identifying a boundary between territories under hierarchical dependency.*
At the same time, certain enclosure identifying boundaries between territories on the *same level* cannot be named facades. In the U.S. real estate industry, for example, this kind of enclosure element is called a *demising wall*. This is a shared separations between territories, also called "party walls", e.g. walls controlled by neither party independently, but by either a higher party such as the building owner in a multi-tenant rental property, or the group of powers, consisting of two occupants sharing the wall. A schematic representation of relationships between a higher territory T1 and included territories T2 is given in diagram 1. Here we can see differences between boundaries T1/T2 (façade) and T2/T2 (demising elements).
Diagram 1 describes the *development of territorial depth over time*, and can be used to clarify specific positions of the façade as a boundary between the lower and higher territory, and demising elements as boundaries between territories on the same level.
- When are the façade elements and the elements of the territorial boundaries the same and when they are different? What happens when a territorial boundary and a facade do not coincide; what happens when they do?
Interaction between form and space is very complex, and here I need to quote again from Habraken: " The "built-unbuilt" separation has its own autonomy different from the autonomy of territories". (1)
By observing relations between elements of the enclosure and territorial boundaries, two basic situations can be identified: 1) the situation in which some façade elements are located on the territorial boundary, and 2) the situation in which elements of the façade are shifted inside the territory, thus establishing a certain intermediate space. This intermediate space will be named '*a margin*'.
Sometimes in reality we can observe that elements of the façade protrude across a boundary line into the higher territory. Other examples show less ambitious extensions. Secondary elements (porticos, decks, landscape, and signage) usually occupy these spaces between boundary of the property and physical boundaries of enclosure. These examples display the possibility of having elements of the façade that do not identify with

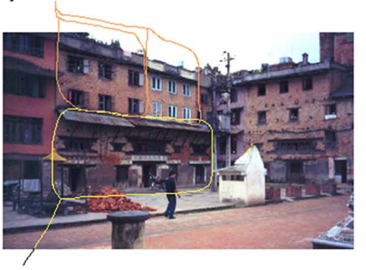
6



M1- margin between street and the house
M2- margin between shared pablic space and the house
M3- margin between individual spaces and the family commons

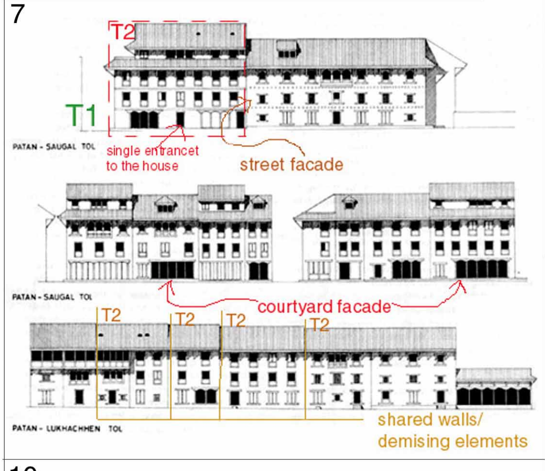
8

Two newer territories could be identifyed by differences in facades of the later additions.

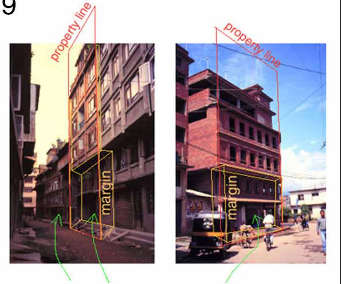


Facade of the initial house, constructed as a single territory

7



9

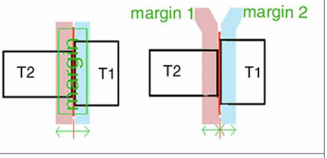


10

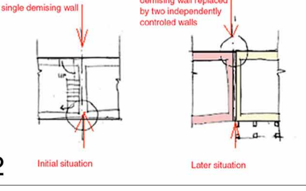
Street facade

Community courtyard facades

11



Typical situation,after division of the property, two new territories developed independently. Initialy a dimising wall, after additions and reconstructions converted into groupe of two independently controled walls.



12

elements of enclosure. This new group of elements controlled by a “lower” territorial power and located within a margin, exposes us to a new way of talking about live configurations of boundaries. These elements have an ability to be changed and modified according to temporary needs of the controlling power.

These secondary elements controlled by a territorial power and located within the margin can be subdivided into two groups,

1) elements of the façade and

2) elements identifying boundaries.

Usually regulations established by “higher” powers are the way of influencing distribution of these elements.

Definition 2.

A margin is a specific part of a territory, located adjacent to or straddling the boundary, which displays characteristics of both territories, where elements of both can interact (2-3). The façade margin is the space within which elements of the façade are located. Relations between façade elements and façade margins are something to be described with the help of Case Studies. In addition, specific qualities of boundaries between territories on different levels will be analyzed according to the discussion above and also the specifics of traditional settlements of the Kathmandu Valey, Nepal.

Case Studies

Two building types

To illustrate some characteristics of the Façade, I look into traditional settlements of the Kathmandu Valley in Nepal. This area attracted me because of its unplanned character, which promised the possibility to discover “natural” qualities of the facades as they developed over a long period of time. Traditional urban settlements in the Kathmandu Valley are largely based on the courtyard house type. To describe the typology of the Kathmandu settlement, a number of examples will be used, starting from smaller courtyard buildings to larger urban fields of the same (courtyard) structure (4- 6).

Bahal (or Vihar) is the name for a common building type, which is also the purest form of the courtyard house. Establishment of the Bahal as a type can be traced to more than 2000 years ago. Descriptions of the type date back to the Buddha’s visit to Kathmandu, when He was staying three years in one of the famous monasteries, Cha Bahil: the place was “ *spacious and enclosed by walls*.”

Some examples, like Chhusya Bahal, a building surrounded by streets, are the simplest and smallest examples of this building type.

Maha Bahal or (Great Courtyard) is a name of a family or community courtyard. This is a higher level of development of the same type, and has become the basic morphological element of the urban fabric in medieval Kathmandu Valley. It is still the defining structure of the city core.

There are two typical locations of the Bahals within the city fabric. In the first example Than Bahil, (Bahil is one of the forms of Bahal), we see the type surrounded by it’s settlement.

This is a good example of changes of the territorial boundaries over period of time. Demarcation of territory has occurred by building a row of rooms around it every time it had been extended. Now we can see how over a long period of time, each extension left traces of walls, which used to be the boundaries of the Bahil, but are now included into the enlarged courtyard.
The next example shows how the city fabric restricted the territory of the Bahal from growing. In these examples we can observe how this type of courtyard house became a territorial structure of the urban fabric of the entire city. Smaller courtyards on both maps are the individual family houses, while bigger courtyards are communities or groups of distantly related families. Territorial depth of such formal organizations can increase over time, when density increases. Then, some of the single-family courtyards change into courtyards for group of new families. This happens, for example, during the division of the house as a form of divided inheritance between the sons.

Facades of the traditional courtyard

The diagram (1) is used to illustrate change of territorial depth over time. It does not show some of the aspects found specifically in the *courtyard housing system*. To illustrate the change of territorial depth in the courtyard-based structural organization, a similar diagram can be used.
Schematically, the structure of the “courtyard house” type at any level of territorial depth is simple and can be described as common space surrounded by individual units.
In terms of our study of facades, courtyard houses can illustrate qualities of the facades of two hierarchical levels: façade of a given level and façade of the sequentially next higher level (4, 5).

Traditionally, the owner of the land owns the house built on it. This simple horizontal distribution of ownership allows us to observe specific qualities of the facades constantly undergoing change, while distinguishing it’s specific qualities from qualities of other territorial boundaries.

Case studies of facades in traditional building types

To illustrate observations of the façades in the context of the traditional housing in Kathmandu two specific examples can be used.
- *Another example of the smallest form of courtyard type building* is the house for one extended family (6), usually of complex structure. A minimum of three generations typically lives together. The living spaces and circulation areas usually enclose a courtyard or a series of courtyards.
The street façade (7) has one entrance to the house, small windows, and doors to the retail shops or to the storage spaces on the ground floor. Upper floors have windows overlooking the street, commonly placed there in order for inhabitants to observe activity on the street.
The courtyard façade (7) typically has a colonnaded verandah on the ground floor, providing ground level access to the storage rooms and staircases. Upper floors have bigger windows or frequently decorated balconies.

The facades of the courtyard have wider margins, compared to the facades located on the street side.

- Maha Bahal is an example of the biggest form of the courtyard system, known as a community courtyard.

This example (8) illustrates territorial depth and also reveals the changes over a long period of time. Generational change can be also observed in the change of preferences for materials and forms of the windows in the later additions.

In general the facades of this type can be described according to their location.

The street façade has one entrance to the courtyard and many doors for the retail shops, frequently rented. This façade also provides access to some traditional public resting houses attached or built into the wall, especially at the street corners. Upper floors are descriptive of their functions, and are decorated and designed to provide the chance to observe the street from the privacy of the rooms. The street façade also has visible protective qualities, becoming the face of the family business in the form of the retail shops, usually accessible only from the street. Upper floors are not accessible from the ground floor but have visual connection to the street in the form of beautifully carved windows permitting views from the house and protecting occupants from being observed from outside.

The courtyard façade (7) has main entrances and staircases usually located there, as well as small windows to the storage or bathrooms. The first floor has the main room's windows and one or two upper floors have comfortable windows from bedrooms. Kitchens usually do not have any windows and are located in the attics.

The courtyard façade, as described, has a more open character, has visible entrances to the upper level of rooms and provides communicating areas, verandahs and balconies, as well as demonstrates use of lighter materials, traditionally wood.

Façade Margins

Typical streets in Kathmandu provide many examples of the façade margins. Theses street facades (9) illustrate such margins, when elements of the lower floors are recessed into the territory, creating a raised plinth with steps and ramps for cycles. This level can be used by pedestrians as well as by the owners of the shops. The "flatness" of the façades of the upper floors reveals that the margin there is minimal. All other buildings on the street evidently follow the same margin, the size of which is typically regulated by municipal bylaws.

Walls between neighbors in community courtyards are demising walls and definitely express very difficult joints between facades of the two territories on the same level. Initially, the "Joint" is merely visible, but becomes more evident when change occurs. Development of these joints over time is one of the most interesting phenomena in the traditional housing. At first we see just a wall between different rooms of the house. Then it becomes a demising wall after division of the property through inheritance. To enable owners of both territories to adapt their houses according to their new needs, these walls

have to be rebuilt, jointly or independently. Typically two new walls will appear in place of the single wall where the structure permits. In the case of less sound structures, one of the parties gets the chance to dismantle the old wall or even the entire house to rebuild it with new “double” wall in between these two new territories. The traditional structural systems of the houses allow relative flexibility in the location of the crossectional walls (11).
In the examples (10), we can see demising walls are clearly identifiable within the court-yard settlements. The diagram (12) can help to show examples of transformations of demising walls into groups of two independent walls.

These examples illustrate that a margin is a characteristic of the façade, and absence of a margin means absence of a façade. It explains some of the façade’s qualities. It also helps to explain the role of regulations or traditions in influencing lower territorial powers through influencing elements located within the margins. This means that façade elements and façade margins have to establish unique mutual relations according to where and in between which of the territories they are located.

Conclusions and questions for further research

As observed in the case studies, *a margin is the property of the façade*. The size and relative position of the margin to the property line plays an important role in façade transformations. We are also convinced that margins established between territories on different levels can be maintained over time. They are, therefore, one of the constant conditions of façade regeneration.
Relations between territorial boundaries and the margins can be narrowed down to three basic ways.
1) A Margin located within territory T2, but regulated by T1 territory;
2) A Margin located in territory T1, but controlled by T2;
3) A Margin stradding territorial boundary.
Elements of the façade are always controlled by lower territorial power, when sizes and flexibility of the margins typically result from rules and regulations established by higher power. We can observe different qualities of the margins in the first and second options, and a third option can be translated into combination of first two (11). Therefore *Margin 1* is the part of the lower territory, where regulations established by higher territorial power are applied, and *Margin 2* is the part of the territory T1 (higher territory), where elements of the live configurations controlled by lower power could be located.
Different architectural details have been developed over time for facades located within the margins of all these categories. Professionals today may benefit from understanding the factors that shape elements within these traditional situations of territorial control.

This study opens new questions.
- What are the design solutions for these categories of facades with all three types of margin/boundary relations?
- How can these design solutions help in the development of the technical details for contemporary housing with regenerative qualities?

- Which of the margin types are more suitable for establishment of such regenerative qualities of the facades?

At the same time, lessons drawn from these studies are very surprising at first, because difficulties in development of living facades commonly are not “technical”. We learn that “living” functions of façades could be achieved if understanding of the territorial control issues is incorporated in the design process. Architectural decisions, informed by knowledge of territorial control, can facilitate built environments with facades capable of natural regeneration over time. Traditional and unplanned environments can thus be an inspiration for professionals, as examples of living architecture.

Sources:

1. N. J. Habraken, Structure of the ordinary,

2. N. J. Habraken, Transformations of site,

3. N. J. Habraken, J. T. Boekholt, A. P. Thijssen, P. J. M. Dinjens, Variations, The systematic design of supports,

4. Wolfgang Korn, The traditional Architecture of the Kathmandu Valley,

5. Robert Harbison, Thirteen Ways, Theoretical investigation in Architecture,

6. Helmut Wimmer, On stage of Living,

Constructional interface for Agile Architecture

Li-Chu Lin
Instructor, Dept. of Construction Eng., National Kaohsiung First Univ. of S/T
1, University Rd., Yuanchau,Kaohsiung 824, Taiwan, R.O.C.

Dr. Ming-Hung Wang
Professor, Dept. of Architecture, National Cheng Kung University
1, University Rd., Tainan 701, Taiwan, R.O.C.

Constructional interface for Agile Architecture

ABSTRACT
Renovation on infill level has been a critical issue nowadays for many countries like East European countries and those of saturated construction market. Living autonomy through spatial adjustment and environmental sustainability through construction are pursued. Since sustainability has been an emerging issue globally, not only natural environment is fully under threat but also social, economic aspects are closely involved. Although green building, intelligent building are working on energy and environmental issues to a large extent, open building has been recognized as one of the more comprehensively responding theories and methods to sustainability as a whole. This study presents the relations of them, and interface is the key constructional factor of them.

Constructional interface for Agile Architecture

Introduction

Sustainable construction refers to lifelong building practice in environmental, economic and social- cultural aspects. Two concepts are generally accepted as a goal: *dematerialization* and *zero waste*. Although increasing efficiency to “Factor 4” or “Factor 10” could help greatly in delaying or decreasing the pressure of resources depletion and living environment destruction, which could only be survived through structural changes in technological approaches, people’s lifestyle and social systems.

“Zero waste” is a direction rather than a destination. C&D Construction & Demolition waste has formed a significant waste stream in many countries. Minimization of waste from building C&D becomes one of the main issues in sustainable construction. Among those C&D waste demolition of building structures plays a major part. Therefore, study on *deconstruction process* is critical, not only for minimization of waste but also for optimization of recycle and reuse.

Agile architecture is dealing with building lifelong adjustment, which accommodates technical and organizational changes, in a way of maximum freedom and minimum conflict, cost and waste. Adjustment usually involves demolition and renovation works, Open Building theory can lead its deconstruction process in a better way; Deconstruction process is attributed to tectonics, and “Level” is the core idea for building tectonics. In terms of material flows, level is not only environment related tectonic hierarchy of control but also de-composition depths for recycle. Between material levels there are “interfaces”. Interface of open capacity is the key technology for tectonics and deconstruction towards sustainability.

Interface for Agile Architecture

Interface Characteristics

Adjustment over time involves actions such as changing floor plan, expanding spaces, replacing deteriorated elements or upgrading performances of building equipments, even reconfiguring infill elements by size, shape or materials are often happened.

Based on our previous study ref. 4, three criteria of interface with open capacity to meet the requirements of the above mentioned actions are concluded: *de-composibility, re-composibility* and *incorporatability*. Which are taking building tectonics and deconstruction into account. Also their key factors are found: fixing method, joint position, jointing or detaching approach, component perimeter, joint profile, and independent and linked utility channel.

Material Levels

In each environmental level of form, such as building structure, infill elements, furniture, there are building production hierarchy inside. Three material levels are recognized in general_elements, components and raw materials_see Fig.1; arrows indicate direction of control_. Although these material levels may have subsystems as "sub-levels", their hierarchical natures are the same. "Elements" are parts of a form; which create spatial function by a spatial interface by assembling components or sub-components. "Raw materials" are parts of assembling elements or sub-elements. "Components" are parts of an element; which plays a role as component; which holds a configuration with material property by manufacturing raw materials.

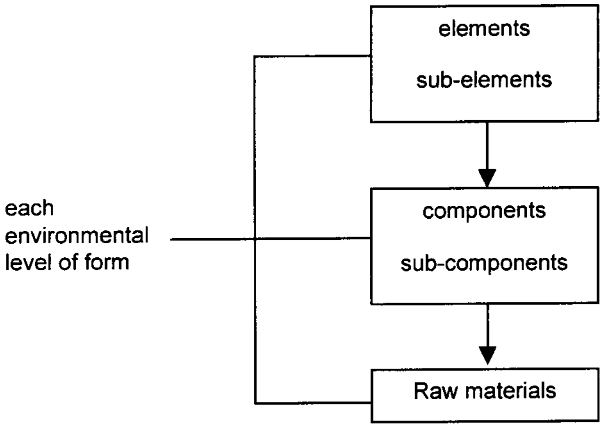


Figure 1- Material Levels

The more material levels there are, the stronger dominance the composition is. Relatively, the more parts in a material level there are, the smaller and lighter the parts are. In fact, parts in each material level, especially element level, are rapidly increasing in the last two centuries due to technology innovation, which mainly are mechanical and electrical equipments. No matter what is vertical division or horizontal division in levels, more division will offer more variety for choice and create more interfaces for tectonics and deconstruction. On the contrary, Modern Movement tends to reduce material levels and "integrate" varied parts by *molding*, which have affected contemporary architecture globally for the whole 20th century. Although "systemization" helps increasing material levels and parts in a level, molding tendency makes them to be "close systems"

Material Flows

From the building material life cycle viewpoint, sustainable material flows are as Fig.2.

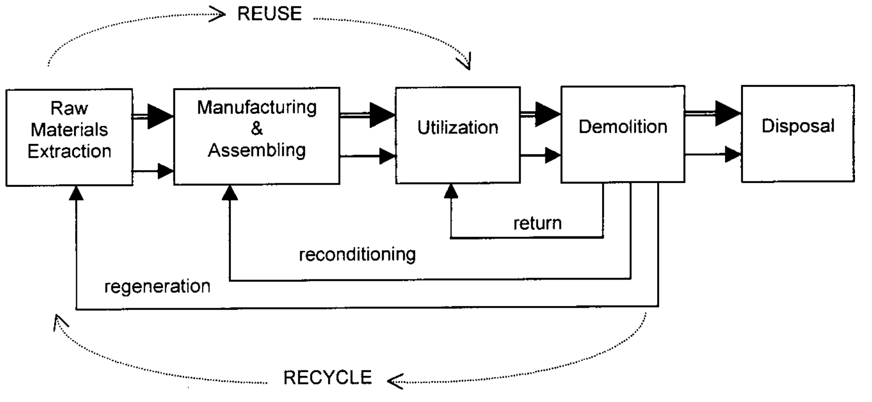


Figure 2- Sustainable Building Material Life Cycle

Recycle is a reverse material flows, which also consumes energy/ resources and by-produces wastes/ pollutions. *Recycle Depth*, in terms of "return", "reconditioning" and "regeneration", depends on the degree of deconstruction. Regeneration is the deepest recycle. Referring to material levels, return is to bring the deconstructed "elements" back for direct reuse, reconditioning is to repair, upgrade or reconfigure the deconstructed "elements or components" for indirect reuse, and regeneration is to extract or manufacture deconstructed "raw materials" for the same usage or different usage. Among these three recycle depth, regeneration is a matter of material science, while reconditioning and return have to do with "open building" theory, of which interface is the key technology. The deeper the recycle is, the more energy/ resources inputs and waste/ pollution outputs are. That is to say, the extent of sustainable construction refers to recycle depth, which refers to the material level of deconstruction and open building technology. See Fig. 3.

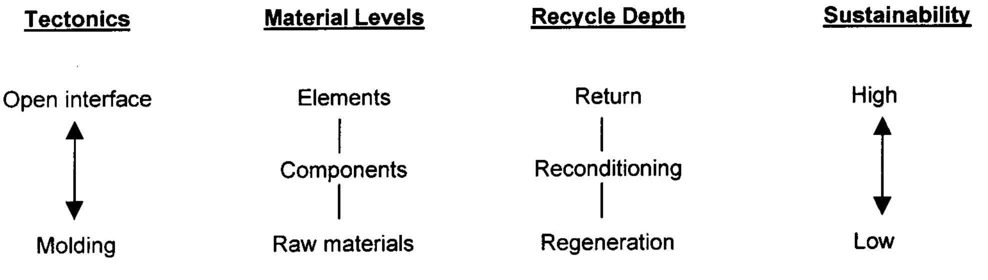


Figure 3- Relationship of Open Building and Sustainable Construction

Reverse material flow analysis

With a view to continuing developing interface technology on infill level, sustainability on reverse material flow needs to be further studied.

Recycle process starts from deconstruction, the extent of damage during deconstruction is a critical issue to sustainability. Lower material consumption and fewer repairing works are pursued. They are interrelated to each other due to jointing method and the durability of material itself. Material property referring to material science is not the issue discussed here. As to jointing methods, referred to previous study_ref. 4_, jointing process, jointing directness, fixing methods, jointing position, joint face and jointing products are involved.

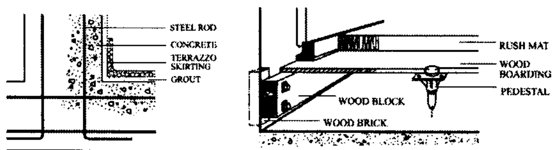
If damage only makes the reusable parts in bad shapes, *repairs* are to refresh and trim them to be acceptable in market. It includes the parts themselves and possibly jointing products. Consumption is little during such reparation. If damage causes complete destruction of the whole parts, no matter what are elements or components, repairs are useless, valuable materials among them can be extracted for regeneration; others attributed to consumption are for final disposal. Those parts can be replaced with the new ones. Therefore, for each recycle depth, *consumption* is inevitable but repairs depend; for regeneration, there is no need for repairs. For return, repairing is the only type of work needed in recycle process, but for reconditioning, repairs are the preliminary works and replacement or reconfiguration is the following. Besides, Reconfiguration itself involves complicated activities such as de-composition, reshaping, resizing and refinishing of elements or components before re-composition, these activities also cause consumption and repairs.

Ideally most of the consumed materials are jointing products such as nails, sealants, grout, solder, strips, blocks and finishing materials, but some of them are reusable if with care, such as screws, anchors and strips. Repairs are works basically for elements or components, such as cleaning or refreshing surfaces, filling holes or cracks, strengthening corners and trimming edges; other works for jointing products such as flattening anchors are possible.

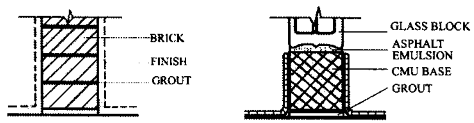
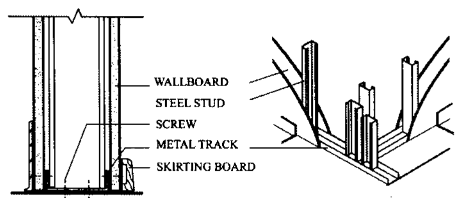
Observations from case study interface between partition wall and floor

Partition wall plays an important role in living adjustment on infill level. Because it has interface relationships with almost all elements not only on infill level but also conventionally on support level, and often with fixed furniture on furniture level. Utility systems in a building unit are usually distributed on floors and ceilings, and their outlets and inlets are on walls in height easy for service. Therefore, interface between partition wall and floor is one of the most critical ones for study. Analyses of its open capacity through conventional construction types are as the attached table (see Table 1 as example).

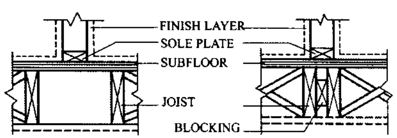
TABLE 1- ANALYSIS OF INTERFACE BETWEEN PARTITION WALL AND FLOOR

<table>
<tr><th>JOINT TYPE</th><th colspan="2">JOINTING METHOD</th><th>OPEN CAPACITY</th></tr>
<tr><td>(1)
MONOLITHIC
WALL
R.C.
STRUCTURAL
FLOOR</td><td>
</td><td rowspan="2">_PROCESS_
1.(1) Binding steel rods and nailing molds for wall and floor slab, then pouring concrete into it.
(2) Laying bricks or concrete blocks with grout.
3. Finishing wall.
4. Finishing floor by terrazzo, laminated tiles or raised floor.
FEATURES
1. Jointing way: Direct
2. Fixing method: Adhesion
3. Jointing position: The whole wall sill
4. Joint face: The whole joint profile
5. Jointing products:
(1) Steel rod
(2) Concrete, grout</td><td rowspan="2">• De-composibility: No
- Consumption: the whole wall
- Repairs: floor surface

• Re-composibility: No

• Incorporatability: Hard
- Pre-embedding duct
- Digging trough</td></tr>
<tr><td>(2)
LAID
WALL
R.C.
STRUCTURAL
FLOOR</td><td>
</td></tr>
<tr><td>(3)
FRAMED
WALL
R.C. OR
WOOD
STRUCTURAL
FLOOR</td><td>
</td><td rowspan="2">_PROCESS_
1. Nailing metal track or wood plate on floor.
2. Erecting studs on track or plate.
3. Nailing wallboards on studs.
4. Finishing wall.
5. Finishing floor and fixing skirting board.
FEATURES
1. Jointing way: Direct
2. Fixing method: Fastening
3. Jointing position: spacing
4. Joint face: The whole joint profile
5. Jointing products:
(1) Screw, nail</td><td rowspan="2">• De-composibility: Yes
- Consumption: Wall finish, Skirting board, Nails
- Repairs: Nailing holes on floor and wallboards

• Re-composibility:
- Original: Yes
- Exchangeable: changing wallboard: Yes
- Deformed: changing wall thickness Yes

• Incorporatability: (3) Hard
(4) No</td></tr>
<tr><td>(4)
FRAMED
WALL
WOOD
STRUCTURAL
FLOOR</td><td>
</td></tr>
</table>

Three conventional partition wall construction types are classified monolithic such as reinforced concrete or hallow core panel, laid such as brick, concrete block or glass block and framed such as stud wall . And three conventional floor construction types are monolithic, laminated and raised. In general, partition walls used to be fixed to structural floor slabs rather than flooring. And duct and pipelines never show on construction details.

For de-composition, only framed walls can possibly detached from floors without destroying the whole elements, no matter what kind of floors they are, and their material consumption and repairs can be managed although not easy enough.

For re-composition, only the de-composable or disassembled are possible to be re-composed. There is no problem if their joints are in direct way, because their joint faces are free of dimensional constraint. But if in indirect way, original and exchangeable re-composition are possible in most cases due to the same size, while deformed re-composition is confined by jointing products such as block, metal track, of which ad-hoc devices are incompatible with other wall elements of different sizes. But these jointing products can be replaced with adaptable ones easily. Therefore consumption increase due to this replacement may be acceptable.

For incorporatability, although stud walls and raised floors may have cavities for ducts and pipes, which are not linked as a system and their outlets and inlets are usually integrated with other components monolithically in a destructive way. Therefore, their consumptions are latently great and repairs are impossible. Skirting board is a separate component of wall to cover the joint of wall and floor. It can be assumed as an interface of them in form. Since the joints of wall and floor bear more structural forces than other interfaces between infill elements, their joint faces are better to be the whole joint profiles without cavities for the penetration of utility lines. Skirting board may play an intermediate role for this.

Key Factors and Indicators for Sustainable Recycle

Incorporation of utility lines is probably the most emerging issue to sustainability from the above analyses. *Incorporation is also a kind of composition*, but not like the composition of elements. The latter is in plan or elevation by the perimeters and surfaces of elements, while the former is mainly in section, one may enclose another. In other word, utility lines play a role as supplemented components of an infill element, but these components have to be connected to each other in a systematic way. Therefore, the interface design for incorporation refers to jointing method of open capacity.

As mentioned above, the extents of consumption and repairs depend on *material durability* and *jointing method*, which are the key factors for sustainable recycle. Material lifetime is a matter of material science, which is subject to improve from time to time. Therefore, material lifetime is a factor of sustainable recycle but not an issue of tectonics in terms of assembling sequence. As to jointing method, its jointing process or assembling sequence, if elements/ components and their joints are well designed, may be handled by a certain contractor or the occupants themselves as so called DIY through manuals or instructions without involving different parties, therefore no interference between different parties will happen and repeated consumption and repairs due to this may be avoided. Other conditions of jointing method such as jointing directness, fixing methods, jointing position, joint face and jointing products are all related to joint design. Separating joints from elements or components is the better way to reduce consumption and repairs.

Consumption and repairs during recycle are recognized as indicators of sustainability. They are outcomes of de-composition and re-composition. For measurement, material *consumption rate* and natural *resources input rate* by repairs are taken into account. Although, in practice, it is not easy to get reliable data from those measurements, *de-composed material levels* and *recycle depth* could be supplementary index. For sure, composition and de-composition by environmental levels are in favor of it.

Conclusion

Open building approach starts from a new way of seeing man-made environment and leads to technical change of general building practice. The trends of its development by now can be recognized; in theoretical aspect, its target moves from adaptation flexibility to that of sustainability. In technical aspect, they are from spatial openness to constructional openness, from participation of decision-making to DIY, utility lines from integration to incorporation.

Building Utilities Distribution

Although utility lines, like spatial circulation, are penetrating all the environmental levels, they serve occupants on furniture level and infill level. For efficiency reason, they are used to be pre-embedded into the elements on structure level and infill level. Which cause great interference during new construction and entanglements in renovation. Although shafts or channels have been employed to mainstream lines, the extension of these lines to the service points by incorporating with infill elements in an agile way still needs further development.

Since it is practical to keep utility lines laid out on floor and ceiling, and extended to partitions for service, the interfaces between them for line linkage are of great importance. It thus appears sound that partition walls are connected with floor and ceiling instead of with structural slab. That is, *each of ceiling and floor form a separate layer from building structure, and partition walls are positioned in-between and play a role to bridge them.*

Interface for Sustainability

In terms of renovation, different types of renovation have to be taken into account. Reconfiguration of elements or components is probably the most complicated one, which involves changing size, material and shape of themselves and re-composing through their new interfaces. Sustainability of renovation depends on material durability and their jointing methods. And its consumption and repairs are two indicators, which are referred to “waste” and “material input”. In general, two design guidelines of interface towards sustainability are concluded:

1. *Interface is of open capacity.*
   They are de-composibility, re-composibility and utility incorporability. The key factors of interface design are within jointing methods, which include joint process, jointing directness, jointing position, joint face, fixing methods and jointing products.
2. *Interfaces are located in terms of environmental levels and material levels.*
   The elements or components tend to be generic in joint profiles, various in kinds, and their interfaces to be sophisticated in shape, which is compatible/ flexible in size and in jointing method.

Selected References

1. Habraken, N. J. 1998. The Structure of the Ordinary, The MIT Press.
2. Kendall, S. H. 1992. “The Ecology of Production: Patterns of Control in Parts Making”, EDRA 23.
3. Kibert, C. 2000. “Construction Ecology: Natural Systems Models for the Built Environment”, Strategies for a Sustainable Built Environment_Proceedings of the 2nd. Southern African Conference, Pretoria, South Africa: CSIR Boutek.
4. Lin, L-C & Wang, M-H 2000. ”Technological Change of Infill Construction for Continuous Customization”, Proceedings of Continuous Customization in Housing, Tokyo: OBT2000 Organizing Committee.
5. van Randen, A. 1992. “Consumer Oriented Building: in Full Control of and Behind One’s Frontdoor”, Entangled Building...?, Delft: Workgroup OBOM.

Living Façades

Peng Liu

Graduate student
Department of Architecture
College of Architecture and Planning
Ball State University
Muncie, IN 47306- 0305
USA
Tel: (765) 214-0004 (H)
(765) 285-2757 (O)
E-mail: PLIU69@yahoo.com

Living Facades

Case studies about the behavior and the future of living facades

ABSTRACT:

Observations:

Living facades are both the reality and the requirement of the real world. This study is to identify some rules of living facades through four case studies, and thus to find ways in architectural design to make living facades easier to accomplish in order to more efficiently match what really happens to building over their lives.

There are tree types of changes resulted from different requirements.

- Change because of function
- Change because of preference
- Change because of deterioration

These changes occur individually or together.

Case Studies:

The behavior of living facades is studied through four case studies. Those case studies are from projects built in different countries and time. Analyses are made on the features of the facades, the way the facades changed over the years and the reasons for those changes.

Proposals:

From the observations and analyses in the case studies, some rules of the changing facades are drawn. The following factors have significant influence on living facades.

- The demountability of facade elements
- The availability of products used facade elements
- The quality of products used facade elements
- Interference to territories when changing the facades
- Proportion of changing facade in a community

Through these rules, proposals for enabling and encouraging living facades in architectural design are posed.

- Improve the demountability of facade elements.
- Use widely available products as facade elements.
- Produce affordable high-quality facade elements.
- Decrease territorial influence of changing the facades.
- Provide equal possibility of changing the facades to individuals in one community.

KEY WORDS: facades zone; territory; power; facade element

Living Façades

Peng Liu

Part1: Introduction

This study concerns the performance of building facades or enclosures under conditions of change. The questions at hand arise from the more general problems of the behavior of complex artifacts when they are subject to transformation during use-replacement, removal, or repositioning.

Built environment is the result of human dwelling. It is changed by occupants, and it influences the occupants' life at the same time. The interaction between built environment and occupants has never stopped since the act of dwelling has never stopped.

Of many parts of dwelling, the facade is particularly interesting. In the real world, the façade of any building changes to some extent over time, no matter if changes were planned or not. In that sense, every building has a living façade.

Living facades, or changeable facades, offer occupants possibilities to choose the life style they want. So living facades are important not only for identification of the occupied places, but also for authentic identification of the life inside dwellings. The deprivation of the control of facade in modern buildings, especially in high-rise buildings, causes the loss of individual occupant's choice of life style and his identification as well.

The changes of facades can be distinguished as three types.

- Change because of function

Functional change is caused by change of the requirements of use. For example, to control ventilation, windows should be operable. When space use changes from an office to a storeroom, part of the façade should be changed from translucent to opaque for different requirement of light.

- Change because of preference

Façades are an important way for users to express their characters. When a given user's characters change or there is a change of user, façades tend to change to express new characters, because of different preferences. For example, different companies needs different "faces" for their businesses although they initially rent units with the same façades, or a person may have different preference concerning the style of windows of his home after ten years.

- Change because of deterioration

Parts of a building need to be replaced with new and improved parts before the old parts have deteriorated. The important thing is that not all parts of a building have the same duration, so deterioration happens “part by part”, over the whole building, including its façade. The efficient and sustainable way is to allow part by part replacement to happen, according to the degree of deterioration.

There are also changes that have the characteristic of two or all of the above.

Living façades or changing façades are both the reality and the requirement of the real world. The purpose of this research has been to identify some rules of living facades through four case studies, and thus to find ways in architectural design and technology to make living facades easier to accomplish in order to more efficiently match what really happens to buildings over their lives.

Part2: Definitions

The following definitions are used to analyze performance of facades.

Living:
General meaning: alive
Defined meaning: capable of being changed, including being replaced, removed, or repositioned

Façade / Façade Zone:
General meaning: the front of a building; appearance
Defined meaning: the plane and its associated space separating territories on different hierarchical levels, either interior or exterior; a “Façade Zone’s” width is variable. Façade zones may belong to one or more territories.

Territory:
General meaning: area of land, especially ruled by one government, one or a group of persons or animals
Defined meaning: a space, or an arrangement of spaces that is under control of one power (Habraken, 1988: P24)

Power/Occupant:
General meaning: right to govern, to give orders, or to be obeyed
Defined meaning: any person or group of persons with the ability to change the physical reality of the site (Habraken, 1988: P12)

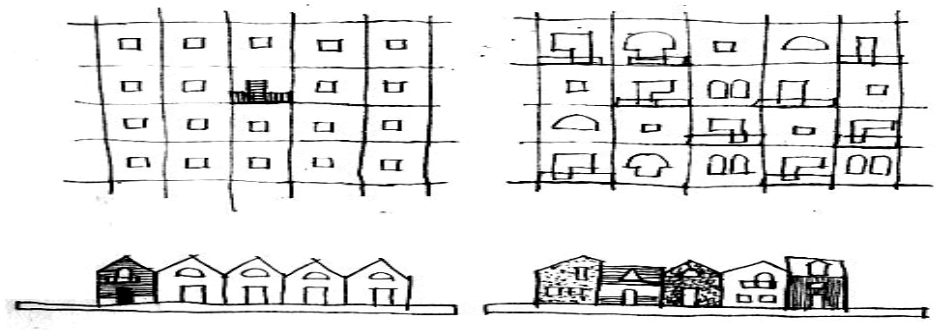


Diagram of Definitions: Position of the Façade Zone

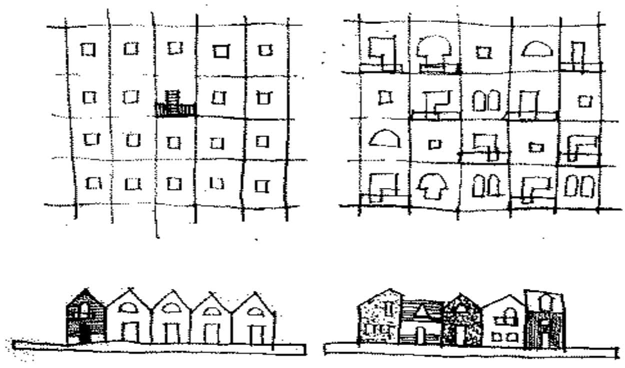


Diagram of Definitions: Inside the Façade Zone

Part 3: Case Studies

Although every project in the following cases has special features in many aspects, the performance of their facade is focused in this study.

1. Student Housing at the medical faculty buildings, Woluwe-St Lambert, Belgium

Source:

Book: An Architecture of Complexity

Author: Lucien Kroll (Translated and foreword by Peter Blundell Jones)

Press: The MIT Press, 1987

Description:

This project was designed by the Belgian architect Lucien Kroll in the early 1970's. He is known for his iconoclastic way of making architecture with complex and idiosyncratic forms. The Student Housing at the medical faculty buildings for the University of Leaven outside of Brussels aroused widespread controversy by its improvisational appearance-the result of a deliberate participatory design process and a highly disciplined design method. Kroll had two main goals in this project. First, he wanted to reject the monolithic and bureaucratic uniformity of typical university architecture. Second, he showed that variety on the façade and plan could be realized by industrial products and would not be more expensive than uniformity. To echo these goals, one of his efforts is the changeable façade for Student Housing in this group of buildings.

Features of the façade:
- The façade elements are designed to be changeable.
- All façade elements are standard industrial products.
- Based on the SAR Tartan grid, Façade elements with limited standard sizes are arranged in an apparently random way (Kroll, 1987: P).

Observations:
- The façade elements, including windows, doors and walls are all industrial products with limited standard sizes. These products are widely available. Possibility of changing the façade is provided by using façade elements that are widely available.
- The connections among façade elements and those between them and the main structure are clearly separable, enabling them to be independently changed. For example, doors are connected with the floor, walls, and windows by screws. Occupants can remove a door easily by just loosening some screws, without damaging any other elements that are connected with it. Changing the façade is enabled by making connections among façade elements easily separable.
- More than 20 years after this project was build, there is almost no change accomplished on the façade of this building.

Analysis:
The possibility of changing the façade, including separable connections and widely available facade elements, is only part of the prerequisites of changing the façade.
The other factors are:
- The interference to other territories influences changing the façade.
  Although changing the façade will not interrupt the neighbors' interior territory, it will have some influence on their outside territories (or the shared territory), such as the potential danger of dropping parts during construction.
- The length of occupancy influences changing the façade, such as the rate of change and the degree of change
  All the occupants of this building are students who live in it temporarily, so no mater what their needs are; the short time of occupancy reduces their interest in any change of large scale such as changing façade elements.
- The rules of higher-level territorial powers influence changing the façade.
- Of the two territories along the two sides of a facade, one is on higher hierarchical level. The rules of higher-level powers influence changing the façade. For example, if the university, operating on the higher level, had regulations forbidding occupants' changing the façade, then change could not happen.

The Herman Miller furniture factory, Bath, UK

Source:

http://www.ngrimshaw.co.uk/projects/projectsfolder.htm

Description:

The Herman Miller furniture factory, designed by the Farrell/Grimshaw Partnership in 1976, put new ideas about building for industry into practice. The aim was to produce an industrial facility capable of responding to the client's need for layout changes and other building adjustments that also provided better amenities for staff.

The building is sited on the River Avon near Bath. Great care went into developing the design to fit the sensitive context. Success in this respect is reflected in the Civic Trust Commendation awarded in 1978.

Features of the façade:

- The structure of the building is a simple primary and secondary beam system with columns on a 10m x 20m grid. Also, the grid and the size of the panels and glazing on its façade are uniform.
- The height of the building enables it to be used very effectively for high volume palletized storage as well as manufacturing processes. The cladding system is completely demountable, enabling the panels and glazing to be interchanged to alter the building's facade to suit changing internal needs.
- The interchange of the panel and glazing can be easily done by unskilled labor, enabling the staff to make facade adjustments at any time.

Observations:

- The glass, the cladding panels, the doors and even the courtyard spaces can be repositioned.
- The building is now 20 years old and has gone through many such changes.
- Everybody likes it; however, the urban planners have been unable to work out how to treat this building because it is continuously changing its skin (Grimshaw, 1999: P1).

Analysis:

- If there is no interference between territories when changing the façade, the change can be done frequently, and will involve only technical issues without territorial issues.
- People's attitude about living façades is changing, from feeling strange to accepting and liking it (Grimshall, 1999: P1).

Hellersdorf, Berlin, Germany

Source:

Book: ENFIL CHEZ SOI... REHABILITATION DE PREFABRIQUES (in French)

Author: Lucien Kroll (Introductions by Jurgen Klemann and Jack Gelfort)

Press: AUAI, Bruxelles, 1996

Description:

This project is a renovation of one of millions of prefabricated “social” housing projects. The architect of this project is Lucien Kroll. To inspire the occupants to change their balconies, Kroll designed the concrete structural frame for all the balconies and the 1st floor to the 4th floor additions). From the 5th floor to 11th floor, the balconies were designed by the occupants.

Features of the façade:

- The original façade is not easily changeable.
- The intention of the architect in regard to the façade is not to make it changeable but to make it complex and fit for individual needs, compared with the original monotonous façade that left no possibility and no space for individual households to control their immediate outside environment.
- The change of façade in this project is a proposal and was not realized.

Observations:

- According to the architect’s way of modifying the façade (from the 1st floor to the 4th floor), territorial changes are one result of changing the facade, just as shown on the proposal for the development of the whole community.
- Although the proposal by the occupants for the upper floors (the 5th to 11th floor) is more cautious to their immediate territories than the proposal by the architect (for the 1st to 4th floor), it is still braver than what happened in ordinary residential buildings in reality.
- The façade elements are not prepared standard industrial products. The connections of those elements with the main structure are not easily separable.

Analysis:

1. If change of façade will result in a change of territory, it will be very difficult to be realized in the real word, especially when there are strict rules defining territories and boundaries or interfaces. It is much easier to alter a facade when it is inside a territory.
   Related to territories, regulations and conventions also influence changing the facade. To make changing the facade easier to accomplish, we should follow the regulations and conventions. In the reality, there are “regulations” of forms and actions in one territory, by a power occupying another territory. Regulation is an often-accepted “invasion” of territory by another power. Conventions are informal regulations. Regulations and conventions are influenced by the local cultures.
   For example, when uniform appearance is required, the outside color of curtains of an individual house (one territory) is decided by a power from the community (another territory) through regulations. In some cultures, neighbors are not welcome to watch the others’ family life in courtyard. So openings on the wall of one house (one territory) may be forbidden by a power from the adjacent house (another territory through regulations.
2. Using easily separable connections and widely available products on the façade will reduce the intrusions to other territories, especially in the procedure of construction on

changing the facades. For example, if a window can be demounted by only loosening a few screws instead of damaging part of walls, the neighbor downstairs can avoid noise and the danger of material falling into his territory.

3. In this project, compared with the architect of the original building, Kroll's effort showed that architects' attitudes in the development of façade was changing from deciding everything to encouraging different occupants deciding and acting.

Residential tower, China

Description:

The following are three typical changes that happen on façades of residential towers in China during their occupancy.

1. Enclosing the balcony for adding living space or avoiding polluted air
2. Adding cages to the window for plants, storage or for avoiding thieves
3. Making hanging truss for laundry.

Features on the façade:

- Some original façade elements are changed and some are not because of varying requirements of occupants.
- Over the years, façade elements are continuously changed with the change of occupants and replacement of parts that have ended their useful life.
- The quality of changed façade elements various considerably. Some façade elements are products such as the entire window for enclosing the balcony; some are constructed by industrial materials such as plastic roof panels and steel studs; and some are made of hand made elements such as wooden screens.

Observations:

- All changes on the façade are cautious, because occupants are prohibited from extending their territory into adjacent territories by rules, regulations and conventions. In some situations, the struggling of territorial boundaries can be clearly seen. For example, the added hanging truss could be installed with a more reasonable supporting angle if the occupant can use part of the wall in the territory of his neighbor below.
- Supplies of related products for the change of façades are insufficient. People often experience difficulties in getting suitable materials and products, so they have to find their own way and the quality of changed façade is hard to predict.
- These changes on the façade are forbidden in more and more residential communities. The reasons include maintaining the uniform image of the whole community, and preserving the buildings from changes of low quality.

Analysis:

1. Territory is an important issue that greatly influences living façades in all countries or areas independent of strict or lenient territorial rules.
2. The availability of related products influences the quality of changed façades.

3. There are different attitudes to living façades and different attitudes to complexity (or variety) and uniformity in different cultures.

Part 4: Proposal

From the observations and analyses in the above cases, the following proposals are drawn for enabling to enable living façades to be accomplished.

1. Improve the demountability of facade elements.

Improving the demountability of facade elements is to make the connections between facade elements and the connections between the facade and other structures separable. The purpose of this is: when some facade elements need to change, they can be demounted easily without much labor, noise and damage to other parts of the building. This can reduce both the labor cost and the distribution of potential damage to the adjacent territories.

2. Use widely available products and materials as facade elements.

Using widely available products and materials as facade elements enable occupants be able to easily find the needed products and materials. Those products and materials include standard industrial products in a variety of scales and local materials.

3. Produce affordable high-quality products and materials for changing facades.

The quality of the changed facade is decided to a large extent by the quality of the products and materials used. Changing facades is forbidden in some areas because the quality of the modified facades is low and the low quality not only destroys the appearance of the building but also results safety problems, such as leaking water and falling parts. If affordable high-quality products and materials for changing facades are available, the quality of living facades can in improved.

4. Decrease territorial influence of living facades.

Decreasing territorial influence of living facades makes them easier to accomplish. When changing facades would result in interrupting the existing territorial boundaries, the work is difficult. To decrease territorial influence, facade elements that belong to different territories should be able to be separated without damaging each other. Regulations and conventions about territories also need to be followed.

5. Promote the appreciation to living facades in culture.

Promoting the appreciation to living facades in culture makes living facades more realizable, by following regulations and conventions from culture.

Although all individual occupants need living facades because of their changing situations, living facades are sometimes blocked by regulations. If we can make living facades follow the regulations; the appreciation to living facades in culture can be promoted.

For example, in some cultures, regulations are set to forbid any individual changes on the facade to keep uniformity in a community. The intent of the regulations is to keep the equal right of each component of the community. If we can follow the regulations by providing each occupant the SAME possibility and extent of changing the facade, no matter if the possibility and extent are large or not, the equality of the community can be maintained. And at the same time, changing the facade is realizable according to the occupants' needs.

Part 5: Living facades and high-rise buildings

The study of living facades has a special meaning in high-rise buildings. The proportion of people living or working in high-rise buildings is increasing. Compared with the interior layouts, providing a living facade is more difficult in high-rise buildings because of techniques and regulations. However, the requirement of living facades in high-rise buildings is the strongest one, because at present, thousands of different occupants are forced to use the uniform arrangements on their dwellings' periphery. Their connection to environment, and their faces to the human society are thus standardized and at odds with the natural difference among people.

The proposals raised in this study are especially expected to initiate further study conceptual principles about the living facades in high-rise buildings. The purpose is to help individual occupants in high-rise buildings get rid of the feeling of being in prisons due to losing control of their places. The increased possibility of individual control provided by living facades could also reestablish the lost individual identification of occupants in high-rise buildings.

Eventually, all the proposals aiming to promote the development of living facades are to improve the quality of life beyond only providing spacious interior environment but by really "giving forms" to the users, allowing them to use the forms as they will and as they need. That is the radical purpose of this study.

References:

1. N. J. Habraken, Transformations of the site. Awater Press, 3rd, revised edition (1988)

2. Lucien Kroll, translation and foreword by Peter Blundell Jones, An Architecture of complexity. The MIT Press (1987)

3. Nicholas Grimshaw, Equilibrium, Architecture and Environment. XXth UIA Beijing'99 Congress

Product development for Agile Architecture

Jos Lichtenberg
A+
Kelperheide 50
6037 SZ Kelpen-Oler
tel: +31 495 652380
fax: +31 495 652336
www.a-plus.nl

Product development for Agile Architecture

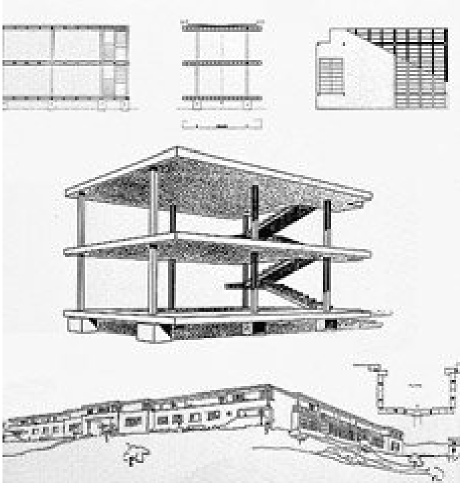
Jos Lichtenberg

Introduction:

A+ is a consultants group in the field of product development for the building market. A recent development is for example a in building parts integrated low temperature heating system based on heat pump technology obtaining a low energy heating system for the winter and cooling system for the summer period.
Another development is a robot for placing ceramic floor tiles in order to enlighten the labour circumstances of the tiler and to enlarge the output.
Besides product development A+ also is active in the field of energy saving.
Apart from being the general manager of A+, Jos Lichtenberg is also chairman of Booosting a foundation active in the field of building innovations. At the moment he is in the final stage to write a thesis about the development and marketing of new products for the building market.
The subject of this contribution is based on the involvement with the so called ISB project and the development of the INFRA+ floor system.
ISB was one of the products born as a spin off of the ideas of Professor Nico Habraken. At the end of this contribution it is presented together with the follow up development of the INFRA+ system.
Through the involvement of both product developments A+ is striving for an innovative approach facilitating the realisation of industrial building methods and flexible buildings, without affecting the architectural freedom and at the same or lower building costs.
Before introducing the developments the philosophy is explained in four statements.

Statement 1:

The level of flexibility on building level is very much depending on the flexibility of the services
As Le Corbusier realised his Dom-ino house in 1914 he stated to have obtained a maximum flexibility for variation in floorplans. Only some columns and the stairs were the inflexible elements.



The Dom-ino house

However he could hardly have foreseen the role of services, since these components were rather limited in those days.
From the sixties and early seventies on, it was explained to the market why the services are quite crucial in relation to flexibility. In a kind of roentgen picture it was explained that the servicing easily would obstruct the flexibility of several building parts since they are interwoven with these parts. A.o. both Professor Nico Habraken and Professor Age van Randen were promoting this message through the SAR (Foundation for Architectural Research) and the foundation for Open Building.
The world was on the search for solutions and architectural approaches were developed wherein the services became part of the architectural concept.

Centre Pompidou

What can happen if change (functional flexibility) become necessary in buildings with a technical duration of over 50 years is shown in the next photo's who speak for themselves.

Left the 'röntgen photo" of a house which shows the role of services in the limitation of flexibility, left some consequences of changing non flexible buildings

Now 40 years after the message of Habraken en van Randen was proclaimed the meaning of the message is as vital as it has never been before. Nowadays the costs of services are around 35%.

Statement 2:

It is recommendable to concentrate 95% of all services in one building part or zone

Whether the choice is the floor, the façade, hollow structural parts, it is always recommendable to choose for one of these building part, to prevent the interweaving of services through all building parts, which would brings us back to the roentgen photo as already shown.

However exceptions (5%) should be accepted to prevent market resistance from a point of view of the user. In other words: Choose a philosophy but do not be too strict if it is in conflict with market requirements.

Statement 3:

The building part 'floor' is the most suitable building part to concentrate the services in.

The reasons for this choice are:

- The floor is from an architectural point of view a quite anonymous building part. In the architect only draws two lines, the upper and the underside. What's happening in between is the domain of the mechanical engineer rather than the architect. Services in this zone will thus never obstruct the architectural freedom. The façade on the contrary would be very much affected by services.
- Floors always border on rooms. Gravity prevents us from being not on a floor for a long time. From every spot in the building, the floor is at a distance from your desktop of a

maximum of 0.75 m. Most of the rooms also are also bordered up with a façade and partition walls, but the distance from your desktop might be more than several meters.

- Apart from a few columns, shafts and the stairs the floor does not contain discontinuities. Wasn't that the already the core of Le Corbusiers' message? Façades and partitions are quite frequently traversed by doors or windows.

Statement 4:

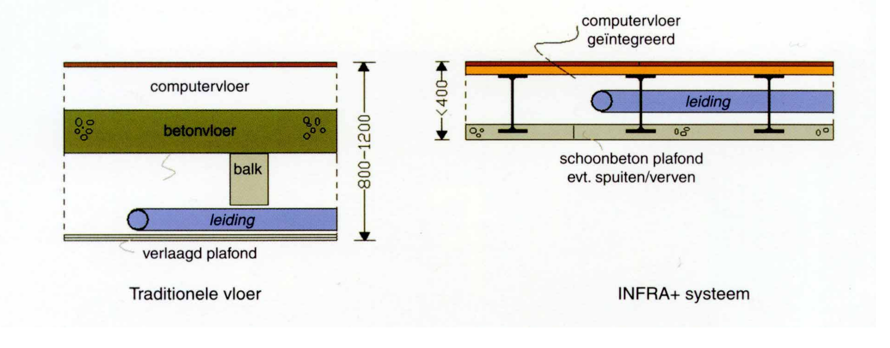
In order to be cost effective it is necessary to use the zone of the structural floor rather then putting the services upon or beneath the floor.

In commercial buildings the services are in fact already concentrated close to the floor. In general they are placed beneath the floor and are covered with a suspended ceiling, in some cases they are positioned in a raised floor system.

In residential buildings it is not common practise to integrate the services behind a suspended ceiling or floor. Until now services are quite limited in houses and more or less concentrated in vertical parts (shafts, walls). Nevertheless, also electrical wiring and sewer pipes are being poured in concrete in the floor, causing inflexibility in the construction phase (the architect has to decide very early in the process about the geography of the floor plans).

Services, product evolution by addition

All these systems are additional to the constructive floor and will enlarge the total floor thickness.



Schema vloer met leidingen erop en eronder in vergelijking met infra+

The floor thickness can be directly related to building costs. A thicker floor means: More façade, longer shafts, more stairs (and also more floor space for the extra steps), longer vertical structural parts and services.

Commercial buildings:
It has been calculated that for every cm floor construction height the costs are between 1,50 EURO and 2,50 EURO per m2. Ceilings are in many cases mounted on a distance of at least 0.3-0.4 m beneath the floor. The extra building costs caused by this choice is thus 45.00 EURO up to 100.00 EURO per m2.
Apart from that, the costs of the ceiling- (20.00 EURO up to 50.00 EURO) and or the suspended floor system (50.00 EURO up to 100.00 EURO) are additional and in case of a ceiling extra provisions have to be made in order to prevent flanking sound transmission over the ceiling.
The usual way to prevent this problem is to connect the partition wall directly to the structural floor. The sound transmission through the ceiling cavity is being blocked by that provision. In practice this is a quite complicated solution, since a lot of services have to cross this barrier. The transit of services demands a proper treatment of the created gaps. In fact this activity is again an interweaving of services with structural components. Another problem is that this solution will turn out to be a barrier for flexibility.

	Floor+Ceiling	**Floo**
Structural floor incl finishing	60	
Ceiling / raised floor	>20	
Sound insulating provisions	20	
Extra stairs	3	
Extra costs for elevator/shafts	3	
Structure	100	
Services	350	
Process velocity (overheads)	50	
Other costs	600	
Total	**>1,206**	

Table: Comparison building costs in function of integrating services into floors (in EURO).

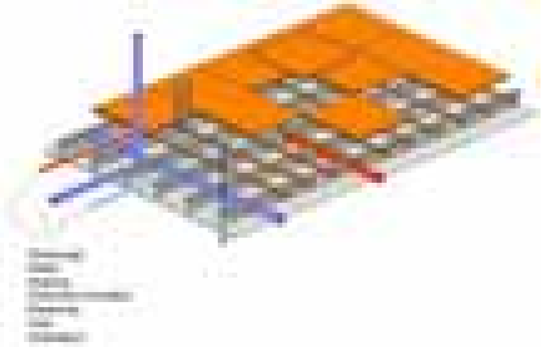
In total the cost reductions can be obtained on a level of in between 40,- - 100,- Euro. On a total building costs of 1,000.00 EURO to 1,300.00 EURO this is quite substantial (4 - 10%).

ISB and Infra+

ISB was developed from the eighties. In 1994 a full-scale prototype was established at the Technical University of Eindhoven in co-operation with eight companies.
The philosophy is based on industrialisation, flexibility and variability. As a structural material was chosen for steel. This choice enabled to put services in the structural zone as it is shown in the pictures.

After the prototype was realised the feasibility could be investigated. It turned out to be that a break even situation could be obtained at a yearly production of about 100 houses. Besides some technical obstacles had still to be concurred. A.o the extension of the span of the floor (in ISB it was limited to 4.2 m) and a problem with unexpected vibrations in the floor construction.
Enlarging the span was quite complicated, because in that case the height of the profile had to be in the order of 200-230 mm which required a rolling street which is not available in the market. The alternative was to choose for a thicker steel sheet but in that case the handling and the economy of the system became a problem.
The vibration problem was related to the fact that the Dutch consumer is used to concrete floors as a reference. The behaviour was to compare to wood frame constructions. Nobody was prepared to take the risks and in 1996 the ISB project was stopped.

However as a spin off Infra+ was developed according to the very same philosophy about flexibility and the relation with the services in the period of 1996-1998. The strength of the concept is, that it is limited to only a floor system based on standard products and technology. No major investments have to be done which reduces the risks tremendously.



Infra+, the concept

The building approach is really based on the ideas of Le Corbusier by raising skeletons

containing columns and beams. After mounting the floor the façade and roof the building is closed. The services can be installed in only one planning step and after that the top floor, partition walls and finishing parts can be installed.
By that move the building process including the finishing change into a serial process in stead of the traditional parallel process (at the end of the process everybody wants to work in the same spot at the same time). Working in serial avoids a lot of planning problems, failure costs, building time and buildingcosts.

The system is marketed in the Netherlands since 1999 by PFL.
The pictures in the next figure give an impression of the first experiences on small scale level.
Meanwhile a lot of additional reassert was carried out in order to be able to meet the fire and sound insulation requirements for high rise buildings. Last year TNO reported a more than two hours fire resistance and, related two the double scaled construction, a superb sound insulation. Meanwhile several large scale projects are in preparation.

Testing and application examples

Epilogue

The investments in hardware are limited as said. New products however always have to overcome rational and emotional obstacles. Questions one has to deal with are:

"The floor is light weight, how does this affect the behaviour in relation to vibrations? And how does this affect the sound insulating properties?"

"There is steel being used as a structural component, how does this affect the fire resistance?"

"Is the floor able to contribute in the structure of the building (diaphragm action)?"

Et cetera.

Behind these questions a world of non rational (emotional) obstructions are hidden. In his book *"Diffusion of innovations"*[1] Rogers explains the psychology behind the hardware. Nevertheless one can only overcome the rational questions and to aim for the first demonstration projects. That is exactly what PFL has done for the past few years.

All possible technical test such as on fire resistance, mechanical performance and sound insulation tests have been carried out, a flexible top floor system is in development, provisions were made to enlighten the fixation of services, new components for services were developed et cetera. By approvals on the superior properties (over 2 hours fire resistance, up to 65 dB sound insulation, etc) the first projects were realised (see pictures) and a breakthrough is expected on short term.

---

1 Rogers, E.M.: "Diffusion of innovations", The Free Press, New York, 1995.

Life Cycle Assessment of Support/Infill Housing in House Japan Project

Shuichi Matsumura, Prof.,Dr.Eng.

Dept. of Architecture, School of Engineering, the University of Tokyo
7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-8656 Japan
TEL81-3-5841-6152 FAX81-3-5841-8518
smatsu@buildcon.t.u-tokyo.ac.jp

Life Cycle Assessment of Support / Infill Housing in House Japan Project

ABSTRACT:
House Japan Project was a seven years (April 1994 - March 2001) research and development project conducted by former Ministry of International Trade and Industry (MITI) in Japan. In this project, in which about forty companies had participated, one of its four major purposes was to improve life cycle performances of Japanese house-buildings. To realize that the open building concept was applied and about ten companies developed their own new infill systems. In this paper those infill systems are introduced at first.
In the last year (from April 2000 to March 2001) two kinds of integrated design of single-family dwellings and multi-family dwellings using those infill systems were the major tasks of the members of House Japan Project. In this paper life cycle assessment of those integrated design is shown secondly.
Lastly based on the results of House Japan Project, the effectiveness of the application of the open building concept is discussed.

Life Cycle Assessment of Support/Infill Housing in House Japan Project

Introduction

House Japan Project, former MITI's (Ministry of International Trade and Industry) seven years technology development project for house-building in Japan, finished at the end of March in 2001. In this project, which 38 companies participated in, about seventy themes had been tackled. Those can be classified into four groups shown as below.

(a) establishment of performance evaluation and indication system using IT
(b) realization of long-life residential building using support / infill concept
(c) improvement of indoor comfort
(d) improvement of energy saving in residential buildings

As for the theme(b), ten companies, which included six component and material manufacturers, three general contractors and one detached house manufacturer and supplier, developed each infill system or infill component and four companies were engaged in development works to improve the capacity of support systems.

In seven years each of them built one unit or one room at the least to find out what to improve. In the sixth year some of them participated in an experimental building project of multi-family dwellings, which was named Flexsus 21. In the final year of the project, they designed one detached house and one condominium using every infill system or component developed in order to examine the superiority of life cycle cost saving.

In this paper the result of the final examination is shown after classifying those infill system and component development in House Japan Project.

Infill Systems and Components Developed in House Japan Project

Infill systems and components developed in House Japan Project can be classified into three groups as shown below.

(a) Interior components which can be easily installed and changed by residents
(b) Integrated infill systems for effective construction and alteration
(c) Changeable sanitary equipments

Interior Components for DIY installation

1. A Partition Wall System for Detached Houses by Juken Sangyo Co.,Ltd.

The purpose of the development by Juken Sangyo is to realize a partition wall system which is easy for residents to install and move. The final system is composed of LVL(Laminated Veneer Lumber) attachment parts and 600mm wide panels made of LVL frames, paper honeycomb and MDF(Medium Density Fiberboard) boards. In this system wiring is easily placed between one attachment part and another.

Their experimental installation by two persons made clear that this system reduced the installation time by 40% and the remove time by 60%. And they estimated that alteration works cost using this system could be less than a third of that using conventional methods although the initial installation cost for this system could be 1.3 times as high as conventional construction.

2. A Partition System for Detached Houses by Sumitomo Forestry Co.,Ltd
The purpose of the development by Sumitomo Forestry is similar to that by Juken Sangyo. The system is composed of partition walls, partition furniture and DIY assembling doors. Based on the fact that more than 80% of Japanese residents have only small screwdrivers, cutters and a hammer concerning DIY tools, this system is designed to be installed only with those three kinds of tools. And in this system almost components are not panels nor boxes but boards in order to make handling works easy for residents.

3. Floor Finish Components by Dantani Corporation
Those who want to change floor finish from carpets or tatami mats to wooden floorings for better indoor air quality have recently increased in Japan. Dantani focuses on this kind of demands. In stead of conventional wooden flooring components fixed by nail attachment and adhesion, they developed thin finish boards to be easily cut and fixing system with adsorption tapes.
Their products were developed on the basis of fact-finding studies about Japanese residents' skill. After several experimental installation they realized floor finish components which can be fixed for about 7 square meter room in two and a half hours by residents themselves. Although their material cost is about 1.4 times as high as that of general wooden flooring components, their total cost can be reduced by 30% because of 100% reduction of labor cost.

4. A Ceiling and Partition Wall System for Multi-family Dwellings by Obayashi Corporation
Obayashi Corporation developed their own ceiling and partition wall system for multi-family dwellings. As they introduced the details of integrated ceiling and removable partition wall system for high-rise office buildings to such residential buildings, they could reduce the labor cost for changing the floor layout as well as the initial construction and made residents' work possible while the material cost increased. At the final phase they redesigned the details to have two kinds of systems. One is called "general type" which uses cheaper materials to reduce the material cost. And the other is called "SOHO type" which uses rather expensive metal details to make changing works simpler, for SOHO(Small Office Home Office) seems to need more frequent changes of floor layouts.

Integrated Infill Systems for Effective Construction and Alteration
1. An Infill System for Multi-family Dwellings as well as Detached Houses by Matsushita Electric Works,Ltd.
Matsushita Electric Works' infill system is composed of raised floor components, suspended ceiling components and partition wall components. The partition wall, which has

been the focus of their development, is composed of general-purpose wall materials and highly accurate and durable aluminum stud columns. They can be disassembled by removing the screws and nails and reassembled to be used in other areas. Wiring devices and wires are installed within the stud columns' area so that they can be easily changed even after the wall is finished.

2. An Infill System to Realize Special Use Room by Nippon Sheet Glass Co.,Ltd.
Nippon Sheet Glass tried to respond to the change of residents' life stage with value-added infill systems. They gave attention to remodeling works from general rooms to care-rooms for elderly people or sound-proof rooms for those who wanted to enjoy their specific audio visual devices and playing instruments. Their system is mainly composed of panels.
Their experimental construction showed the necessary man-power could be reduced by 78% and removing cost by 14% in case of the care-room type. Also they made sure of the noize-reduction performance of the sound-proof room type.

3. An Infill System for Multi-family Dwellings by Takenaka Corporation
Takenaka's system is composed of six kinds of components. The first ones are movable storage partition components which enables woman's DIY works without the sacrifice of their sound-proof performance. The second ones are sliding walls which ease the short-term change of the floor layout with not so much sacrifice of their physical performance as partition walls. The third ones are light weight partition wall components using steel which enable residents' installation and alteration. The forth ones are wiring components at the bottom of the partition walls and around the doors which can be changed independently from partition walls and floors. The fifth ones are simple raised floor components. The sixth ones compose the HVAC system which can follow various changes of the floor layout using the space under the floor and above the ceiling as chambers for HVAC system.
Their experimental construction confirms 23% reduction of the alteration cost and 56% reduction of the alteration time compared with conventional methods, while they know 23% increase of the initial construction cost because of components manufactured outside of the general production line.

4. An Infill System for Multi-family Dwellings by Kajima Corporation
Kajima developed not only their own infill system but also the design technique utilizing the infill system. Their infill system is composed of partition wall components and new wiring devices. As to partition walls three types of movable partition wall components are developed so that designers can select appropriate partition wall components to meet the required specification for uses, locations and so on. In the development of the new wiring devices, centralized control functions of electric lines are realized with loop series wiring using optical fiber in order to make the change of wiring easier.
The design technique developed is called "Free Choice System", which allows expected residents to do computer-aided design of the suitable floor plan by combining the selected layout variations in each of three zones- the family zone, the sanitary zone and the private

zone. They can utilize this CD-ROM based system in case of remodeling as well as newly building.

Changeable Sanitary Equipments

1. A Flexible Sanitary Plumbing System by INAX Corporation

In order to clearly separate infill from support in case of multi-family dwellings, it is important to locate the common piping space outside of each housing unit. But as drainage pipes need appropriate slope the freedom of floor layout of each housing unit is often limited by the location of common vertical pipes. To overcome such difficulties and improve the freedom of the layout of the infill, INAX developed a new plumbing system using a pressure pump.

Concerning the pressure pump, two types- 200V type and 100V type are developed to minimize the noise and vibration problem and to make maintenance simple. As for the piping system, compact integrated piping space under the floor or on the wall is designed to save related construction works in case of piping works and to secure maintenance accessibility for piping. As the result of that, construction time for changing the layout of the sanitary space can be reduced by more than 50%.

2. A Partly Changeable Kitchen System by TOTO Ltd

TOTO's fact finding study clarified that kitchens needed to be remodeled once every 15 years in average and the construction cost was almost equivalent to that of new kitchen cabinets and built-in appliances themselves in Japan. In order to reduce the construction cost, a kitchen system is developed using a framework to which cabinets and built-in appliances can be attached and that minimizes the necessary work for integration of the kitchen cabinets and built-in appliances into a house's structure. With this system kitchen remodeling can be a DIY project, since residents only need a screwdriver to replace components.

They estimate that this system yields an overall savings of 30% if a kitchen is remodeled twice, while the price of the kitchen furnishings is higher by 80% than conventional ones.

The Life Cycle Effect of Utilizing the Infill Systems and Components

In the last year of the project, integrated design and life cycle cost estimation groups were organized. There are two groups. One is the detached houses group including Juken Sangyo, Sumitomo Forestry, Dantani, Nippon Sheet Glass, Matsushita Electric Works, INAX, TOTO and Mitsui Home which has developed technologies for support. And the other is the multi-family dwellings group including Obayashi, Matsushita Electric Works, Takenaka, Kajima, INAX and three other companies which have been engaged in other themes than infill system development.

Conditions for the life cycle cost estimation in case of detached houses group are defined as shown below. Those in case of multi-family dwellings group are similar.

1. to omit energy cost for living because the purpose of estimation is to compare their design to an ordinary house design and no difference of thermal performance is between them

2. to suppose that the cost for remove and demolishing will increase by 10% every 15 years
3. to neglect the increase of prices, interest and rent
4. to suppose that, only in case of their design, it will be unnecessary for residents to move out to another house when floor plan alteration will be executed
5. to include even repairs and changes of small parts
6. to use up-to-date prices

A scenario was prepared for estimating life cycle costs. The outline of the scenario for a detached house is:

a. large alteration of floor plan will occur in the fifteenth year
b. In the thirtieth year a two story conventional house will be demolished and a new three story house will be built, in which the third story will be added with the technologies developed in House Japan Project according to each company
c. A special care-room will be needed in the forty-fifth year and be removed in the fifty-second year
d. In the sixtieth year both will be demolished.

The outline of the scenario for a multi-family dwellings' case is:

e. large alteration of floor plan of all the fifty-three housing units in a nine story building will occur in the fifteenth, the thirty-fifth, the fiftieth, the sixty-fifth and the eighty-fifth year
f. large renovation works for common facilities and common space will be executed in every twenty-five years
g. a conventional building will be demolished and rebuilt in the fiftieth year, while the building following their design will last for a hundred year because of the upgrading of support and the application of support / infill concept.

Consequently, while the initial cost of the integrated design in House Japan Project is higher than that of conventional design by 10% in case of detached houses and by 7% in case of multi-family dwellings, the life cycle cost of the integrated design is lower than that of conventional design by 27% in case of detached houses during sixty years and by 23.5% in case of multi-family dwellings during one hundred years.
In the detail of multi-family dwellings' case, the reduction rate of life cycle cost of each infill system or components compared with its conventional counterpart is: (fig.1)

SUBSYSTEM	APPLICATION OF DEVELOPED INFILL	APPLICATION OF DEVELOPED SUPPORT	INDIRECT INFLUENCE OF DEVELOPED INFILL	LCC OF HOUSE JAPAN DESIGN (A) yen	LCC OF CONVENTIONAL DESIGN (B) yen	REDUCTION OF LCC (B-A) yen	RATIO OF REDUCTION (B-A)/(B) %	(B-A)/(C) %
Temporary Works			yes	4.307.000	6.581.000	2.274.000	34,55	7,03
Soil Works		yes		1.962.000	2.991.000	1.029.000	34,4	3,18
Structure		yes		14.716.000	18.636.000	3.920.000	21,03	12,12
Building Envelope		yes		13.216.000	16.733.000	3.517.000	21,02	10,87
Raised Floor	**yes**			**1.180.000**	**2.572.000**	**1.392.000**	**54,12**	**4,3**
Partition Wall	**yes**			**4.352.000**	**5.504.000**	**1.152.000**	**20,93**	**3,56**
Interior Doors	**yes**			**3.888.000**	**4.902.000**	**1.014.000**	**20,69**	**3,14**
Ceiling	**yes**			**2.276.000**	**3.330.000**	**1.054.000**	**31,65**	**3,26**
Storage Cabinet	**yes**			**2.628.000**	**3.684.000**	**1.056.000**	**28,66**	**3,26**
Other Interior Works			yes	3.555.000	4.680.000	1.125.000	24,04	3,48
Kitchen,Bath and Powder Cabinet	**yes**		**yes**	**6.178.000**	**7.817.000**	**1.639.000**	**20,97**	**5,07**
Exterior Works				5.644.000	5.644.000	0	0	0
Electric Works			yes	15.132.000	18.230.000	3.098.000	16,99	9,58
Plumbing and Sanitary Equipments	**yes**			**3.949.000**	**4.770.000**	**821.000**	**17,21**	**2,54**
Gas, Boiler and Floor Heating			yes	5.480.000	8.913.000	3.433.000	38,52	10,61
Air Conditioning			yes	10.980.000	12.600.000	1.620.000	12,86	5,01
Elevator and Other Equipments				5.510.000	5.510.000	0	0	0
Rent of Temporary Residence in case of Rebuilding				0	4.200.000	4.200.000	100	12,99
TOTAL				104.953.000	137.297.000	(C) 32,344,000	**23,56**	100

Fig 1. Comparison of Life Cycle Cost per One Housing Unit between House Japan Integrated Design and Conventional Design in case of Multi-family Dwellings

Simple raised floor components (Takenaka) : 54.12%
Movable storage partition components (Takenaka) : 28.66%
Wiring components (Takenaka) : 20.93%
Movable partition components (Kajima) : 20.93%
Changeable doors (Kajima) : 20.69%
Partition walls (Matsushita Electric Works) : 20.93%
Ceiling components “general type” (Obayashi) : 31.65%
Flexible sanitary plumbing system (INAX) : 17.12%

Conclusion

Thus the application of those infill systems and components are examined to be effective especially from the viewpoint of life cycle cost, owing to their continuous improvement through experimental construction. But it should be understood that life cycle cost estimation much depends on supposed conditions and a scenario. It is why some detailed explanation is done in this paper. The conditions can change following the design and the scenario can differ in each country.

In Japan the results shown here may have persuasive power in the real industry. The rest of difficulties against the diffusion of those new technologies is to organize housing process using those. For that, every participant in housing should understand the fact that housing means long lasting continuous process in stead of the former story that housing means building a new house.

Refferences

1. “The Twenty-First Century Style of Housing in Japan”, supervised by S. Matsumura and S. Tanabe, edited by House Japan Project association, Toyo Keizai Shinpou-sha, 2001
2. “Final Report on Each Theme”, House Japan Project association, 2001
3. “Final Results to the Initial Objectives”, House Japan Project association, 2001
4. “Final Drawings”, House Japan Project association, 2001
5. “The Proceedings of Japan- Scandinavian Countries Seminar on Housing in Sweden”, edited by Peter Adler,1997
6. “The Proceedings of Japan- Scandinavian Countries Seminar on Housing in Finland”, edited by Asko Sarja, 2000
7. “The Proceedings of Japan- Germany Seminar on Housing at Munich”, edited by Thomas Bock,1999

Sustainable Changes in Japanese Detached Houses

Eiichi TOBE
Shin MURAKAMI
Nobuhisa MOTOOKA

Sugiyama Jogakuen University, Dept. of Human Environment
17-3 Hoshigaoka-motomachi, Chikusa-ku, Nagoya, 464-8662 JAPAN
e-mail: shin@he.sugiyama-u.ac.jp (access to S.MURAKAMI)

Sustainable Changes in Japanese Detached Houses

ABSTRACT

In this research, we explain the building construction types of modern houses in Japan, in terms of changes in forms and dwelling styles from those of traditional houses. We analyzed the results of our investigation of plans of modern detached houses and questionnaire survey to their dwellers, in terms of, 1. inheritance of and changes in traditional forms, and 2. changes in dwelling styles in modern houses. Seeing a traditional house in light of "Japanese-style building construction", which was supported by the idea that social status overweighs other elements, the building construction of modern houses can be grouped under the category of "integration of Japanese and Western styles", that attaches importance to enrichment of family's life with joyful living and freer expression of individual's sense and taste. With these observations, we conclude that integration of Japanese-style and Western-style is the typical building construction of Japanese modern houses. The integrated design aims for expression of individual's personality as well as enjoyment of daily life. Based on the concept of integration of Japanese and Western styles, S. Murakami and N. Motooka developed a project of housing design in order to achieve the following goals: 1.Japanese-style and Western-style exist independently; that is, co-existence of these styles has logical significance. 2.These two styles complement each other. 3. There is no disagreement in co-existence of these two styles. We opted for a renovation process as an ideal model for the aim of incorporating another factor 'sustainability' into this concept. The subject, a traditional Japanese wooden house, was built in 1868, remodeled in 1951, and is being renovated in 2001.

Sustainable Changes in Japanese Detached Houses

Eiichi TOBE
Shin MURAKAMI
Nobuhisa MOTOOKA

Introduction

A traditional Japanese house which is characterized by its wooden framework was originally sustainable. This is because of separation of building frame and infill in terms of building construction as well as its adaptability to various ways of room-partition that best suit different purposes or uses on many occasions, which enables dwellers enjoy "tailor-making living". Most houses built before the Second World War were livable for hundred years further. However, the characteristic of sustainability has been gradually lost since the Japan entered into the new era of mass production and mass consumption.
The purpose of this study was to find and analyze the common features among current Japanese detached houses, and to investigate into the background of the decline of quality of sustainability, for the aim of clarify specific challenges to be met in order to restore sustainability. Furthermore, in this article, we propose our project of sustainable renovation of a traditional Japanese house based on our findings.
The primary concept as the assumption in our research was that framework/structure, room layout, and dwelling styles are integrated. From these three aspects, we investigated common points of surveyed houses in order to analyze changes of traditional houses and characteristics of modern houses.
The relevant survey has been continued since 1984, mainly consisting of sampling of floor plans and questionnaire survey of dwellers.

Traditional Japanese detached houses in comparison with modern houses

Most of traditional houses of Japan are wooden houses. They are built according to a building construction, which starts from building of framework and roof and then proceeds to room partition. Pillars and walls were arranged in a way that the pillars are exposed externally with the walls put behind ("*Shinkabe*" method) for durability and aeration. Partitions are usually made of "*fusuma*" (papered sliding door) and "*itado*" (wooden panel door), both of which are easily removable when larger room is needed. Because these houses generally have no corridors, dwellers can walk through every adjoining room. Still, there once was rigid distinction of room use, making definite differentiation between the function of reception and that of daily family life (the front side and the back side), and respecting social status and circumstances (superiority and importance of a person). The room of the highest position is "*zashiki*"(drawing room), with "*zasiki-gamae*" or decoration consisting of "*tokonoma*" (alcove), "*shoin*" (study) and "*chigaidana*" (staggered wall shelves). It also has "*ranma*" (a wooden panel with openwork carving used as a decorative transom above paper sliding doors) between "*nageshi*" (horizontal piece of timber) and "*tsughinoma*" (anteroom). The traditional Japanese dwelling style was based on such an adapted structure that was suitable for sitting on floors for long hours. The most important background that had long supported the above housing structure and dwelling style was the principles of old times (from *Edo era* (beginning in the early 17th century) through the early 20th century). Those principles attached great importance to reception of guests and modest life style in accordance with individual's condition. They had been supported by the strict rank system that influenced subsequent family systems even after it became merely a name.

However, after the end of the Second World War, the surroundings that had supported these principles were toppled from their foundations. There were no longer needs to follow traditional room layout and expressions.

Now the principles and conditions, which made the base of the traditional building construction, are abandoned and new conditions are establishing the modern life style. In our survey, many people expressed their wills to build up a house with individual's aesthetic sense, interests and taste, abandoning existing forms. This tendency may be called a positive attitude toward enriched life.

Further analysis led us to the observation that this attitude has two aspects; one for enjoyment of individual or family life and the other for showing individual's sense and taste to people outside the family. We have actually seen a variety of decorations and ornaments (which are placed freely as they please) in entrances and rooms. They were not only a form of expression of joy and memory to be shared among family members but also a social tool to express a family's sense, tastes, and even economic status to people who visit.

For joyful living, families are trying to enrich their lives based on the respect for individual personality. To be specific, they attach importance to two things; securement of privacy and private amusement and fulfillment of a happy family circle (enjoyment brought through a lot of communication between family members). This approach may have become a core of the modern housing that came up with separation of common use rooms and private rooms. It is noteworthy, however, that there were some cases of mixed-use of private space and common use space, such as use of *tsuzukima* (suite) as a bedroom and having fun to oneself in a common use room. Such uses seem to have contributed to establish the recent unique Japanese lifestyle. "Separation of private rooms and common use rooms with frequent exceptions" may be the best description of the actual dwelling style, considering the fact that people often use common use space to have fun to themselves.

This life style appears to be influencing the dwelling life, too. Traditionally, the most important function in a house was guest reception, and this was clearly separated from daily life of family. Little importance was laid on the aspect of private life. After the war (when there were no longer needs to follow strict distinction between formality and informality), life was divided into two sides; family life and private life. Guest reception is still a part of home life but often regarded as a concept opposed to pleasant time when family members can have together. On the contrary, some families find fun in welcoming guests. In other words, the modern life can be explained more satisfactorily as a life that has two sides: one side attaches importance to duty and rationalism, and the other side pursues fun and enjoyment.

Life as fun can be categorized into three types; fun to be had to oneself, fun of communicating with other family members, and fun of communicating people outside the family.

The dwellers of surveyed houses recently think more of "having fun through activities" (reading, talking, eating and dining, etc.) and "having fun through designs and decorations of dwelling space" (having comforting impressions, feeling the personality of the resident(s), etc.). Further analysis has led us to a possible conclusion that people make much of "relaxing impression" and "bracing impression (heart-touching)" from designs and decorations.

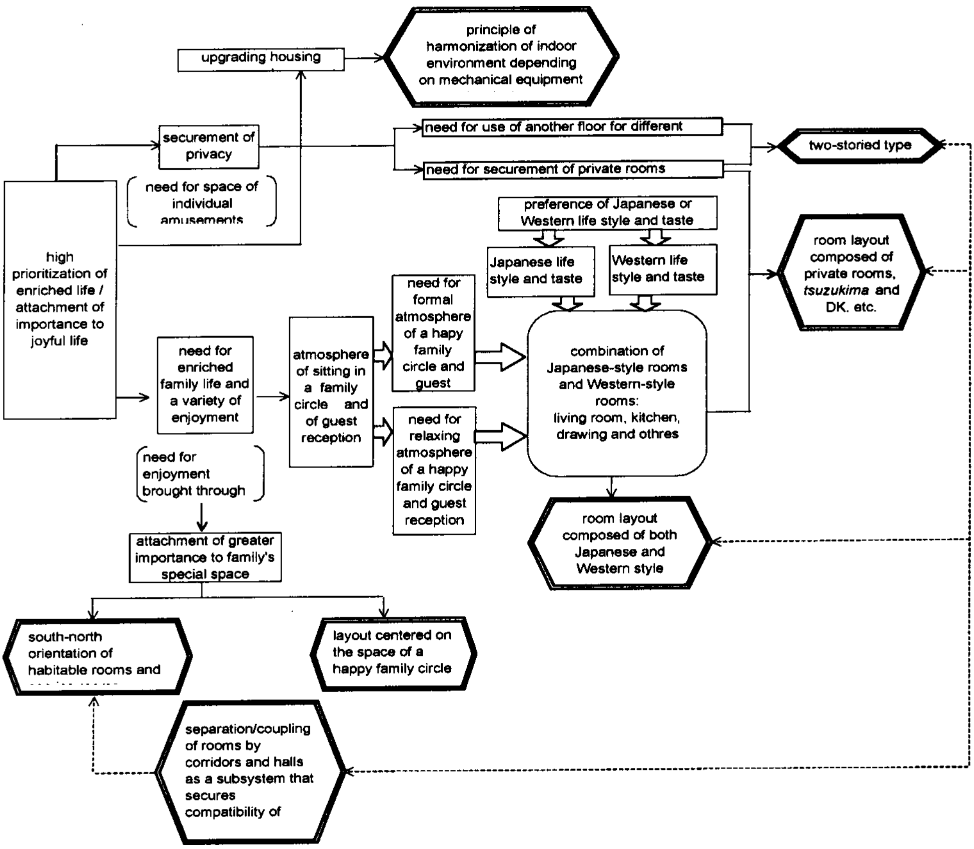
In response to these significant changes in people's attitude toward dwelling and life styles, the housing pattern has also undergone great changes. Westernization is a core of these changes. Westernization of houses is a remarkable and outstanding change.

The design of Western-style room itself is much different from the original design found in houses of the US and Western European countries because the former has incorporated some Japanesque elements, modified to be suitable for industrial production in the domestic market. Nevertheless, a certain form of "Western-style" floor planning has been established.

In a Western-style room, we can see chairs that are not found in a Japanese-style room, a planned combination of furniture items, and free and original expressions. A Western-style room does not only reflect a new life style, but also serves as a place to make harmony of Western designs of domestic articles and furniture items. For example, setting a piano in a Western-style room has already become an apparently strong tendency. There are not a few cases that floor plan had to catch up with living requirements including the above example. When building a house, it is likely that people are ready to take in new things even though they have no experience about them. Such attitude may also contribute promotion of Westernization. Many attempts were made during the rapid economic growth period before reaching at the recent general concept of Westernization. In any case, it is of no doubt that modern housing has the basic concepts of "separation of private rooms and common use rooms with frequent exceptions" and "combination of Japanese and Western styles".

Our next challenge was to find a relationship between these two concepts. Combination of Japanese-style rooms and Western-style rooms, and room layout composed of private rooms, *tsuzukima*, dining kitchen, etc. may be representing different aspects of the same floor plan. Combination of Japanese-style rooms and Western-style rooms are for a dwelling style that enables preference of either Japanese or Western life style according to the room design. The layout of different types of rooms including private rooms, *tsuzukima*, dining kitchen, etc. represents the different functions of rooms that draw line of private space and common space (A separated room is used as a private room and a bedroom, and the rest are for common use). They probably have a relationship of vertical axis and horizontal axis, in other words, a relationship between a housing form and dwelling style.

The two-storied type is a subsystem that functions especially for idealized layout of private rooms. South-north orientation of habitable rooms and service space in the direction from



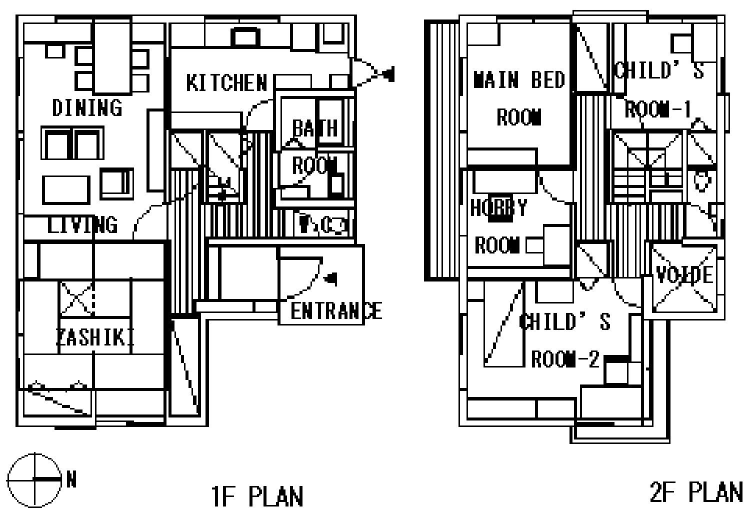


fig.1 Relationship between needs & forms and an example in modern housing

south to north and the traditional flow planning are considered to be another subsystem of layout of common use rooms. Coupling of rooms by corridors and halls is the form that made it possible to materialize these layouts and to secure the spaces of different uses. With corridors and halls, families can make independent and exclusive use of each room. In this respect, all of these layouts and plans are subsystems of the building construction of modern houses. They are combined to one another organically to build up a house and a life. These are the actual conditions of building of modern houses.

Seeing a traditional house in light of "Japanese-style building construction", which was supported by the idea that social status overweighs other elements, the building construction of modern houses can be grouped under the category of "integration of Japanese and Western styles", that is supported by interests in enrichment of life through joyful living and freer expression of individual's sense and taste.

Problems of modern houses from a viewpoint of sustainability.

A large majority of the modern houses in Japan were newly built after the war, and the rest have undergone extension and/or alteration. Particularly in the period of high economic growth, a great number of new houses were supplied with the boom of mass-production and mass-consumption. On the contrary, traditional houses, including those stocks which only needed some renovation to be kept livable, were gradually demolished or abandoned. Four (4) main contributing factors for this action are suggested as follows:

1. upgrading housing needs
2. development of building construction and economic efficiency
3. regulations of city-planning system
4. problems of maintenance of traditional houses

As discussed above, the typical style of Japanese houses has been greatly altered with changes in family relationship and westernization of life style. There were even some people who wanted to reject a traditional house for the reason that it just symbolizes old and feudal family relationship. A move toward renovation of traditional houses according to new family relationship and life style could hardly be made under such circumstances. Furthermore, increasing needs for control of thermal environment, including use of air-conditioning and heating equipment, were beyond the capacity of a traditional house, which is basically designed to utilize surrounding natural environment. These factors might have led to the fact that the concept of "new house is needed for new life style" came to filtrate into the public, while the idea of sustainable renovation of traditional houses failed to gain popularity.

Development of building construction and pursuit of economic efficiency also played an important role in the tendency toward choice of new construction. "*Shinkabe*" method is thought to be unsatisfactorily earthquake resistant because frame is supported by pillars and beams only. Bracing and earthquake resisting walls are naturally required for reinforcement. On the other hand, "*Ôkabe*" method, which has been spread widely after the war, is a construction method that covers pillars with exterior walls and finishing materials. This method has some advantages as follows:

1. Cost-saving. (Unattractive parts of pillars (e.g. knots) can also be used. No need to

finish the pillars.)

2. Bracing, thermal insulating materials and other materials can be put between interior walls and exterior walls.
3. A variety of interior decorations are possible. Particularly, this is necessary to generalize adoption of Western-style rooms.

Housing production centered on this method was systematized in order to meet increasing demands for mass production, leading to development of the domestic housing industry. Although traditional houses also had solid building frames, they required bracing, earthquake resistant walls and additional work on the walls when a room was to be changed into Western-style. Naturally, new construction was much easier and economical.

A major problem regarding city-planning system is the regulation on prevention of spreading of fire in city areas. According to the building codes, dwellers of houses in city areas have legal obligation to use noncombustible materials for exterior walls. The walls of traditional houses built by *Shinkabe* method were against the codes. This also has hindered actions to achieve sustainable renovation of traditional houses.

The lastly listed maintenance problems are also serious. Living in a traditional house usually necessitates daily (routine) maintenance work such as relaying and repair of exterior walls, cleaning of pillars, floors, and roof truss, and renewing of *tatami* mats and *fusuma*, even though details of maintenance work may widely differ depending on the materials used. Such a troublesome work is hard for modern people who are used to live free of maintenance work.

Plan for sustainable remodeling of traditional houses

In this article, based on the above analysis results, we propose our project of renovation of private houses centered focused on sustainability of traditional houses.

Westernization of Japanese life style has gradually blended in with Japanese traditional style to create original combination of “Japanese and Western style”. Generally, the change from old Japanese-style to this combination took its most distinct shape with construction of new houses which adopt both Western and Japanese construction methods. Alternatively to this type of housing, the proposed project is an attempt to effectively utilize sustainability that Japanese houses of wooden framework had originally had. To be specific, in our plan, existing housing stocks are to be reused and given equipment improvement so that they are proved to be capable of adaptation to the combined Western-Japanese-style. The most important points in our planning was to allow “Japanese-style (existing stock)” and “Western-style (functions modified to new life style)” exist independently, still complementing each other, and to avoid disagreement between the space created by existing structure and the current life style. Taking a difference between rapidity of changes of life style and durable period of equipment and house skeleton into considerations, basic concepts of open-building could also be incorporated into this plan.

As a subject of the proposed project, a private house located in suburbs of Nagoya City, middle part of the main island of Japan, was selected as model of renovation. S.Murakami and N. Motooka carried out the planning and design. The building was a wooden house, which was built according to a traditional Japanese construction method in 1868. The rooms were partitioned with “fusuma”, or removable panels, which enabled increase or decrease of a room size for various uses. The interior space was organized in order of gradual increase of formality from the entrance to the innermost room. The house was a typical model of private houses that had a traditional Japanese-style.

As this Japanese-style house was built over a hundred years ago, we were not surprised to find that it has underwent several times of repair and improvement according to the changes of life style. In 1951, the east part of the main building was added. This part was mainly occupied with plumbing system, including lavatory, bathroom, and kitchen. The details of the planning of the space surrounding the entrance at the time of building in 1868 were unknown. However, as the timbers used in the structure of the east part from the entrance are those added in 1951, it was confirmed that the whole of the extended part including its structure was newly built. We presumed that the entrance part was originally had an earthen floor with plumbing set at the end of the space. In 1951, during the period of high economic growth, westernization of the dwellers’ life style led to performance of major reconstruction including a new dining kitchen with a table and chairs, westernization of the plumbing system, and interior decoration with flooring. Furthermore, in 1983, an annex was added for the reasons of change of family make-up (Children grew up) and need for private rooms. Since the completion of building of this annex, the subject, i.e. the old building, has not been used except for special occasions.

The proposed project is to rehabilitate such a traditional Japanese house that is now of little use. As one of the first steps of rehabilitation, we developed a repair plan that utilizes sustainability that Japanese-style houses had possessed from the beginning. In this case, we investigated into possible repair processes that protect wooden structure of 1868 as well as meet different needs for functions of modern living style.

As discussed above, the factors underlying demolition of existing stocks include upgrading housing needs (No. 1 of the above list). How to bring the needed functions into the existing structure without disharmony was an important issue. In order to solve this problem, we planned to divided the building into two from the entrance, the east half and the west half. We decided to basically keep the present condition of the west part and to spare most of its space for traditional life style. As for the east part, we planned to introduce new space in order to respond to upgrading housing needs by using “*Ôkabe*” method. We gathered most of the functions of daily

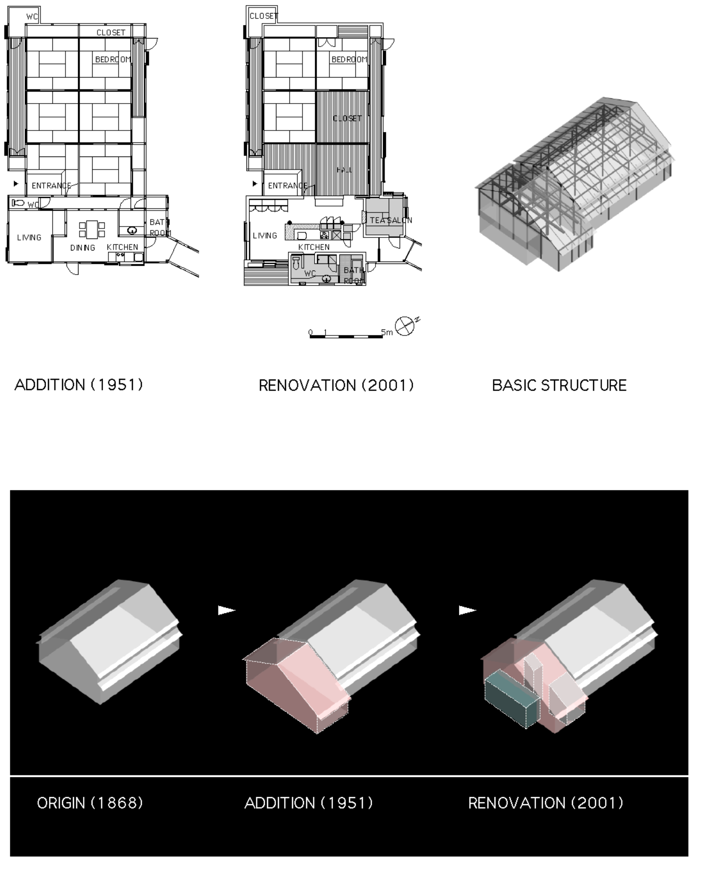


Fig.2 Renovation project

living, such as living room, bathroom, and lavatory, in this part. This room layout is a result of our examination of harmony of existing space and the ideal life style.

As shown in the figure 2, this project aims to maintain most of the frames of the existing house. Those pillars and walls which became unnecessary were removed. Additionally, some pillars which did not conform to our plan were shifted from their original positions. We held these structural changes to the minimum. The rest of the existing frame parts including the exterior walls and the roof frames were still useful and kept intact. However, partial reinforcement by splice with metallic tools was performed on pillar-beam joints for safety against earthquake. These repair works should let the old wooden frames live over another hundred years, as confirmed by the survey of the carpenters in charge. Needless to say, it is a prerequisite for successful maintenance to continue adequate repair and cleaning in the future. Generally, ventilation (this is necessary for the structural part to be kept free from damp) and air tightness (this is necessary for indoor space) are often incompatible. In this project, we attempted achievement of securement of both ventilation in the attic and comfortable thermal environment by means of heat insulation of the ceiling surface facing indoor. We also spared space for ventilation inside the exterior walls that were built according to *Ôkabe* method as a measure to protect the structural body from humidity.

While the structural body itself has still kept good quality for long use, the plumbing system installed in 1951 was no longer of much use since it has not been kept in repair for years. Therefore, we decided to set entire new plumbing equipment.

Dissatisfaction with modern houses and nostalgia for old days have recently made people think better of such traditional houses. Currently in Japan, there are many examples of "private house rehabilitation", including our project. Their uniqueness in architectural design, such as emphasis on Japanese-style, is drawing increasing attention. However, more important are the sustainability of a traditional Japanese private house and its opening building system including original dimensional structure.

This project is scheduled to be completed by December 2001.

Conclusions

In this research, we were able to explain the theory of building construction of modern detached houses in Japan, and predict problems involved in sustainable renovation of traditional houses. Our proposed project is an attempt to perform sustainable renovation of a traditional house even under such difficult situations and to get perspective of future development of this segment.

Today, purely Japanese-style houses were very few. There are some important aspects to be considered when planning renovation of these houses as follows:

1. How to adapt traditional rooms to current housing needs. Effective use of the space, where installment of complete air-conditioning and heating equipment is nearly impossible, is particularly important.
2. How to produce harmony of structures of traditional parts and those of new/renovated parts. A device to let out moisture, securement of ventilation and interior heat insulation, addition of bracing and earthquake-resistant walls, and finishing of exterior walls in accordance to the regulation of fireproof are primary considerations.
3. How to secure sustainability of added/renovated parts, or, how to develop a program for maintenance. Sustainability of the whole building can only be achieved when both added/renovated parts and traditional parts are taken into consideration. It is critical to examine feasible programs in advance.
4. Development of an efficient system of maintenance of materials such as roof, floor, walls, and fusuma. This issue has rarely been taken up for assessment so far.

Cooperation centred on the users

Ib Steen Olsen
Head of Division, Advisory
Danish Ministry of Housing and Urban Affairs
Slotsholmsgade 1
DK-1216 Copenhagen K
Phone: 45 33 92 61 00
Fax: 45 33 92 61 64
e-mail: iso@bm.dk

Cooperation centred on the users

ABSTRACT

"Better cooperation" is a key concept in the building sector in Denmark. It applies in all phases of a building project - from idea to operation.

Better cooperation is intended to lead to more precise covering of the users' needs and to greater productivity.

The vision is flexible forms of construction that offer the possibility of individualised buildings that can be changed in step with new user needs. The development is taking place around "Open Building", which builds upon the ideas in the Danish building industry concerning industrialised, open building systems.

Experience from a number of experimental building projects has led to a new division of the phases in a building project: establishment of values, planning of cooperation, construction with autonomous multi-gangs, and management of operating tasks.

This autumn brings the conclusion of a development programme on "New Forms of Cooperation". Here, 10 building blocks are suggested for improving the cooperation during the planning of a building project.

At the same time as this programme ends, a new programme "Clients create values" is being established with the aim of developing new forms of interaction between the users, the client and the building industry.

In the construction phase, the aim is to develop new forms of cooperation that promote interaction between different trades in so-called autonomous multi-gangs at the building site. At the present time, this phase is touched upon only marginally in the experimental building projects carried out.

Lastly, new forms of management must be developed for the operation of buildings that promote "green" operation by various means, including indicators and benchmarking.

The results of the first two phases - establishment of values and planning of the building project - are presented below. Open Building plays an important role in the development work.

Cooperation centred on the users

Ib Steen Olsen

New planning method

The main aims in the development of the new planning model are:

- better alignment to the needs of the market through dialogue with the users
- greater productivity by involving manufacturers of building components and contractors at an early stage of the planning process, and
- reduction of building defects through more effective interaction between the parties in a building project.

In Denmark, the Ministry of Housing and Urban Affairs, in cooperation with the Ministry of Trade and Industry, has analysed the situation in the building industry. The analysis points to three important problems.
Firstly, productivity has not improved at the same rate as in other sectors of industry. Looking at the development of productivity in other countries as well, action is needed to improve productivity.
Secondly, there is a need for greater transparency for the users. It is often difficult for the user to compare the quality and financial pros and cons of different solutions. It is also difficult for professional clients to get a clear picture of the consequences of different solutions.
Lastly, there is a need to reduce the number of building defects. In the last few years, the Danish building industry has managed to halve the number of building defects, but the impression is that further improvement is possible.

On the basis of this analysis, 28 proposals have been put forward for improving productivity, covering user needs and reducing building defects.

The analysis also contains some pointers for the future development of the Danish building industry. These pointers will now be translated into indicators that can be used in the individual experimental building projects and in that way show whether the new processes and products promote development in the building sector.

Experimental building projects used to gather experience

In Denmark, experimental building projects have been used since the 1970s to promote quality, productivity and competitiveness. New processes and products are tested and evaluated in the projects. The basic development work normally takes place at the planning stage.
The building projects are collected into groups or networks with the same theme - for example, Clients create Values and New Forms of Cooperation. The results from these

networks are used as the basis for the new planning model.
Two forms of evaluation are used. Either an independent evaluator, chosen in a competition on the basis of pre-agreed criteria, prepares an evaluation report or a result contract is entered into between the ministry and the development group in which the latter undertakes to use some agreed indicators to record the results achieved. These indicators reflect nationally established goals for the development of the building industry. For example, indicators of productivity, building defects, accidents at the worksite, financial aspects, etc.

Phase 1 - establishment of values
In this phase, the users' values in the coming building projects must be established.
For example, it may be of great value to the users of the new building/building project to have noise reduced as much as possible - both outside noise and noise from neighbours. It could also be a value that the building/building project is as environment-friendly as possible.
In other words, one is not operating with concrete solutions - bricks, concrete, wood, etc. - but with values to which the users attach importance later on - during use of the building.
One thus achieves a discussion that is not bound by materials or form of construction.
When establishing values, it is also necessary to look at the financial consequences.
Today, it is very difficult to get hold of data that shed light on this aspect. That will be one of the tasks in the coming development work.
At the present time, the following 6 building blocks have been suggested and will now be discussed in detail with the network in which the experimental building projects are anchored, "Clients create Values":
- *mapping* of regulations concerning the site, such as scheduling, local plan, etc.
- objective/quantitative *estimates and basic assumptions*, possibly minimum/maximum, e.g. area, functions, cost, prepared by the client for use in a dialogue with the users
- *workshops*, as organised dialogue based the above-mentioned estimates and basic assumptions, AV aids, etc.
- assessments from *experts* concerning, for example, work conditions, fire, natural conditions, layout, conditions for disabled users, etc.
- *contact* with "lead users", e.g. from similar building projects, international experience, etc.
- comparisons, *benchmarking*, e.g. concerning area, functions, cost, calculated per person, m^2, m^3, etc.

Experimental building projects show the way
In analyses of Danish building projects from recent years - both from the government and the building industry - targets have been set up for the development of the building industry. These targets, which apply to the industry as a whole, are now being converted and broken down into indicators that can be used in experimental building projects.
This makes it possible to put the results of the projects in relation to national and international efforts. At the same time, a better basis is being created for judging whether and to

what extent the processes and products tested are worth continuing with. And the involved firms can refer to the results achieved and perhaps advertise that they belong to "the building industry's super-league".
For example, one target is for productivity in the Danish building industry to increase by 33 per cent more than in neighbouring countries. If the development of productivity in those countries is put at 3 per cent, the Danish building industry must achieve 4 per cent. The indicator in the individual building project is thus productivity, and an improvement of 4 per cent in comparison with similar projects is agreed. The group responsible for the experimental building project must document its results by recording, for example, man-hour consumption.

Phase 2 - planning of the building project
A 3-year development programme on "New Forms of Cooperation" ends at the end of 2001. The programme comprises 9 building projects in which different elements of new forms of cooperation are being tested and evaluated.

The new forms of cooperation are also known as partnering. The experience with the new forms of cooperation has generally been very good, although there are big differences in the ability of different companies to enter into partnering. There is a need for dissemination of experience and supplementary training, which have already taken place in the last couple of years.

The experience from the New Forms of Cooperation programme shows that the following 10 "building blocks" can usefully be included in a partnering agreement:
- *Common goals and values*: From the very start, the partners discuss and agree some common goals for the building project and - through these discussions - arrive at a common understanding of the values that are to apply to the cooperation.
- *Respect for each other's success criteria*: The partners enter into the cooperation with their respective criteria and goals, which the other partners must respect. It may be useful to get each of the partners' goals clearly formulated.
- *Incentives are OK*: "Profit sharing" and rewarding delivery without defects strengthen the cooperation and counteract sub-optimisation.
- *Use of indicators*: Use of benchmarks shows whether the goals are being achieved and thus in itself acts as an incentive. In the experimental building projects, benchmarks have been used for compliance with budget, lifetime costs, defects on delivery and user satisfaction.
- *Transparent estimates and accounts*: Mutual transparency concerning financial aspects generates trust but is also a prerequisite for partnering, in which one works with incentives and benchmarks, and in which the price is fixed by negotiation.
- *Teambuilding and workshops*: New forms of cooperation develop best when the form of meeting encourages common decisions through trustful dialogue.
- *Conflicts are resolved through dialogue*: Cooperation in partnering is no guarantee against disagreement and disputes, but the parties agree to resolve them without

recourse to law and without there being losers.

- *Contractors participate in the project design*: The best way of ensuring that a project is as suitable as possible for construction is to have the contractor participate in relevant parts of the design work. The main subcontractors (tradesmen) should also be involved to the greatest possible extent in relevant matters.
- *Multigang*: The interdisciplinary cooperation in the design of a project can be advantageously continued in the construction phase with a view to counteracting sub-optimisation. The cooperation can, for example, take the form of multi-trade gangs.
- *Key people stay on the project all the way through it*: It is important for successful cooperation that the key people are willing to stay on the project all the way through it.

3rd and 4th phase

Up to the present time, these phases have only been touched upon marginally in the experimental building projects carried out. The aim is to gather the experience gained so far and supplement it with new experimental projects.
In the case of the operating tasks, a network has been built up for exchange of key figures for operation of buildings, e.g. energy consumption per m^2, maintenance costs per m^2, etc.

Open Building - incorporation

The new planning method opens the way for:

- the creation of individualised building projects
- a dialogue between the users and the manufacturers of components, and
- planning and decision-making at different “levels” that reflect and ensure flexibility for later users.

The new planning method can only work if broad cooperation is organised and accepted. In the case of subsidised housing, for example, new legislation is being discussed that, on the basis of experience from a number of experimental building projects, will give the occupants themselves the possibility of investing and having a say in 20 per cent of the costs of a home. These investments can, for example, be used for lightweight partition walls, floors, cupboard units and installations within the framework of a carcass that allows a number of variations and thus also the possibility of later alterations.

Ever since the first experiments with industrialised building methods in the 1950s, the goal has been to increase the proportion of prefabricated components in Danish buildings and to be able to combine components from different manufacturers in one and the same building, thereby enabling architects to design individualised buildings. Rules on dimensional coordination were therefore developed at an early stage.
The new planning method, which stresses cooperation and shows ways of achieving it, is the next step on the path.

The new planning method is not simply one specific procedure but contains a a series of '"building blocks" that must be assessed and used according to the building project in question.

In all, the new planning method offers a range of possibilities for planning a procedure that is suitable for the use of Open Building.

Project-related product innovations by architects

Mieke Oostra
Faculty of Architecture, Delft University of Technology,
P.O. Box 5043, NL-2600 GA Delft, the Netherlands
m.oostra@bk.tudelft.nl

Project-related product innovations by architects

ABSTRACT

Architects generate designs for new buildings and make proposals for adjustments or additions to existing buildings. It may not be possible, or satisfying, to realize part of these designs with standard products. Therefore, architects have an interest in product innovation. Architects have opportunities to initiate special product innovation. These special products are developed for a specific building. Most research into product innovation is, however, focusing on manufacturers and the development of standard products. In contrast, this paper discusses the results of a study aimed at describing the contribution of architects in special products innovation.

The results of this study are derived from five different cases. These results were supplemented with statements on product innovation and the construction industry made by architects, manufacturers, product developers, contractors, construction engineers and academics who were not part of the case studies. Finally the results were validated by checking the responses to these results of architects active in product innovation. Project management factors in these product innovation processes are described as well as the strategies which emerged. Architects use these strategies to exert a favorable influence on design and development processes of special products.

Project-related product innovations by architects

Mieke Oostra

Introduction

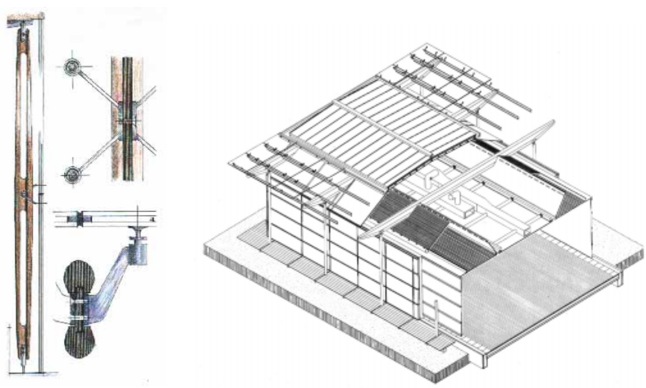
Innovation in any branch of industry is important if it is to keep up with the changes in regulations, as well as the preferences and requirements of clients. [1,2]. Although product innovations are desirable given the surplus value they offer to firms and their clients [3], the building industry would seem to attach little importance to innovations if one looks at the industry's low ratings [4, 5, 6]. Incremental process innovations are the commonest sort of innovation in this branch. [7, 8]. Generally speaking the manufacturers are seen as the ideal product developers. However, other parties also make important contributions to product innovation. Architects, for example, play an important role in initiating the design and development of products in specific building tasks [9]. In planning a building, architects encounter design proposals that cannot be realized with standard products. In such situations they have the choice of adapting the design to existing products or initiating the development of new products. To achieve results by special product innovation, architects must be open to collaborating with others [10]. They will need production facilities, and hence must collaborate with manufacturers. In most instances architects will also need complementary expertise from other people such as constructors or other advisors.

For present purposes, an architect is defined as a licensed person operating alone or on behalf of a group of individuals, usually a firm of architects. The aim of an architect is to prepare design documents for buildings or other objects in cooperation with people outside his own firm, on the basis of which the building can be constructed. The building process is the process in which plans and specifications for a building project are generated and are converted into a physical building. The achievement of this goal requires many different kinds of expertise, generally represented by individuals from different companies. The study proceeded from two kinds of building processes: a 'traditional' building process and the building team. In the 'traditional' building process an architect directs the other parties involved in the project on behalf of a client. In case of a design team client, architect, contractor, sub-contractors, manufacturers, project manager and advisors cooperate from an early stage. The general opinion among architects is that even this relatively powerful position of the 'traditional' building process does not give them much freedom to design special components for a building. However, in most cases a building process is the setting in which architects initiate the innovation of special products.

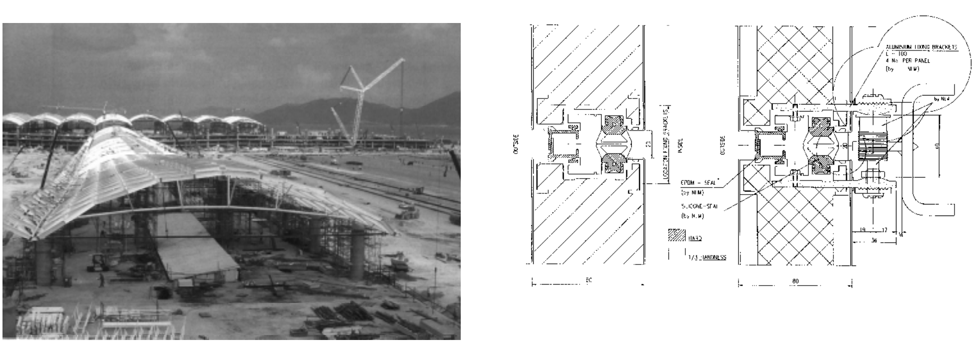
Methodology

In the first instance the aim of my doctoral research, of which this study is a part, was to catalogue and describe product development processes in the building industry. An initial study was carried out that focused mainly on manufacturers. In interviews with manufactur-

ers, there were two important sources that lay behind the introduction of innovative products to the Dutch market. The first concerned products launched by a related or competing foreign company. The second source was requests from architects for the supply of special non-existent components for their building projects. It also turned out that manufacturers use some of these ideas to generate new standard products.
In contrast to the development processes of standard products in the building industry, special product development initiated by architects is a virtually uncharted territory. I decided to make this the central subject of my Ph.D. research.
Since very little research has been done on special product innovation in the building industry, case studies were used. The decision to opt for case study research is based on Yin's considerations [11]. In short, case studies offer the opportunity to acquire overview over this new research area.[1]
This paper considers the results of five exploratory case studies that enabled an examination of how architects guide product innovation. The first case study investigated how Lignostone, processed beechwood, was applied. The second case study concerned the design and development of a building facade paneling system with high sound proofing properties. The third case the emergence of a prefabricated curved concrete beam was investigated. The fourth case study considered the design and development process of a new highway crash barrier. Finally, in the fifth case studied the generation of the design and development of a new structural floor system.

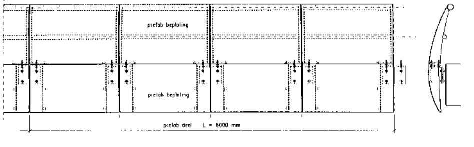


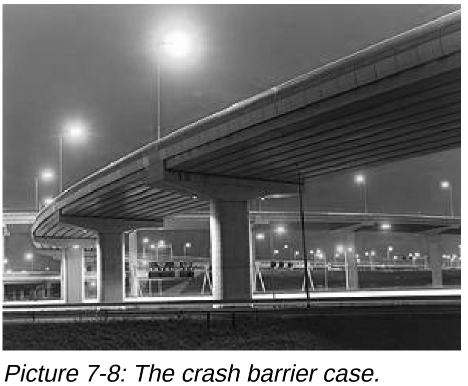
Picture 1-2: The Lignostone case.



Picture 3-4: The sandwich panel case.

Picture 5-6: The curved beam case.





Picture 7-8: The crash barrier case.

Picture 9-10: The floor system case.

Semi-structured interviews were held with employees of manufacturing companies and architectural practices. The concepts underlying the interviews questions came from business administration literature on innovations and product development in other branches of industry. An overview of these concepts is to be found in the state-of-the-art report on product innovation [12].

THEME'S	**CASE STUDIES**				
	Ligno-stone	**Sandwich panels**	**Curved beam**	**Crash barrier**	**Floor-system**
BUILDING PROCESS					
Certifying	x	x			
Building Assignments		x		x	
PRODUCT INNOVATION					
Reliability	x	x		x	
Amount of products	x			x	
Alternatives	x		x	x	x
Acceptance by the client	x				
Decision making	x		x		
Coordination of disciplines	x	x		x	x
Purpose of mock-up	x			x	x
Duration of the development	x	x		x	x
Requirements	x	x	x	x	x
Evaluation	x	x	x	x	x
Evaluation criteria	x			x	
Phases	x	x		x	x
Obstacles	x		x	x	x
Instructions for use / maintenance	x	x		x	
Initiative	x	x	x	x	x
Climate architectural office	x				
Costs	x	x		x	x
Life span	x				
Market				x	x
Reasons for product innovation	x			x	x
Reasons for cooperation	x	x		x	x
Organisation					x
External influences		x			x
Plans			x		x
General remarks	x	x			x
Price per element	x		x		
Problems in the process	x	x		x	x
Steering of the process	x	x	x	x	
Role of the architect		x			x
Product testing	x	x		x	x
KNOWLEDGE DISSEMINATION					
Advise to manufacturers / clients	x	x			
Product idea source	x	x	x	x	x
Design as a cooperative process	x			x	x
External diffusion	x				x
Communication tools	x				
Information sources	x	x		x	x
Innovation necessary	x				
Internal communication	x	x		x	x
External communication	x	x	x	x	x
Incubation time of the idea	x				
Promotion of the company		x			

Table 1-2 Concepts underlying the interview questions

The case study results were validated with statements made by several professionals who were not part of the case studies. This resulted in data from interviews and lectures given by different kinds of professionals involved or related to the construction industry or product innovation.

group of professionals		group of professionals	
architects	29	academics	34
manufacturers	12	consultants	10
product developers	6	government	2
construction engineers	10	clients	3
contractors	6	others	3
project developers	2		
		total number	117

Table 3   Additional data derived from different groups of professionals

The game theory perspective was used to interpret and link together the data generated in the context of this study. Historians date the origins of game theory as far back as 1654. [14] Game theory initially began as an abstract mathematical invention, the theory of probability. Since then it has evolved into a model for all kinds of interdependent decision-making processes. The social sciences began to use game theory to explain and predict behaviour [15, 16, 17].

In their book Actors and Systems, Crozier & Friedberg [18] show that games provide an excellent frame to study companies and industries. According to the authors, the creation and use of structured games is one of mankind's more important inventions, making possible the achievement of common goals, which require the co-operation of many different individuals. Contributing to a common goal also allows each individual to advance his own interests. The way in which an industry and companies are organised, however, has an important influence on the behaviour of the individuals involved. People are not controlled by the rules of the game but by its structure. In other words there is scope within the rules for the players to determine their own strategies, which will allow them to play in the way they personally find satisfactory. Usually they will only be able to achieve their own goals as long as they go on contributing to the common goal.

Following Crozier and Friedberg, a distinction has been made between resources, constraints and strategies in this study. Architects have certain resources at their disposal to use in a product innovation process. They will encounter difficulties, which they will have to overcome if the process is to be brought to a successful end. Deliberately or otherwise architects use certain strategies to take full advantage of their resources, or to side-step or get around any difficulties. How architects see their resources, address constraints and evolve strategies depends in part on the 'frame' [19] they use to assess their own situation.

1. For a more elaborate expose on research methodology see my PhD thesis: Mieke Oostra (2001) Componentontwerpen; de rol van de architect in productinnovatie, Eburon, Delft.

The following path has been used to come to a new theory on component design:

writing interview reports

↓

writing case descriptions

↓

analysis of theme’s within the cases

↓

clustering of information of the different theme’s

↓

clustering of information of theme’s and patterns from different cases

↓

adding per theme and pattern additional research data
(looking at differences and similarities)

↓

connecting different theme’s
based on questions raised by Schön [19] and Crozier & Friedberg [18]

↓

construction of theory

Before going into the results of the study, a brief outline of the theoretical basis will be given.

Theoretical basis

Of the many aspects in product innovation, three are crucial: the distinction between standard and special products, the consumer-oriented product innovations and influencing factors in project management.

Special products versus standard products

It is important to make a distinction between two product categories: standard products and special products (inspired by Eekhout [20]). A standard product can be manufactured independently without a client being involved. All products are identical, even though a manufacturer can include a number of varieties in his range, differing for instance in colour or measurements. He will know precisely what requirements the product in question must comply with. In the case of a special product a manufacturer may get a request from a

client that cannot be met with a product from his range. A completely new product must be developed for a specific building task.
There is an essential difference between the parties who take the decision whether or not to make a product. A manufacturer decides on the making of a new standard product. In the case of special products it is the client, who initiates the innovation process. The manufacturer's clients may play different roles in the building process, for example a principal, contractor, consultant or an architect. This paper focuses on the situation in which it is the architect who decides whether or not a new product should be made. From now on, I will use the term component design to refer to an architect's contribution to special product innovation.
A second basic difference between special component innovation and standard product innovation is whether or not the design and development is related to a specific building process.

Consumer-oriented product innovation
The literature from the perspective of the manufacturer of standard products has a long tradition [21, 22, 23 etc.]. Von Hippel has introduced the consumer active paradigm (CAP) as a counterpart of the manufacturer active paradigm (MAP) [24]. His research suggests that clients in the business-to-business market usually look for a manufacturer who is able to make the product they have in mind. Clients thus respond to technology capacity in general and a company's capacity in particular [25]. Something similar is also taking place in the building industry. Architects who design and develop an idea and initiate product innovation on behalf of their client fit in with Von Hippel's consumer active paradigm (CAP).

Project management
Architects employ strategies to manage the available manpower, means and information in the design and development process of a special product. They have to operate within the constraints of the building process. The general knowledge of these strategies is found in the discipline of project management.
Wijnen, Renes & Storm [26], authorities in the field of project management, categorise the aspects to be controlled in managing a project into: (a) money, (b) time, (c) quality, (d) information and (e) organisation. Other aspects that are emphasised in the literature are communication [27] and monitoring the work sphere in which trust among team members is important [28]. These aspects provide a basis to divide the strategies used by architects to direct project development into the following factors:
- time
- budget
- quality
- information
- organisation
- atmosphere

Architects will have to deal with these factors in order to get their ideas translated into real products.

Research findings

In order to find out how architects deal with the project management factors mentioned above, these factors were analysed in the cases of this research. Architects will use all kinds of tactics and strategies to steer product development processes. On top of that an inventory has been made of the arguments architects use to motivate the initiation of new building components and their roles in product innovation processes.

Project management factors

Important factors for realising special products are budget, time, information and access to facilities. Since most architects do not have extensive knowledge about the appropriate technologies to manufacture a special product, they need other parties to collaborate with them. In this context, the aim of collaboration is to gain knowledge and have manufacturing and testing facilities at one's disposal.

Product development budget

There is a link between the commissioning of a building project and the budget allocated for its construction. The prevailing opinion among architects is that a higher than average budget for a building, or a higher than average fee for an architect, is a precondition for initiating the development of new components. To show that this need not be the case is an example given by a young product development company oriented towards the building market. The money that had been put aside to purchase standard light fittings for an office was used to develop new fittings. Development costs and the manufacturer's fee came well within the budget reserved for light fittings.

Time

The time allocated to a building process may in part be spent on developing new components. The planning of design work determines the time available for product innovation. It could be that a building has to be completed so quickly that there is no time left for an architect to design a new building component.

Information

An architect depends on the support of other parties, those who have the knowledge and facilities needed to realise a new product. For this, an architect needs at least a manufacturer who is willing to make a new product. The Lignostone case proved that this collaboration is not always as obvious as it seems. The manufacturer, who specialised in sports goods, was not interested in delivering building products. It took much power of persuasion to move this market-dominating manufacturer to collaborate.
Because the parties involved in a building process do not see the design and development of new products as essential, an architect will have to motivate the parties whose collaboration is needed to develop a product. Money can play an important role in this respect. But other reasons could also motivate a person or an organisation to contribute to product innovation.
The following arguments for co-operative behaviour towards architects have been found:

- product innovation is part of the declared aims of the company (a client organisation);
- involvement in research into the material in question (a researcher at a university of technology);
- interest in encouraging the use of steel in buildings with this new product (an institution concerned with the promotion of steel structures);
- interest in applying this new composite material in the construction industry (a structural engineer)
- enjoyment for being involved in doing something new, while the project is not seen as an immediate financial success for the company (a supplier);
- interest in using the involvement to establish a innovative image for the firm (a supplier);
- interest in creating new opportunities to increase turnover (a supplier).

Obtaining relevant information is crucial. Colin Davidson distinguishes between two sorts of information [29] that are relevant here: (1) project-related information and (2) general information. He defines them as follows:
'Project-related information, as its name implies, denotes information that is particular to an individual [building][2] project and is accumulated during the project-related processes of design, manufacture and construction. General information is, at least in principle, available to nourish the processes of any construction or any research project; it is accumulated constantly as more and more is learnt about building-related technology, and about the application of the human and natural sciences to building.'

An important part of the information relevant to product innovation is obtained in exchange with others. This study also looked into the matter of information exchange in closer detail. The exchange of information relevant to component design has different characteristics depending on the sort of information. These two sorts of information are found in different contexts and time scales. In the case of standard products it is in the producers' interest that potential specifiers are aware of the existence and advantages of these products. It is of immediate advantage to make the new product known as widely as possible among those involved in the building industry who specify building products. The aim is to make knowledge of products part of the reservoir of general information of the industry.
In contrast, it is not so obvious for project-related information to be disseminated. Project-related information is built up at the start of a building assignment, by the different members of the building team. These members have to find a common format in order to communicate for the duration of the project. When the project is realised and all decisions concerning it have been taken this information largely disappears. Only a part is stored in archives or kept for maintenance purposes. The same goes for a part of the information linked to the development processes of special products. This information has not disappeared but remains only in the form of experiential knowledge for the people concerned, or as it is instantiated in the product itself.

---

2 Added by the author of this paper.

Fostering innovation through information

The information needed for developing a new product is a combination of these two sorts of information. As a result, a distinction needs to be drawn between these two sorts of information in fostering innovation in building. Architects use ‘general information’ in the innovation process for special products as a means to find producers. Besides drawing from their own experience, they use trade literature with this end in mind. However, this literature is inadequate for this purpose. To stimulate the development of special products by architects, additional information has to become available. This information is now mainly part of the project-related information reservoir. Because of the fact that this reservoir is hard to access, there is a need for an intermediary between architects and producers. This role is being taken on by a number of newly emerging firms, but these only reach a small group of architects. To encourage product innovation on a larger scale relevant information needs to be made more widely available. A database accessible via the Internet could provide a solution. An independent body would have to make an inventory of the various projects using special components already realised. Information would need to be provided about the parties concerned together with a short description of the product developed. Ideally there should also be a survey available of the production facilities of the different producers involved in the building industry, with an assessment of their technical knowledge. In Holland the firm of Booosting has the potential for this. They have the proper contacts and objectives even though they do not yet have the financial means to realise such a database.

Constraints and uncertainty

When architects design components they will, for instance, have to allow for a number of constraints including the codes and standards of the industry, which might thwart the development and application of new products. Insurance companies, clients, financiers, producers, contractors, politicians, project developers and even fellow architects may place obstacles in the way of architects’ initiatives to design and develop new components. [30]

Innovation goes hand-in-hand with uncertainty [18], particularly in the initial phases. Furthermore, innovation requires people to adjust their habits. In general the other players will try to keep such uncertainties under control and try to escape limitations, which others try to impose on them [18]. In a defensive reaction [31] a structural engineer will use to the usual methods of calculation, a manufacturer will employ the usual methods of production and a contractor to the products and construction techniques with which he is familiar. Architects whose aim it is to develop special products need other parties to collaborate with them and to offer their expertise. However, the same parties could also obstruct the product design process. Architects should be prepared to anticipate and respond to possible obstruction in the product development process.

Examples of such instances are the following.

- An insurer may impede the application of existing products in an unconventional way, let alone the application of new products.
- There may also be problems if suppliers have set up a cartel with the aim of dividing the market between them.

- Things can be difficult if there turns out to be only one supplier who can supply what an architect requires, but that supplier is barred from doing so by the terms of an agreement with his fellow suppliers. The required products will not be forthcoming.
- Any attempt to cut out subcontractors will discourage innovation, as low prices do not guarantee the quality of a subcontractor's work. Particularly when a subcontractor contributes to a new product, cutting him out can have an unfavourable effect. This situation may also result in a deterioration of mutual relationships, which in turn would affect communication between the parties involved, resulting in on-site co-ordination problems.

Arguments for product innovation

Although architects may initiate new product innovation, their main interest is not focused on the individual product but on the complete building project. Products are secondary in the sense that they are only the means by which (parts) of buildings are realised. But this central preoccupation with the realisation of the building can in fact provide a motive to create new products. Frustration may be the trigger here. For example, it may not be possible to realise part of a building design using existing standard products in a way that satisfies the architect. If the discrepancy between the desired result and the available solutions is big enough and there is time available, then the architect will explore the feasibility of product innovation. The architect must consider product innovation to be an option in the first place, though. Some architects will only use products already available on the market.

Another argument used to design new components is the desire to distinguish themselves from their colleagues. Architects have to compete in order to get building contracts from clients.

A third reason to innovate among architects is interest in technology and a quest for new and improved solutions for design problems. In this case architects are interested in exploring new possibilities and they will try to gain more in-depth knowledge. They will look for occasions in a building design process to utilise these new insights and ideas.

Roles

Architects choose between possible solutions for their building designs and so are in a position to persuade their partners to co-operate in product innovation. Taking on the role of initiator of project related product innovation makes adopting the role of motivator inevitable since other parties, such as the client and the contractor, have to be convinced of the need for the new product. The architect also has to find at least one manufacturer, who may or may not operate in the building industry, willing to develop and manufacture a new product based on his idea and at an appropriate price.

When they initiate product innovation architects usually play an active role as designers in the product development process. Although not responsible for all design tasks, architects make the final decisions concerning the appearance of new products. They can therefore take up a position as client or as co-designer (and occasionally as co-developer), depending on how much they rely on the aesthetic abilities of the manufacturer.[3]

Strategies and tactics towards the influencing factors

The design and development of a component is embedded, or nested in another process [32], the building process. This constraints the product innovation process. The fact that component design is embedded in the building process forces an architect to use strategies at two levels and so exert a favourable influence, i.e.:

- at the level of the building process;
- and at the level of the product innovation process.

In particular, many architects find it difficult to manage the embedding of the product innovation process into the building process. This is seen as a stumbling block. Although some architects would certainly like to develop a new product, a number of circumstances prevent them from actually doing so.

Some examples of these strategies with regard to the different project management factors found in this study are presented in the following table. [4]

Table 4 Some tactics in regard to the factors influencing product innovation used by architects to manage component design

---

In regard to time

- Persuade a client to increase the amount of time for the creation of new products by convincing him of their advantages.
- Start the product development process as early as possible in the building process, so increasing the amount of time available.

In regard to budget

- Reserve part of the building budget.
- Reallocate costs in the building budget.
- Persuade a client to increase the budget by convincing him of the advantages of the new products.
- Inquire about possible subsidies.

In regard to quality

- Call on the knowledge of third parties - competing manufacturers or product developers - to overcome problems.

In regard to information exchange

- Have an open-minded attitude towards a manufacturer to make it easier to exchange information about a product's feasibility and the way in which it is composed.
- Ensure that a client remains enthusiastic not just about the building project but also about the component to be developed. This is important. If there is any uncertainty about possible risks he may reconsider his decision.

In regard to process organisation

- Consider whether product innovation can or should be kept separate from the building

project.
- Come up with new forms for the organisation of the building process which are more favourable for initiating product innovation.

In regard to the attitude of the people involved
- Involve people in the building process who are receptive to new ideas.
- Improve motivation in the pre-tendering phase by paying for development work.

Conclusion
The way product innovation is been studied in general prevents us to realise what the contribution of architects is towards product innovation. Architects can learn from the strategies and tactics their fellow architects use in managing special product innovation processes and so achieve components that are better adapted to their own and their clients requirements and demands.

---

3 There are more roles architects have in product innovation processes. For a more elaborate description of these roles see my PhD thesis Componentontwerpen.

4 For a more elaborate description of strategies and tactics architects can use to stimulate product innovation see my PhD thesis Componentontwerpen.

References

[1] Philip Kotler (1994) Marketing Management; Analysis, Planning, Implementation and Control. Prentice Hall, Englewood Cliffs, New Jersey, USA.

[2] Booz, Allen & Hamilton (1982) New Product Management for the 1980's. Booz, Allen & Hamilton, New York, USA.

[3] Jacobs, Dany (1996) Het kennisoffensief; Slim concurreren in de kenniseconomie. Samson Bedrijfsinformatie, Alphen a/d Rijn, the Netherlands.

[4] A.D. Little D. Little International Inc. (1996) A technology map for dutch business. Report Arthur D. Little International Inc., no. 51500, Rotterdam, the Netherlands.

[5] Egan J. (1998) Rethinking Construction. Construction Task Force of the Department of the Environment, Transport and the Regions. www.construction.detr.gov.uk/cis/rethink/index.htm, UK.

[6] Shields, Rob (1999) Synthesis Report; Construction Industry Roundtable on Innovation. National Research Council of Canada, Canada.

[7] Pries, Frens (1995) Innovatie in de bouwnijverheid. PhD dissertation Erasmus University, the Netherlands.

[8] Jacobs, Dany , J. Kuijpers & B. Roes (1992) De economische kracht van de bouw; Noodzaak van een culturele trendbreuk. TNO-Beleidsstudies The Hague Stichting Maatschappij en Onderneming (SMO), the Netherlands.

[9] Oostra, Mieke (1998) 'Initiatives for product development in the building industry: the architect as product innovator'. Conference Proceedings: Detail Design in Architecture, Leeds, UK.

[10] Oostra, Mieke (2000) 'Project-related development of building products as a coopera-

tive process'. Collaborative Design, Stephen A.R. Scrivener, Linden J. Ball & Andrée Woodcock (eds.) Conference proceedings CoDesigning Coventry, Springer, London, UK.

[11] Yin, Robert K. (1989) Case Study Research; Design and Methods. Sage Publications, Newbury Park,California, USA.

[12] Oostra, Mieke (1996) Productontwikkeling van bouwcomponenten. Unpublished.

[13] Glaser, Barney G. & Anselm L. Strauss (1967) The Discovery of Grounded Theory; Strategies for Qualitative Research. Aldine Publishing Company, Chicago, USA.

[14] Colman AM (1995) Game Theory & its Applications: in the social and biological sciences. 2nd edition, Butterworth-Heinemann Ltd, Oxford

[15] Harold W. Kuhn (1997) Classics in Game Theory. Princeton University Press, USA.

[16] Morton D. Davis (1983) Game Theory; a nontechnical introduction. Revised edition, New York Basic Books, New York. USA.

[17] Drew Fudenberg & Jean Tirole (1991) Game Theory. MIT Press, USA.

[18] Crozier M, Friedberg E (1980) Actors and Systems: The Politics of Collective Action, 2nd edition, The University of Chicago Press, Chicago, USA.

[19] Schön, Donald A. (1983) The Reflective Practitioner; How Proffesionals Think in Action. Basic Books, Inc., USA.

[20] Eekhout, Mick (1997) POPO; Of ontwerpmethoden voor bouwproducten en bouwcomponenten. Delft University Press, the Netherlands.

[21] Bruce, Mararet & Wim G. Biemans (1995) Product Development; Meeting the Challenge ot the Design-Marketing Interface. John Wiley & Sons, Chichester, UK.

[22] Hollins, Bill & Stuart Pugh (1990) Successful Product Design; What to do and when. Butterworths, London, UK.

[23] Clark, Kim B. & Steven C. Wheelwright (1994) The Product Devlopment Challenge. Havard Business Review Book, Boston, USA.

[24] Hippel, Eric von (1988) The sources of innovation. Oxford University Press, New York, USA.

[25] Hutt, Michael D. & Thomas W. Speh (1995) Business Marketing Management; A strategic View of Industrial and Organizational Markets .Fort Worth, Dryden Press, USA.

[26] Wijnen, Gert, Willem Renes & Peter Storm (1988) Projectmatig werken. Het Spectrum/Marka, Utrecht, the Netherlands.

[27] Robbins, Stephen P. (1996) Organizational Behavior; Concepts, Contorversies, Applications. 7th edn. Prentice Hall, Englewood Cliffs, New Jersey, USA.

[28] Bennis, Warren (1994) An invented life. Dutch translation: De manager als koorddanser. Contact, Amsterdam, the Netherlands.

[29] Colin Davidson (1998) Information in the Building Industry: Problems and Solution. http://www.cibat.qc.ca/if/va/ifpubdex.htm

[30] Oostra, Mieke (1999) De architect als componentontwerper. Lecture for Boosting at Octatube, Delft, the Netherlands.

[31] Argyris & Schön (1996) Organizational learning II; theory, method and practice. Addison-Weseley, Amsterdam, the Netherlands.

[32] Kendall, Stephen (1990) Control of Parts. Unpublished PhD dissertation MIT, USA.
[33] Paffen, Tom J. & Felix Janszen (1994) ‘Management of architectures and the role of standardisation in the telecommunications innovations process’. Paper conference proceedings EIASM part 2.
[34] Urban & Hauser (1993) Design and Marketing of New Products. 2nd edition, Prentice Hall Inc., Englewood Cliffs, New Jersey, USA.

Presentation of a new floor

Researcher: **Arno Pronk**
Delft University of Technology
Faculty of Architecture
Chair: Partitions and finishes
A.D.C.Pronk@bk.tudelft.bk

Presentation of a new floor

ABSTRACT

The paper gives a survey of the most commonly used floor systems and how these have dealt with flexibility in the past. After analysing these floors the conclusion is that floors are approached unilaterally as partitioning elements which can bear and span. Flexibility is achieved by introducing a zone on top of, or beneath a given architectural structure. The adding up of demands and zones generally results in a increased price per square meter. Even after proving that flexibility in term repays itself, an client is often not interested in paying that higher price.

My thesis is that flexibility is only feasible when an integration of the different functions of the building-components perform is achieved. The consequence is that in designing building products there must be an integral approach leading to an integral building product.

The Infra+ floor is an example of such an integrated building product which, in addition to the traditional tasks a floor must perform, provides space for ducts, ceiling heating/cooling, the demand for lighter constructions, and a smaller gross storey
height.
We are currently working on the development of a new floor concept which offers a cheaper finishing floor and some flexibility during use, in relation to the infra+ floor. In relation to other floors like the bubbledeck floor, the wingplus floor and the “leidingvloer” this floor has the advantage of offering a large amount of flexibility in duct layout and building sequence. In addition it is possible to combine this floor system with most of the current building systems; steel framework, concrete casting, and element-stacking.

We are currently testing prototypes. In October we will tell more about that.

Presentation of a new floor

Arno Pronk

The following presentation of a new form of a concrete floor is built up as follows:

- Commonly-used concrete floors
- Methods of dealing with ducts
- Floors which respond to the duct issue
- Sandwich floors
- The combination of sandwich and duct floors
- The advantages and disadvantages of the developed floor

Commonly used concrete floors

The simplest way of making a concrete floor is pouring concrete into a mould. After the concrete has hardened the casing is removed and we have a floor.
The necessary reinforcements have to be contained within the concrete and several additional facilities can be placed. This way of building is still used in today's practice.
Another way of making massive floors is the wide-slab floor. This floor responds to the problem of removing the shuttering by incorporating it as a part of the floor.

Massive floors bend considerably as a result of their high weight, bend considerably this is not the most efficient way of spanning. The solution to this problem has been sought in varying the section of the floor. As a result less concrete is used, which decreases the weight of the floor and allows a greater span without added reinforcing.

Examples of such floors are rib floors, combination floors, steel-concrete composite floors, hollow-core slab floors, double tee plate floors, and the bubble deck floor.

fig 1

fig 2

Of these floors the bubble deck floor holds a special position because it has only recently been brought on the market figure 3. The patent dates from 1995 and focuses solely on the ball which is placed into the floor at the building site. The concrete is poured around it. The predecessor of this floor is the floor shown in figures 1 and 2 in which there was also room for ducts within the system. The advantages of this laborious system did not outweigh the additional.

An example of research on the light concrete floor is the floor of which the prototype is shown in figure 4. It is a reversed wide-slab floor with extra-rigid steel ribs. The problem with very light floors is the vibrational behaviour, which in this floor exceeds the required limits. There are a number of ways to optimise the vibration behaviour of floors:

- Dampening the vibration
- Applying extra weight
- Stiffening the floor

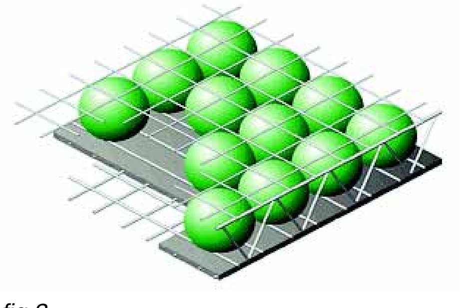


fig 3

fig 4

In this floor the vibration behaviour has been optimised by bedding the floor to the construction.

Methods of dealing with ducts

For years it has been proclaimed in the building industry that flexibility can be achieved by separating the bearing components from the build-in components.
In 1961, in his book *'De dragers en de mensen'* (freely Translated: the bearers and the people) Habraken poses that, "*a bearing component is a construction in which a number of dwellings can be composed which can be built, altered, rebuilt, or demolished independent of the other dwellings*".

This requires flexibility in addition to spanning, bearing and partitioning in the most efficient way. Most floors deal with these basic functions. Flexibility is then achieved by introducing a zone beneath or on top of the given structure. In general extra zones mean an increase in price per square metre. In the same book Habraken says that he" *is in no way competent to handle arguments of financial-technical nature*". Had he taken this effort he would have reached the conclusion that only separating the bearing components from the built-in components leads to an increase in cost which few would want to pay. Even when it has been proven that flexibility in the long run does pay off, a buyer is not often willing to pay the higher price in the initiation phase.

The thesis posed above can be supported with a number of examples.
The matura system
The suspended ceiling
The computer floor

In the 1990's Matura introduced a flexible system for the renovation of houses by means of a built-in system. The higher price would be compensated since later renovations could be realised much more cheaply as result of the matura system. Matura realised a number of projects and was taken over by other shareholders several times, but eventually it went bankrupt and was thus liquidated.

The suspended ceiling is not frequently used in houses and mainly appears in commercial and industrial buildings. The use of lowered ceilings in houses is mostly local, where a great concentration of ducts runs under the floor.

The computer floor is only used in commercial and industrial buildings when a very high concentration of ducts is necessary, along with the demand for adaptability of the ducts. Situations like these occur in spaces where many computers are put together.

From these three examples we learn that flexibility is regarded as valuable when there is a direct need for that flexibility. In addition we might pose that regarding the small demand for flexible constructions, the lack of flexibility in house building is not considered a problem.

It is my thesis that *flexibility is only feasible when an integration of the different functions the building-components perform is achieved*. The consequence is that in developing building products there must be an integral approach leading to an integrated building product.

Floors which deal with the ducting problem

An example of an integrated floor is the steel-concrete composite floor. (fig 5 and 6)
This floor can be realised with an integrated beam. Holes for the ducts can be contained within the beam, and the underside is finished with a ceiling system. Whether it is also possible to run ducts in the other direction and how this may be done is not made clear. It looks as if the ducts have been added afterwards as a commercial argument for supporting the flow system, instead of developing a floor system integrally.

Another integrated floor system is the system, which uses profiled steel plates with holes running through them. (fig 7) This system is too is but an initiative in achieving integration.

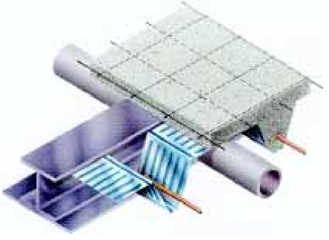


fig 5

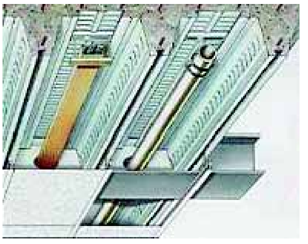


fig 6

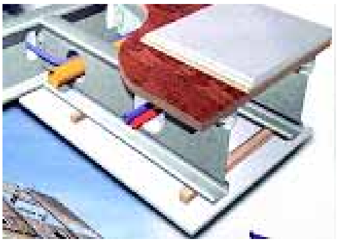


fig 7

Integrated floors, which respond to the demand for flexibility.
The infra+ floor (fig 8, 9 and 10) is an example of a floor developed as an integrated building product. In addition to the traditional tasks a floor must perform- space for ducts, ceiling heating/cooling- the demand for lighter constructions and a smaller gross storey height have also been kept in mind.

fig 8

fig 9

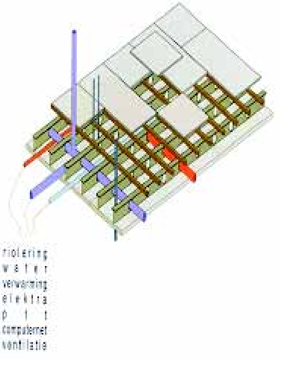


fig 10

The patent for this floor was granted in 1996. At first the floor was designed completely in concrete (fig 8) because the producer was convinced this would be cheaper than a combination of an IPE beam with concrete. Eventually the steel-concrete version proved much cheaper, due to problems in producing the concrete beams on top of the floor.

When considering the validity of a patent, the novelty of an idea is always investigated first, for example by studying other patents or “old” magazines. When dealing with floors it is not sufficient to study only the last ten years. In the magazine ‘*Industrieel bouwen Nr 11, 1970*’, I happened to come across a floor which resembles the infra+ floor. In the book ‘*Typische Baukonstruktionen von 1860 bis 1960*’ a floor is documented which resembles both the infra+ floor and an American patent of 1970.

The essence of the infra+ system, the making of room for ducts, was not affected, and the patent could be filed. The infra+ floor, developed by Buro A+ and myself, has provoked reactions from the producers of existing floors. The hollow-core slab floor for example has been modified, having two “wings” (fig 11). It also has been modified by offering tailored duct slits (fig 12). This was patented in 2000. Another example is the German patent from 1997, which mimics the infra+ concept but is composed completely of separate elements (fig13).

fig 11

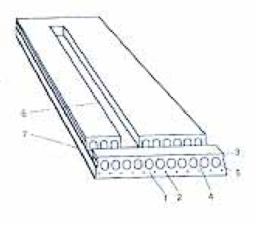


fig 12

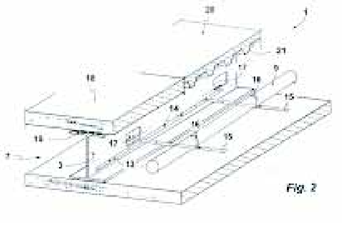


fig 13

There are other floors, which are based upon an integral approach but are executed in a combination of steel with a finishing floor of gypsum or concrete. The disadvantage of these floors is the vibration behaviour and the high price. Examples are the Van Dam floor (fig14), developed by CEPEZED, the ISB system developed in Eindhoven, or the floor shown in fig 15, dating from 1960. The developers of these floors want to be progressive. They don't want anything to do with traditional materials, and put up with the disadvantages of the material, which in their view is new.

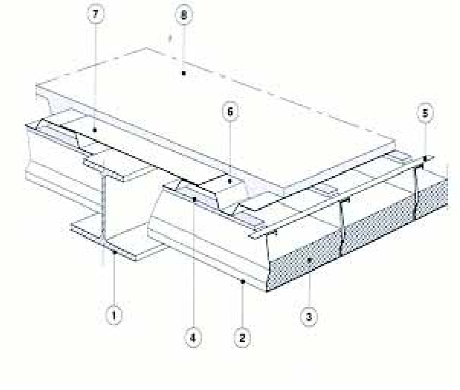


fig 14

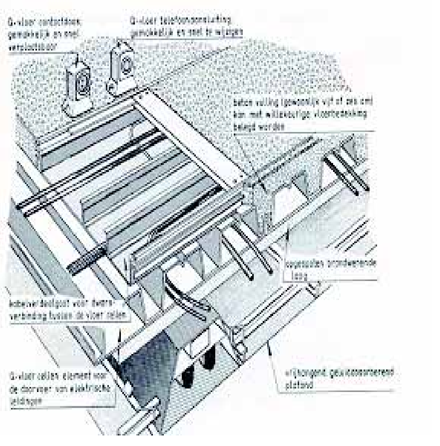


fig 15

Sandwich floors

Before I continue with the floor I have developed in Cupertino with Buro A+ and the Technical University Eindhoven I first want to mention a relatively new floor concept, the sandwich floor. Sandwich constructions are used everywhere in the building industry, except as floors. There are some exceptions. In Denmark for example there is a factory which produces prefab sandwich floors on a modest scale. I also found several patents referring to sandwich floors. In addition sandwich floors are known which are made up of concrete and steel.

The advantage of sandwich floors is that a light floor can be made which has a full section. This is an advantage because the moment of casting the concrete can be delayed to any chosen moment on the construction site. The disadvantage is that at the points of the support the section has to be modified in order to absorb the shear forces. In the Danish Leca floor this has been solved by making the supporting area massive.

The combination of sandwich floors and duct floors

In response to the above analysis I have made a combination in which the advantages of the sandwich floor are combined with those of the infra+ floor.
The resulting floor permits a very high degree of flexibility during construction. The flexibility during the employment phase of the building is believed to be less important, but can still be realised in a limited way. This invention involves a method of casting sandwich floors on site: at the support points an element is automatically created which can absorb the forces occurring in that area. A special feature is that this floor solves the problems of supporting wide-slab floors during construction. The system is suitable for every floor system using a slab-shaped element, on top of which one or several layers are applied at a later stage. In sandwich floors the invention provides a solution to transmitting the shear forces through the brackets into the actual sandwich. In the Danish Leca floor this problem has been solved by omitting the light part of the sandwich at the load bearing points and casting the floor homogeneously. Due to the limited shear forces when using limited spans, it is possible to omit a special area in the sandwich.

The drawing below shows a survey of a floor field as described above. With these drawings the construction of the invention can be illustrated. Onto a wide-slab floor load bearing brackets are attached which are connected to the ends of the floor over a limited length. On the lower side of the floor a temporary support beam is attached between the load-bearing bracket on the ends of the floor. This support beam is linked (bending) to the wide-slab floor and the load-bearing bracket above the beam rigidly. After the concrete hardens the temporary support beam can be removed. The load bearing brackets are contained within the (sandwich) floor and assure that shear forces resulting from the weight of the floor, together with the loads are concentrated in the support points.

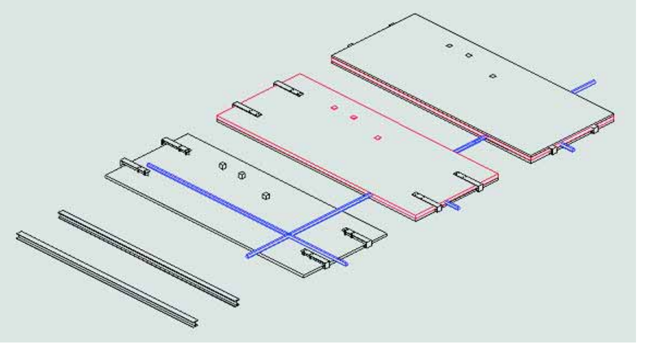


fig 16

The advantages and disadvantages of the developed floor

The invention offers several advantages. The moment of casting a floor with a (light) concrete layer can be delayed until any convenient moment. For example the complete finishing can take place with all the necessary ducts. The floor is poured afterwards with a light concrete layer in case of a sandwich floor. Supports are no longer necessary, and as a result floor systems using temporary supports such as the wide-slab floor and the steel-concrete composite floor can also be used above high spaces. During construction the working floor is free of obstacles. In combination with a sandwich floor a light floor can be made in which the load bearing brackets receive the shear forces and conduct them from the sandwich into the supporting structure. Because more time is available during construction for placing ducts in the floor, buildings can be designed that are less dependent of ducting shafts. There can be more possibilities for differentiating within the design. In addition, ducting trenches can be either cast in or kept free, which can extend a certain degree of flexibility during use.

A combination of the Infra+ floor and the sandwich construction results in a floor in which certain zones allow the possibility of changing duct flow after the building ‘s construction. These zones can be predicted and defined beforehand. Particularly at the support on the facade side and on the corridor side, space is needed for cable trenches. At these supports it is possible not to cast the floor as fully massive, but to make a combination of the Infra+ floor and the sandwichfloor.
By perforating the load bearing brackets, space is created for ducts. The ducting zone can be finished or closed by means of a removable strip of tiles, as is usual in computer floors. The connection of the brackets and the sandwich is tested with the calculating program Diana and do not give a problem.

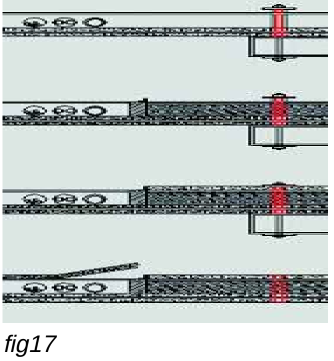


fig17

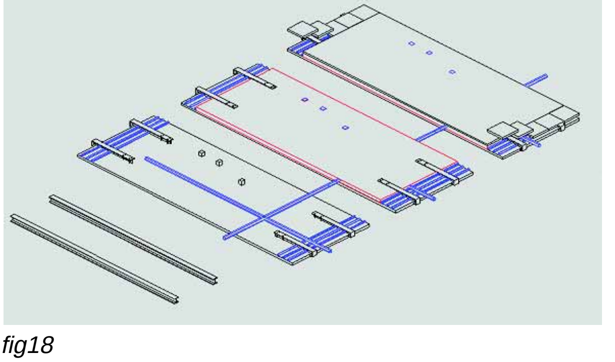


fig18

The conclusion that can be drawn from these developments is that in addition to the integration of the different functions the building components fulfil, we also have to investigate whether these functions apply to the product as a whole, or just to specific areas. In this way we can develop products which better suit markets and need not be unnecessarily expensive.

References:

Ahnert R. Krause K.H. Typische Baukonstructionen van 1860 bis 1960
1985 ISBN 3 7625 2352 5

Dietz and Cutler
Industrialized Builing Systems for housing 1971 ISBN 0 262 04034 4

Habraken N.J. De dragers en de mensen 1961 ISBN 90-70284-03-0
De dragers en de mensen, het einde van de massale woningbouw pleit voor variatie binnen een grotere gegeven structuur die ruimte bied aan die variatie SAR gedachte

Habraken N.J. The structure of the ordinary 1998 ISBN 0 262 08260 8
Form and control of the built enviroment

Werf van der F. Open ontwerpen 1993 ISBN 90 6450 172 6
Een voorbeeld van het in praktijk brengen van het gedachtegoed van de SAR

Verschillende documentatie's van vloerfabrikanten

Verschillende patenten

674711	NL C 1002303	DE 19714211 a1	WO 95/20486
407579	NL C 1011011	WO 98/13560	449530
NL C 1013136	NL C 1006073	5396747	3546830
NL C 1007801	295203 86	EP 0 104262 A1	

High tech, low tech or better no tech at all?

Solving the problem of industrial, flexible and demountable cabling, wiring and plumbing by avoiding it, a case study in a design research for a city office building in Schoonhoven

Christoph Maria Ravesloot, MA M STS
Architect BNA and Sociocratic Organisation Designer SOD
Delft University of Technology
Faculty of Architecture
Department of Building Physics, Installations and Environmental Technical Design
PO Box 5043
NL-2600 GA Delft
E-mail: C.M.Ravesloot@bk.tudelft.nl
Tel + 31 (0)15 2781495
Fax + 31 (0)15 2784178

Stefan Hulsbosch, graduation student Building Technology
Delft University of Technology
C/o Faculty of Architecture
Department of Building Physics, Installations and Environmental Technical Design
PO Box 5043
NL-2600 GA Delft
E-mail: shulsbosch@freeler.nl
Tel + 31 (0)15 2781495
Fax + 31 (0)15 2784178

High tech, low tech or better no tech at all?

Solving the problem of industrial, flexible and demountable cabling, wiring and plumbing by avoiding it, a case study in a design research for a city office building in Schoonhoven

ABSTRACT

If you want to build flexible and sustainable at the same time, the implementation of installations sometimes is really difficult. From the point of view of sustainable building you would rather have either very efficient machinery or no machines at all. From the point of view of flexibility the machinery, with the difficult cabling, wiring and plumbing is best left out completely. However, it is almost impossible to build sustainable, according to modern comfort levels, and build with no tech! The ultimate challenge is to avoid cabling, wiring and plumbing to serve sustainability and flexibility in building. In a case study for a city office in the Dutch town of Schoonhoven, the possibilities of flexibility and sustainability are researched by designing three alternative scenarios. Municipalities often change their organisations and very much need flexible office buildings. Municipalities also want to show their interest in and responsibility for sustainability by setting the right example.
In Schoonhoven three building systems were tested in their sustainability potential versus the flexibility potential.

1 a building system based on prefabricated units, 3m x 6 m x 3 m
2 a building system based on prefabricated components
3 a building system based on prefabricated segments and building junctures

The building systems have different life spans and the integration possibilities for installations with different life spans can be compared. From this comparison conclusions towards the flexibility and sustainability can be drawn. It seems that if you need fewer installations, the more flexible the office building is going to be.

High tech, low tech or better no tech at all?

Solving the problem of industrial, flexible and demountable cabling, wiring and plumbing by avoiding it, a case study in a design research for a city office building in Schoonhoven

Christoph Maria Ravesloot and Stefan Hulsbosch

The best medicine to become better is to avoid getting ill in the first place! This also accounts for many environmental design problems. The American advisor on environmental issues and greenhouse policies, Amory Lovins, once said: Technology is the solution, but what was the problem again?

This paper addresses to the problem in Industrial, Flexible and Demountable (IFD) innovation, that building and constructing the IFD principles are not in line with the need and use of installations. It is not recommendable and often not possible to make demountable installations. Avoiding installations is also not always possible either. But like medicine for curing illness, cabling, plumbing and wiring can be cut down to a level of an absolute minimum, thus leaving more possibilities for industrial, flexible and demountable constructing.
Seen from the point of view of sustainable building you would rather have either very efficient machinery or no machines at all. From the point of view of flexibility the machinery, with the difficult cabling, wiring and plumbing is best left out completely.
However, it is almost impossible to build sustainable, according to modern comfort levels, and build with no tech at all! The ultimate challenge is to avoid cabling, wiring and plumbing to serve sustainability and flexibility in building. By means of a design research on a city office, we hope to show you, how you can solve this problem in favour of sustainability and IFD.

The need for a flexible office building

In The Netherlands, many municipalities want to show their interest in and responsibility for sustainability by setting the right example. Large municipalities have the financial means to invest in knowledge of sustainability, whereas the smaller ones do not have the means and knowledge. The municipality of Schoonhoven also wants to build a new city office. However, at this moment there is very little knowledge of sustainable building technology in Schoonhoven. In comparison to other small municipalities, a big step forward is needed to catch up with newest developments. The design for a new city-office is a great opportunity to bring sustainability on a higher level of the political agenda and to try to catch up.

In a design study for this city office in Schoonhoven, the possibilities of flexibility and sustainability are being researched. We developed three alternative scenarios. Municipalities often change their organisations and very much need flexible office buildings. In the case study in Schoonhoven we compare the three different concepts for flexible and sustainable building in their technical efficiency, the energy efficiency, the way of transportation (industrialisation), the flexibility and the demountability and reuse after demounting. Transportation is an important factor that limits the dimensions of prefabricated components.

For this design, three concepts will be compared to determine which one is best suitable for the benefit of the IFD concept and for minimising the environmental effects:

1. A building system based on prefabricated units, measuring 3 m. x 6 m. x 3 m.
2. A building system based on prefabricated components, mainly 1-dimensional and 2-dimensional elements.
3. A building system based on prefabricated segments and building junctures, being a variant on the second building system.

There are two important reasons why the new city office, from a functional point of view, should be flexible. First, the administrative structure of Schoonhoven, like many other governmental organisations, needs to be reformed from time to time. This is necessary to stay in line with the demands from the community. A change in administrative structure often has a big impact on the acquired internal plan of an office building.
Second, the municipality of Schoonhoven is a relatively small one. It counts only 12,000 inhabitants. Therefore there is enough reason to believe that somewhere in the near future the city will be forced to join with neighbouring villages into a larger municipality. In that case many scenarios would be imaginable. The city office might have to expand to accommodate more city clerks that address the needs of the larger population. Or it might become superfluous because the location is not suitable anymore and a more central location is needed. In the last case it could prove interesting to design a demountable office building, so it can always be moved to a better location if necessary.

Therefor, the municipality of Schoonhoven needed a strong concept for an office building that is both flexible and demountable, with a minimal disturbing effect on the environment. With these starting points, the project matches perfectly with the principles of IFD-building.

Before starting with the design under these conditions, it is necessary to define exactly what the evaluation criteria mean. The I representing industrialisation in IFD relates to:

- Achieving a higher quality in a more easily controllable building process;
- Reducing the construction time;
- Improving working conditions;
- Reducing waste and spillage in the whole process, especially on the building site.

In IFD-building, flexibility is defined as the possibilities to accommodate changing individual needs now and in the future. With demountability, the aim is to reduce costs during the exploitation-period and to reduce the devaluation of the building, by making it adaptable. The technical efficiency and the energy efficiency are the most important functional and environmental criteria to judge the three concepts.

Accommodating future needs of a changing organisation is a tricky thing. It is, after all, impossible to know future developments in an organisation at this stage, certainly not on a scale of perhaps 20 to 30 years. By looking at both the recent history of office planning and at governmental regulations we get some idea of possible future demands.
The office layout has changed over the years from a structure of big open office-spaces to small individual offices and vice-versa. Flex-office, instead of being a total new concept, is in terms of office layout, more like a balanced combination of these two concepts. The flex-office concept does not automatically fit into the governmental regulations. To ensure good working conditions, for instance, the distance from a working place to a window to the outside is limited to 7.2 meters.
One way to meet the conditions from regulation, is to create an open office space that can be divided into smaller units by placing (temporary) walls. With windows on both sides of the office space, the distance between the windows is then limited to 14.4 meters. Then you can stay within the limit of 7.2 meters from both sides of the building.

To incorporate demountability into the design, the building should be made expandable on all sides. And, in case the need for office space is reducing instead of growing, it should be possible to partially take the building apart. All of these adaptations should be made easily and quickly, and with a minimum impact on the environment. Usually here the cabling and wiring gets in the way very much. There is no way around them, accept for avoiding their need in the first place.
From the first results of the design research, we can already conclude that the ventilation shafts and ventilation tubes are the limiting factor to demountability of office buildings. Ventilation is the widest and longest tube in the building and carries either cold air in summer to cool, or it carries warm air in winter to heat.

Apart from the choice for the level of prefabrication, and off course partially influenced by that choice, the design of the building installations is the factor with the biggest impact on the IFD concept. In conventional design, the construction of the installation is started somewhere at the end of the total design process. The office layout is finished and sent to the installations-expert to be completed with pipes and ducts and other equipment. The installations-expert often has to go through great lengths to fit all this into the design, creating what hopefully will be a tailored system that fits the demands of that specific office lay-out. Of course, in a conventional design, there is no possibility to bring in extra demands for IFD and improved energy efficiency.

What happens if you insist on giving the users of the office space the possibility to adapt their building to future needs? What if you insist on a very efficient energy system? With a conventional tailored installation concept, the only option might be to get rid of the old system and to design and mount a new one. This makes the change of the office layout into a costly thing, both in time and money. Especially when fitting the new system into the building means problems with the placement of the pipes, the ducts, and the equipment in relation to the structure of the building. For example air-ducts can be very big and changing

the routing of these ducts is not easy. Apart from the technical problems, you mostly also encounter problems with the changes in the building permit, or at least with the application for a building permit.
Furthermore the option of a completely changed installation concept is not always efficient in terms of environmental effects. The effects could be creating large amounts of wasted fossil energy and wasted building material over the whole life cycle within the exploitation-period.

To make the proper choice in this paradox design-problem, we have to take a look at the three IFD concepts for the municipality office. Then we can look at different IFD, technical and sustainability criteria. After this analysis we see how conclusions force us to change the design of either the installation or the IFD concept.

The first building system, based on large prefabricated units, is an improved version of earlier systems used for other purposes. For example as mobile shelters for building sites and temporary housing for schools. The success of this formula has made the producers of these units look for new markets where they can continue their growth. Large units of 3 metres x 6 metres x 3 metres can be transported over the road and be assembled quickly, thus being combined into larger buildings.

The second system, based on 1-dimensional and 2-dimensional elements, is not new either. Especially in concrete building this system has been used before. Most of the concrete systems however are not demountable because the junctions are usually fixed by poured concrete. Steel and aluminium, and even wood in many cases, offer great opportunities for creating a system that is both highly prefabricated and demountable.

The third system, based on prefabricated segments and building junctures, is already mentioned as a variant on the previous system. By making clever junctions between elements, many problems that usually occur at the meeting-point of elements are solved in the factory. In short the position of the fixtures is moved away from the usual building knots, like the line where facade and roof meet, or the place where the beams meet the column. This makes these fixtures less complicated and easier to demount.

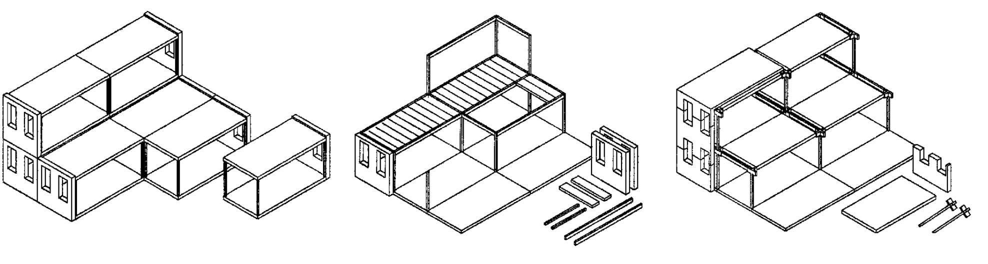


Figure one shows the three IFD concepts, prefabricated units, prefabricated linear elements and prefabricated two- and three-dimensional components.

Construction qualities

Looking at the constructions made with these systems there are some specific characteristics. When making a construction with system number 1, it is almost inevitable that there are superfluous elements in this construction. When joining 2 elements that are, in itself, stabile, we see at 2 places that a pair of columns is formed between the elements, where only one column would be sufficient. When putting one unit atop another one, there is one ceiling too many, or if you wish, one floor. On the other hand, the possibility to make stiff connections in the factory makes it possible to construct without stabilising cross-connections.

When using the second systems, there is a big chance that the construction height increases, because construction elements are piled up. First you erect a set of columns, then you connect them with beams and over these beams comes a 2-dimensional floor element. However, it is also possible to design a system where this problem does not occur. Because stiff connections are difficult to make on a building site, stabilisation is needed by means of incorporating cross-connections or 2-dimensional elements in the construction. The third system is comparable with the previous one.

Industrialisation

When looking at the amount of prefabrication possible in both these systems, the first one has the best possibilities for prefabrication. The whole element can be tailor made in the factory, including the finishing. The second system uses prefabrication on a much smaller scale. Most of the actual construction is done on site, including difficult aspects like making the connection between 2-dimensional elements waterproof. The third system is somewhere in-between. The difficult three-dimensional connections can be made in the factory.

Flexibility

The standard dimensions of the elements limit the building-flexibility of the first system. In the second system, these dimensions can be changed easily. For example you can decide to use longer columns to get a bigger ceiling height. The third system is more compared to the second one, but more flexible compared to the first. This is also the case when looking at long-term flexibility. Reducing or enlarging the building volume in the first system is limited to removing or placing a full element, while the other systems offer more freedom of choice.

Demountability

To demount the first system, the use of rather heavy equipment is necessary to be able to move the elements. In the second system the elements are much smaller and so the equipment can probably be less heavy. The same thing happens with the third system. The transportation of large units requires more trucks then the transportation of the smaller elements of the other systems. However, the logistics of the transports, the sequence of the units transported to the site can be maximised. Storage of many large units on the construction site is difficult but that also depends on the logistics of the transports.

Environmental efficiency

When looking at the efficiency of the use of materials, one might say that more prefabrication makes the material-efficiency better, because the concentration of construction-activity on one spot makes it easier to re-use material that would be considered as building waste at the construction site. Also prefabrication offers more opportunities to standardise measures and to relate these to the standard-measures of the materials from other factories.

The necessity of plumbing, wiring and cabling

Now, let us look at the implications of these systems on climate installations. Incorporating large ducts into all of these three IFD concepts is very difficult. From the original idea of avoiding problems, we are strongly suggested to reduce the size of the ducts. This is especially interesting when you don’t want to use lowered ceilings. All the systems have to deal with the fact that connections will have to be made to create the full duct system, so ducts will have to be made easily accessible.

Ventilation with fresh air straight from the outside, for example through vents in the facade, is not an option when the aim is to make a building system suitable for any location. Sometimes the location does not allow the use of pure outside air and filters are needed. On top of that it is very difficult to provide a good grade of humidity inside the building when the ventilation-air is not pre-conditioned. Therefore the use of pre-conditioned ventilation-air is an unavoidable assumption.

To achieve flexibility in an office layout, we need a ventilation system that functions in an office with separate rooms as well as in an office stretching from window to window. This makes it difficult to use tangential ventilation, based on air that is forced to circulate through the office. Therefore it is better to use a system based on low air-inlets and high air-outlets. The air will first roll softly over the floor and will start rising up at places where it heats up, such as computers and people. This makes it efficient because it brings fresh air at places where it is needed. The outlets will take away the air that has heated up and drifted to the ceiling. This system also works in an office lay-out from window to window.

This means that the air-supply ducts will have to be placed under the floor and return-air will have to go through ducts in the ceiling. This ventilation-system, combined with the need for small ducts, points in the direction of a system with partially pre-conditioned air. The minimum amount of air that is necessary to ventilate an office space can easily be calculated. This air can be partially heated and cooled in a central air-conditioning unit. The rest of the heating or cooling is placed in the offices. After all, there can be many differences between circumstances in the office spaces in terms of orientation, rate and frequency of occupancy, presence of computer equipment, and so forth. Every office can now have its own heating and cooling system to accommodate its own needs, and valves in the air-ducts can regulate the amount of ventilation-air for each office-room.

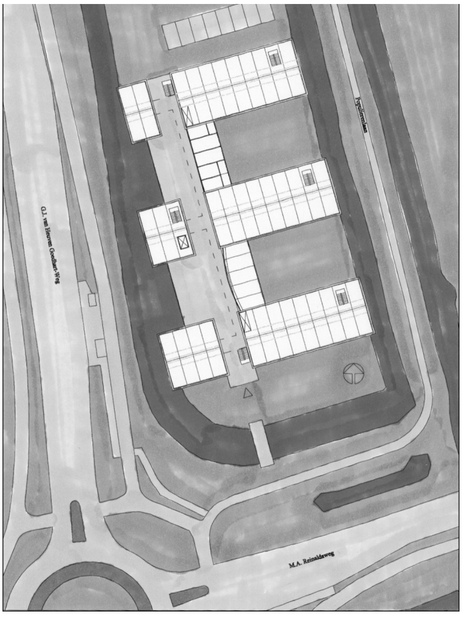


Figure two shows the first floor plan of the office design in Schoonhoven. The orientation of the building is from bottom to top south-north.

To maximise energy-efficiency of heating and cooling, the best system for this would be a low-temperature system like for example floor- or wall heating and cooling. By bringing the return air from the offices back to the installations room, it is possible to connect both the ducts for fresh air and the ducts for return air to a heat-exchanger, to reduce heat-losses through ventilation air in winter.
At this stage of comparison of the three concepts, a proper and reliable conclusion about summer cooling needs can not be reached. We would have to make a more accurate design that at least would incorporate the u-values of walls and glazing.

Conclusion

All these choices, made in order to maintain maximum flexibility of the office space and to ensure demountability and industrialised building, have moved us in the direction of a rather simple, relatively low-tech installation-system. When we compare the building systems of the first part of this paper in relation to the choice of the climate-installation, we can see that all these systems can be fitted with this installation-concept. At this stage of research, we can not yet calculate the environmental effects. At this stage it is not yet possible to make recommendations towards a choice in one of the three building concepts. The bottleneck is still the cooling of the building in summer. Because of this cooling we need ventilation ducts. These ducts do not seem to interfere with one of the three concepts in particular. Regardless from the IFD concept, the ducts are still disturbing an easy demountable construction.

Environmental push or environmental pull? Environmental effects of industrial, flexible and demountable building

Does IFD contribute to strategic sustainable building goals? A scrutinising analysis of the Dutch IFD programme

Christoph Maria Ravesloot, MA M STS
Architect BNA and Sociocratic Organisation Designer SOD
Delft University of Technology
Faculty of Architecture
Department of Building Physics, Installations and Environmental Technical Design
PO Box 5043
NL-2600 GA Delft
E-mail: C.M.Ravesloot@bk.tudelft.nl
Tel + 31 (0)15 2781495
Fax + 31 (0)15 2784178

Ton Kowalczyk, MA
Delft University of Technology
Faculty of Architecture
Department of Building Physics, Installations and Environmental Technical Design
PO Box 5043
NL-2600 GA Delft
E-mail: T.Kowalszyk@bk.tudelft.nl
Tel + 31 (0)15 2784155
Fax + 31 (0)15 2784178

Environmental push or environmental pull? Environmental effects of industrial, flexible and demountable building

Does IFD contribute to strategic sustainable building goals? A scrutinising analysis of the Dutch IFD programme

ABSTRACT

If you analyse the stakeholders in the field of industrial flexible and demountable building, you soon discover that almost every single one of them has to gain something with IFD. However, who is going to defend the gains that are at stake for the environment. You can argue about the form of technology development that is driving IFD innovation. Some say it is technology push, because IFD could very well be the result of an ongoing process of industrialisation. Others argue that IFD is technology pull, because it reflects the newly developing needs of consumers on the housing and office market. Suppose none of them is true. And suppose the innovation of IFD is an autonomous process, what would be the argument for that and how would the argument of sustainability fit in.

Now suppose both of them are true. What would that mean for the argument of sustainability in IFD developments.

And then there are the two possibilities in between. What if one of the two technology developments is true?

Whatever is truly happening with the innovation process of IFD, the importance of sustainability is not covered and thus the potential contribution of IFD to the strategic goals of sustainable building in The Netherlands is at stake.

Environmental push or environmental pull? Environmental effects of industrial, flexible and demountable building

Christoph Maria Ravesloot and Ton Kowalczyk

Does IFD contribute to strategic sustainable building goals? A scrutinising analysis of the Dutch IFD programme

The Dutch IFD building is a development in building that represents three different forces that at present are at work in building technology development.
The I in IFD represents industrialisation
The F in IFD represents flexibility
The D in IFD represents demountability.

If you analyse the stakeholders in the field of industrial flexible and demountable building, you soon discover that every single one of them has to gain something with IFD.

The stakeholders that could gain from I are:
1 developers of new techniques;
2 contractors of buildings with these new techniques;
3 principals like real-estate developers and investors;
Developers use industrialisation to make their products better and cheaper. A social-economical argument for developers to industrialise could be to be independent from human labour in a factory. Industrialisation is driven by money (Riedijk, 1989). The economical benefits from industrialisation of building components directly fall to the developers themselves, the general contractors and finally the principal, as the main investor, too.
Industrialisation pays of, in different amounts, to all participants in the building process. The end-users, tenants of inhabitants, would only experience the gain in quality. Industrialisation in the past made it possible to consume less fossil energy and to consume less raw materials.

The stakeholders that could gain from F are:
1 management and maintenance companies;
2 real-estate renting corporations and housing companies;
3 individual tenants and housing associations;

The flexibility of the IFD concept rules in and between spatial scales as well as in and between organisational layers. In the first case IFD can lead to flexible building components, the smallest industrialised parts in a building, for instance a window frame. It can

lead to stretched building parts adjusted to the maximum measure permitted to be transported on a road transport. Or IFD flexibility leads to extensions of main buildings and to prefabricated units, more or less container like.
IFD concepts can provide flexibility in time too. There seems however no direct relation between the spatial scale of flexibility and the time scale of flexibility. The flexibility in time, however, does seem to have a connection with the administrative and organisational site of building. The industrialised prefabrication of demountable components can be calculated easier and do have less uncertainty in price.

Management and maintenance companies would have fewer costs from flexibility in the buildings. Changing and alternating a building always asks for a lot of effort. In IFD buildings the effort is cut down to a minimum. If IFD buildings are flexible, also real-estate renting corporations and housing companies can benefit. For them the group of possible clients is much bigger. If necessary, they can adjust their building to the potential tenants and users. These individual tenants and corporations then benefit from a to their needs accustomed building, with high standards and also low maintenance cost

The improvement for the environment often can be found in the minimising of the used material, extension of the expectation of life and economical life span. A secondary benefit could be, that flexible building components can also easier be adjusted to needs and wishes of users of the building. This would prevent the building parts to be demolished before the end of the regular technical or economical duration (Ravesloot, 2000-I).

The stakeholders that could gain from D are:
1 retrofit companies and small building companies
2 housing companies and housing associations
3 demolishing companies and recycling companies

At first glance, the demountability is only interesting from the point of view of minimising environmental damage. At second sight, also other parties, like retrofit companies and small building companies, housing companies and housing associations, demolishing companies and recycling companies, can have profits from demountability (Ravesloot, 2000-II). There is very little experience with demountable constructed building components. Demountable for one part comes with flexibility. The arguments valid for flexibility also count for demountability.
The gain for the environment would also be the minimising of the used material, extension of the expectation of life and economical life span. But, demountability also brings us a new problem. Once a component is demounted, were is it kept until we can find a second purpose for it. If we can find a second use at all?

However, as you can see in the proposed list of stakeholders, no one actually directly benefits economically from environment advantages that could be realised in favour of environmental effects.

These gains could be:

1 less use of raw materials, they maintain in a life cycle;
2 less deterioration of landscape;
3 (re)use of building components, fitted to the same function;
4 less demolition waste.

Who is going to defend these gains that are at stake for the environment?

The Dutch government has had a strong political will to defend environmental opportunities. Therefore the Dutch ministries developed strong environmental policies, especially in sustainable building. The Dutch policy on sustainable building started around 1989. In 1995 the operational plan “Sustainable building, investing in the future” (Plan van Aanpak Duurzaam Bouwen: Investeren in de toekomst), was launched, with programmes and pilot projects supported by the central government. In 1997 a second operational plan followed, emphasising on co-operation and communication with all parties involved in the building process. In 1999 the results were monitored (VROM, 2000-I). Sustainable building had become an important part of communication and planning, but a relative minor group of professionals, cities and companies were active. Filling the gap between vanguard and the masses is a major topic now. The relation between sustainable building and healthy building is getting more attention as well as IFD. Legislative measures are not taken. Financial stimuli, covenants with sectoral organisations and transfer of knowledge are preferred instead. After ten years of promotion by the national government, the goal was set to leave sustainable development to the “market” in the year 2004 (VROM, 2000-II). Sustainable quality must at that moment be an integral part of processes in all sectors of policy making. It is up to the cities and municipalities to develop their own operational policy now. From this point of view the benefits for the environment that could emerge from IFD building are not even supposed to be defended by any stakeholder. The public authority is withdrawing, leaving the development of IFD building to the forces of the technological innovation driving forces of the free market.

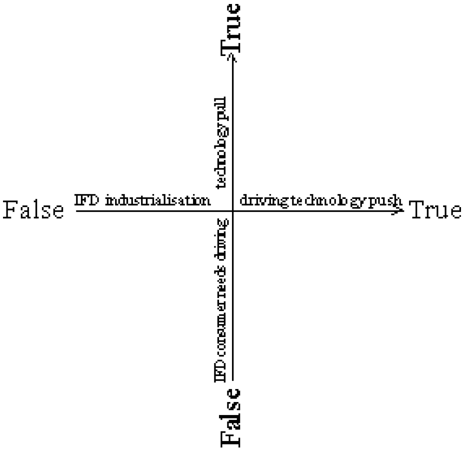
Can the process be influenced at all?

If you mark the development like IFD, as a technological innovation in the sense of interactive and constructive Technology Assessment, you can distinguish three main aspects and directions of development (Schot at.al., 1996; Ravesloot, 2000-I):

1 the technological part of industrialisation (technique)
2 the organisational, legal and economical part (structure)
3 market-oriented part and involvement of end-users and the marketing of social aspects (culture)

You can argue about the form of technology development that is driving IFD innovation. Some say it is technology push, because IFD could very well be the result of an ongoing process of industrialisation. Others argue that IFD is technology pull, because it reflects the newly developing needs of consumers on the housing and office market (Ravesloot, 2000

II).
Suppose none of them is true. And suppose the innovation of IFD is an autonomous process, what would be the argument for that and how would the argument of sustainability fit in.
Now suppose both of them are true. What would that mean for the argument of sustainability in IFD developments.
And then there are the two possibilities in between. What if one of the two technology developments is true?

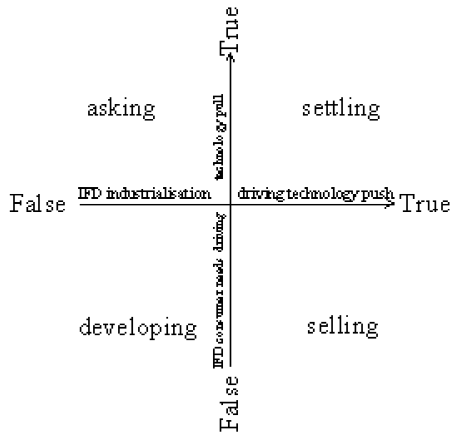


Picture one

Picture one shows the four possible combinations of IFD driving influences. The axe horizontally shows the week influence of industrialisation in IFD (false) transforming in a strong influence of industrialisation (true) leading to technology push. The axe vertically shows the week influence of consumer needs (false) possibly developing into strong consumer needs (true) along a technology pull development of IFD.

From the point of view of sustainable technological development, the technology pull part in IFD development corresponds with the cultural axe. The technology push part in IFD development would correspond with the technical axe. As you probably have noticed is the structural axe, representing the more legislative, organisational and economical part of technological development, not directly covered by the matrix in picture one.

There is still a possible improved technical quality of IFD buildings, claimed by the IFD developers. This could indirectly have positive influence on the environmental effects of building. It is also important to know what sustainable building goals could benefit from IFD innovation. Then we know what the government would have to do if she would not leave these important goals to the stakeholders, but become an important player herself?



Picture two

Picture two shows the direct consequences of technology push and technology pull forces in IFD technological innovation for the environment.

Along the horizontal axe the level of industrialisation is represented. If IFD really is ready to fulfil the claim that it is flexible and demountable, then it can be interesting for clients to buy too. If these clients are interested we have the combination of a true technology push and pull context. The IFD techniques only have to settle (SETTLING). If the market is not ready for IFD yet, developers of IFD still have some marketing and selling to do (SELLING).

Push or pull?

In the case of claims of IFD industry being not true, the technological innovation would not be technology push. Then, depending of buyers interest, the context of technological innovation would we one of asking for these technologies (ASKING). If technological development and market development would not be active, there would be very little motivation for IFD to develop. The innovation context would be one of new development (DEVELOPING).

Whatever is truly happening with the innovation process of IFD, the importance of sustainability is not directly covered and thus the potential contribution of IFD to the strategic goals of sustainable building in The Netherlands is at stake. Since the Dutch government and the municipalities do not seem to have any influence on the development of IFD, we have to conclude that despise technology push or pull, the potential of environmental gains can not be used to its full potential. The public authorities do have influence on the structure of society. They can only influence IFD development by forcing it by law or by subsidising. That is the reason for the success of the Dutch IFD programme, it supports as well technology push as pull. The programme however is also failing in defending the environmental potentials in IFD.

In none of the four cases from a developing IFD technology, a selling or asking context towards a settled context, the responsibility for environmental effects would be taken.
The goal of IFD building, seen from the perspective of sustainable building, should be the technical, functional and sustainable constructing and maintaining of a building, also adjusted to users needs. Here waits a big opportunity for architects and developers of IFD concepts, to develop new concepts for future users. Then IFD could serve the environment too. The Dutch authorities would do very well in supporting the environmental benefits from IFD, more then the benefits for users and producers. They are well taken care of anyway.
If the technical potential of IFD would be further developed in favour of environmental gains, this should also become part of national sustainable building policy.

Literature:

- Kowalczyk, A., Duurzaam herbouwen is selectief slopend, IFD IV, GBW 4-2000, Van Westering Baarn 2000;
- Ravesloot C.M., Op welk schaalniveau past u IFD-techniek toe?, IFD I, GBW 4-2000, Van Westering Baarn 2000;
- Ravesloot C.M., Wat levert IƒD op?, IFD II, GBW 4-2000, Van Westering Baarn 2000;
- Ravesloot C.M., IFD laat containerimago vera achter zich, IFD III, GBW 4-2000, Van Westering Baarn 2000;
- Riedijk W., Appropriate Technology in industrialized countries, Delft University Press 1989;
- Schot J., Rip, A., Misa, T.J., (Eds.), Managing Technology in Society. The Approach of Constructive Technology Assessment, London, Pinter Publishers, New York 1996;
- VROM, Duurzaam Bouwen Monitoring, Resultaten Plannen van Aanpak 1995-1999, VROM Den Haag, 2000-I;
- VROM, Beleidsprogramma Duurzaam Bouwen 2000-2004, ministerie VROM, Den Haag 2000-II;

The 7 Heavens

an Open Building Experience in The Netherlands

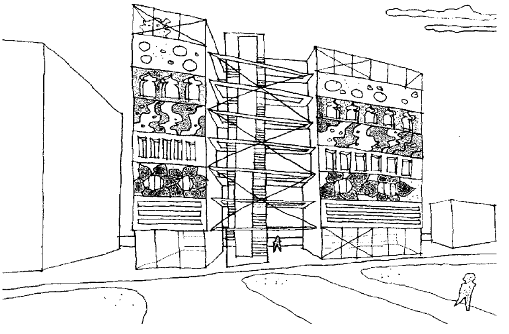
Ir. Frits J.M. Scheublin
Director of HBG Engineering
Rijswijk, The Netherlands
October 2001

PO Box 82, 2280 AB Rijswijk, NL
Tel: +31.70.372.2245,
Fax: +31.70.372.2245,
E-mail: Fscheublin@HBG-BVG.nl

The 7 Heavens

an Open Building Experience in The Netherlands

Open Building in Rotterdam NL (2001)



ABSTRACT

HBG Woningbouw, the housing contractors in the HBG Group - the biggest Dutch Contractors firm - and Bouwfonds Wonen, the housing activity of Bouwfonds the leading Dutch project development corporation want to prepare themselves for an upcoming and new market for apartments build to clients specification. In 2000 they decided to work together on the development of a new concept for apartment building, meeting these new requirements.

“The 7 Heavens” is the first pilot project to test a new strategy for the development of such client oriented apartment building.

Like in the Japanese “Next 21” project the owners are enabled to make their own decisions regarding floor plan and finishing. But unlike Next 21 the apartment owners are also allowed to express their personal preference regarding the design of the facades.

The pilot project will be built in Rotterdam. The apartment building will be located directly adjacent to the Euromast, a 125 meters high tourist attraction and the best-known landmark in Rotterdam.

The building will be steel framed. For the floors several construction principles are examined now, taking into account the wish to change cables and ducting easily and without craftsmen’s help. For the facades the ideal of the project team is to make them demountable.

The 7 Heavens was awarded the IFD nomination 2000. In Dutch IFD is short for Industrial, Flexible and Demountable. The 7 Heavens project received a grant of approximately 200.000 Euro’s for promotion and dissemination of the gathered IFD-knowledge.

The 7 Heavens

an Open Building Experience in The Netherlands.

Ir. Frits J.M. Scheublin

The traditional housing market

In the Dutch housing market clients are used to mass-production with little influence for buyers and tenants. Caused by a shortage of houses, project development companies could sell until recently any house they thought suitable for the market. But market circumstances are changing. In the top segment of luxury apartments there is not a severe shortage any more. Clients can select their house from a number of developments. As a result of these changes there is a growing demand from tenants and owners for influence in the design stage of their private homes development. The project development companies have to meet this new demand. So suddenly a variety of customised housing concepts are coming to market. They are promoted under appealing brand names like Smart Houses (HBG), Personal Living (Bouwfonds), Wish Housing (Slokker), Wild Living (Weeber), Wanted Living and Private Housing.

Partnership for change

HBG Woningbouw, the housing contractors in the HBG Group - the biggest Dutch Contractors firm - and Bouwfonds Wonen, the housing activity of Bouwfonds the leading Dutch project development corporation want to prepare themselves for an upcoming and new market for apartments build to clients specification. In 2000 they decided to work together on the development of a new concept for apartment building, meeting these new requirements.

“The 7 Heavens” is the first pilot project to test a new strategy for the development of such client oriented apartment building.

Comparison to Next 21

The concept will remind Members of W104 and other Open Building supporters to the “Next 21-project” build in Osaka, Japan, some 10 years ago. For those who are not familiar with the Next 21 project a short description may be useful. In Osaka about 20 apartments were constructed in a 4-storey high concrete support system. Facades are made with standardised panels, based on a modular system, allowing to exchange panels when new housing requirements arise. A raised floor system provides space for cabling and ducting, independent from the floor plans of the individual apartments and easy accessible. There are many other innovative features in the Next21 project, like a roof-top garden and low energy consumption, but similarities between the 7 Heavens and Next 21 only concerns the open building aspects.

Like in Osaka the 7 heavens project will provide a complete separation of support and infil and a virtually unlimited freedom for tenants to design their own apartment. The solutions to meet this requirement are in Rotterdam quit different from those in Osaka.

The most striking and clearly visual Open Building aspect of the Rotterdam project is the freedom offered to tenants or owners to design and install their own facade. Unlike the Osaka project each floor will have its own characteristic facade architecture.

Initiative

The 7 Heavens project was initiated in the year 2000 with the selection by Bouwfonds of an architect to develop a concept. This architect, Joris van Hoytema, proposed a 7 story steel frame on a concrete basement. Each floor is designed to accommodate up to 3 apartments, but 2 apartments or even only 1 apartment per floor is also a possibility. Bouwfonds made the decision to select 7 architects, one per floor, to do the interior design and the facades along the private domains. Blue horse productions, a reality-TV company, played a very important role in the initiative stage as they appeared interested to follow the unusual decision making process.

Location

The project will be build in Rotterdam, a city well known world wide for being the biggest harbour in the world, but also well knows among architects for its policy of active architecture promotion. Harbour activities are nowadays, like in many other port cities, moved out of the central district to an area more close to the open sea. Old harbour districts are redeveloped now. The 7-Heavens-Project will be located in such a redevelopment plan, directly adjacent to the Euromast, a 125 meters high tourist attraction and the most famous landmark in Rotterdam. The apartments will all face south and enjoy a beautiful view over the river. The location is really worth the highest ranking possible.

Architectural concept

Like in Next 21 the owners are allowed to make their own decisions regarding floor plan and the standard of finishing. But unlike Next 21 the apartment owners are also allowed to express their most personal preference regarding the design of the facades. To make sure that the supervising architect will not overrule the owner’s choices the project team decided that the project architect will not be allowed to act also as the private architect for the prospective owners. Therefor the project development team prepared a shortlist of 22 young architects; all recently graduated from the Technical University in Delft or the design academy in Rotterdam. To reduce this list to the final selection a jury of experts chaired by the well-known Dutch architect Carel Weeber was invited. A big party was than organised for all people who expressed their intrest to buy an apartment in the 7 Heavens. There all the shortlisted architects presented their view on the project and on their co-operation with the other parties concerned. After the party the jury finally selected 7 architects. These architects will sketch now impressions of their vision on the exterior of the building for the project brochure. The future owners will be invited - after the signing of their contract - to

select the architect that best meets their personal taste.
In the Netherlands building permits are issued by the cities after consultation of a local architects board. The city council is free to reject the architects' advice, but does seldom do so. The client and the supervisory architects' board for the city of Rotterdam accepted the fact that this building may show 7 very different facades. Nevertheless the parties are a little concerned about the effect of three differently designed facades on each floor. This may cause a variety that comes too close to disharmony. For that reasons it was decided that only one architect would be contracted for each floor. On each level the same architect will design all three apartments, including the related facades. So if the maximum of three apartments is build on one floor the three owners share one architect. The project team expects that this procedure is leading to an optimal balance between the variety resulting from different personal preferences and the possibility of disharmony caused by too many architects.

Structural concept

The building will be steel framed. An unusual construction for the Netherlands where most buildings are built with load bearing frames in concrete. Concrete load bearing walls were rejected, as they do not allow changing the number of apartments per floor in future. Even the steel crosses needed to stabilise the building are considered as an obstacle to the open building concept. They had to be accepted, but they were reduced to the structurally absolute minimal dimension.

Open Building concept

The HBG engineers are now involved in the decision making process on some typical Open Building principles such as:

- Raised floors, hollow floors or ductile plinths and door frames to provide for flexibility in cabling and ducting,
- Detailing of demountable facades to allow adjustments to future preferences,
- Riser ducts designed to connect easily when future systems or extensions to existing systems are required.

For the floors several construction principles were studied. Initially a top floor filled with clay balls was considered. The clay balls can be removed partially to allow space for future changes in cabling and ducting. On top of the clay balls a cement floor is proposed. Disadvantage of this approach may be the hard job to cut an opening in the top layer of cement and sand.

Another strategy is the application of an "A+ floor". A registered brand floor system based on I-shaped steel beams, the bottom flange cast into a concrete slab, the top flange supporting a modular system of floor panels. The owner is allowed to remove the floor panels to modify the cables and ducts below. The lower slab it fixed and will provide the required thermal and acoustic isolation. The I-shaped beams are provided with a regular pattern of openings to allow ducts and cables to cross the beam. New acoustic insulation standards coming into effect in The Netherlands by January 1st, 2002 may be a reason to abandon the A+ system though in flexibility this system is preferable.

For the facades the objective of the project team is to make them demountable. The idea is that owners during the life cycle of their family life have changing needs. This regards usually only the floor plan, but may occasionally also concern the facades. One day they may wish to add the space of a balcony to the bedroom while some years later they may prefer to re-install their balcony, and even a more spacious balcony than they had before could be their wish. For the engineering of such a demountable facade element the technical constraints are challenging. The elements must be demountable while neighbours above and below are not disturbed during the exchange operation. Also thermal and acoustic insulation should remain in compliance with standards after any possible change.

The facade details should be suitable for every facade concept whatever the materials used will be. So wooden panel, aluminium frames, but also concrete cladded with granite or brickwork should fit the details.
In the layout there are two riser ducts interconnecting the floors. These risers are located next to the front door to leave maximal flexibility for the partitioning of the private area.

A future market for second hand facade elements?

The initiators of this project are in favour of standardising the details for the facade connections. Such standard details may in future generate a market for second hand facade elements. They consider facilitating such a market by taking used elements in stock. Conditions for a successful second hand market are;

- a widely accepted standard for dimensions of elements,
- a widely accepted standard for the connection of elements to base buildings,
- a certain minimal number of apartments build to these standards,
- a positive approach by architects to the application of used materials
- a positive approach to used materials by supervising architects boards.

As a first step to such a second hand market a stock of used elements on a project basis is considered.

Flexibility of the base building

Some constraints in base buildings to overcome are;

- at internal balconies or loggia’s, the concrete floors are usually a bit lower then in the adjacent rooms to prevent rainwater from running inside, flat concrete floors are preferred when the location of these loggia’s is not a fixed place anymore,
- to make external balconies where wished by the tenants, the support structure must be designed to take the extra load anywhere,
- the separation walls between apartments are often used as stability walls. Where the size of the apartments is not fixed for the lifetime of a building minor concrete elements or steel crosses must provide the stability.

For the 7 Heavens project stability crosses in steel are chosen.

Progress of the work

An agreement has been reached on the construction cost and the prize of the land. The city of Rotterdam is prepared to issue a building permit and the local architect's board did not object to the experimental design process.

The architects and the structural engineers recently started their detailed design work. Mechanical and electrical subcontractors are selected now. They will start their part of the detailed engineering later this year. Many of the open building aspects mentioned above have to be addressed and problems still have to be solved in co-operation of all parties. Inevitably some of the Open Building ideals will appear to be to idealistic to be fully honoured in this project. But that the 7 Heavens will be a splendid example of Open Building architecture is now already beyond doubt.

The execution of the project is planned to start in the spring of 2002.

Awards:

The 7 Heavens was awarded the IFD nomination 2000. In Dutch IFD is short for Industrial, Flexible and Demountable. The IFD nominations are awarded once every two years to encourage projects that are innovative examples of industrial, flexible and demountable building. The Ministry of Housing supports the nominated projects with a prize. The 7 Heavens project received a grant of approximately 200.000 Euro's. This grant is to be used for the promotion and dissemination of IFD-knowledge.

Projectteam:

Initiative	Blue Horse Productions
Cliënt	Bouwfonds Wonen, Hoevelaken
Development	Bouwfonds Wonen, Delft
Architect	Bbvh architects and city planners, Rotterdam
Structural Eng.	HBG Engineering, Rijswijk
Contractor	HBG Woningbouw bv, Rotterdam
Steelwork	Oostingh staalbouw bv

Finnish Developments towards Industrialised Residential Infill Systems

Jyrki Tarpio, M. Arch., Ph.D. student
Helsinki University of Technology, Department of Architecture
P.O.Box 6500, FIN-02015 HUT, Finland
tel: +358-9-451 4466
gsm: +358-50-324 2356
e-mail: jyrki.tarpio@hut.fi

Finnish Developments towards Industrialised Residential Infill Systems

ABSTRACT

In recent years there has been a growing interest in more adaptable housing in Finland. Today it is recognised that values and housing preferences are too varied to be met by universal fit-for-all solutions. There are developments going on in several directions; some of these developments involve high-density low-rise housing, some involve medium-rise housing with wooden load-bearing structures and an emphasis on ecology, and some are following the open building approach.

In this article I first briefly present the structural features that have become common in Finnish housing construction within the last thirty years. This will help to gain an understanding of the potential for open building in Finland. After that, I describe the common features of Finnish residential interiors and the interior product market, and present some interesting interior products that have recently become available. To end the article, I make brief remarks on the major factors that are driving the Finnish industries towards more open building friendly ideas and products.

KEY WORDS: industrialised housing & open building in Finland, adaptable interior systems & products

Finnish Developments towards Industrialised Residential Infill Systems

Jyrki Tarpio

Major development programmes for industrialised housing construction, common practices, and the emerging open building

During the last three decades, the use of various prefabricated parts has become very common in Finnish housing construction. The development programme of Suomen Betoniteollisuuden Keskusjärjestö SBK (The Central Organisation of the Finnish Concrete Industry) in 1968-70 had a major impact on the use of prefabricated parts. The so-called BES (concrete element system) recommendations for the open panel construction system were made in the programme. Based on modular dimensions, pre-cast reinforced concrete wall elements and hollow core floor slabs, BES quickly became very common in both residential and commercial construction. The BES development was quickly followed by PLS, an open flat-slab construction system development programme in 1971-72; however, PLS never became as common as BES in housing.

A further development of the BES programme was organised in 1986-90 by Tekes (the National Technology Agency of Finland) and VTT (the Technical Research Centre of Finland). The theme of the programme was “totally adaptable technology” and a system called TAT was developed as part of the programme. Its main idea was to handle technical subsystems as independent compatible modules or components, and to create a common set of concepts, a dimensioning system, a selection of component types, design instructions and model plans. The TAT principles have had some affect on residential construction, but have mainly been applied to office construction.

The first time a wider interest towards residential open building was recognised in Finland was in connection with the Milieu 2000 Technology Competition organised by Tekes, the Ministry of the Environment and the City of Helsinki in 1990-91. Four winning proposals of the competition were implemented in Herttoniemenranta, Helsinki in 1994-98. The development themes of the proposals included re-configurable building parts and equipment, and user participation.

During the last thirty-years, structural technology based on prefabrication has become dominant in Finnish housing. However, user demands have changed during the period and some structural solutions have proven to be unreliable. The main features of multifamily housing in Finland today are:

Structure and technology:

- the horizontal load bearing structure is usually made of hollow core slabs with a relatively long span

- facades [ES1]are often made of factory produced concrete elements (the skin, however, is usually of bricks laid in-situ due to the problems with the concrete facades of the pre-cast sandwich facade elements made in the 1970's)

User involvement:

- user participation has been relatively uncommon, but future first owners of newly built multifamily housing are becoming more demanding (today developers are forced to make many alterations to original apartment plans during construction of owner-occupied multifamily housing)

Fittings and amenities:

- apartments include saunas (until the 1980's, saunas in Finnish apartment buildings were shared, and private apartment saunas were uncommon; these days, private saunas are being built in even small one-room apartments)

Projects and actors aiming for adaptable housing

The implemented housing projects in Finland that include the main characteristics of the open building approach[1] are not yet very numerous. However, there are certain parties that are striving rather progressively towards open building with a more adaptable building technology[2], three examples of which are given below.

Building concept development: from Laivalahdenkaari 18 Housing to +Koti

VVO Laivalahdenkaari 18 is a 5-6-storey rental apartment building with 97 units located in Herttoniemenranta, Helsinki. It is designed by Kahri & Co., Architects, and finished in 1995. The original project included user participation and various adaptable components. The occupants had a selection of two to six-plan layouts [ES2]to choose from for their dwelling. They were also able to decide the material of the balcony railings, balcony glazing and the lower parts of the window openings. The choices were pre-priced, and their impact on the rent was calculated. Adaptable frames, variable panels and balcony systems, an individual heating and ventilation system for each apartment without radiators, and a de-mountable partition system were introduced in Laivalahdenkaari 18. The designer has continued developing the scheme (both in terms of the technology and the user participatory concept) with another developer; the scheme has been renamed as +Koti (+Home).

Competition for residential open building technology in Helsinki

The City of Helsinki and Tekes organised a technology and site-allocation competition for Arabianranta in 2000-01. The aim of the competition was to promote resident-oriented housing construction by applying the principles of open building. User-oriented operating models for the construction process, and new building systems and building products were the key development targets of the competition. Development groups with one of the

---

1 The main characteristics referred to are "user as decision maker", "open spatial structure", "separation of support and infill systems", and "open building process". For the division of characteristics by Ulpu Tiuri, see Tiuri-Hedman 1998, p. 23.

2 The major Finnish commercial developments and housing projects aiming for adaptability in the 1990's are described in "Developments Towards Open Building in Finland" written by Ulpu Tiuri and Markku Hedman.

partners acting as principal were entitled to take part. Four groups took part in the competition. “Sato-PlusKoti” of Sato developers and Kahri & Co., Architects, won the competition.

Progressive developer: Keski-Suomen YH-Rakennuttajat

Developers Keski-Suomen YH-Rakennuttajat have been applying several technical solutions in their projects to develop more flexible renovations and newly built housing. Individual mechanical engineering distribution boxes for each apartment, the placing of vertical ventilation ducts in the perimeter area of the apartments (integrated into façade walls or staircase structures), various solutions for wet spaces and several modifications of access floors are some applications developed in collaboration with certain manufacturers. In its projects, Keski-Suomen YH-Rakennuttajat has gradually introduced new technology over several years with the aim of increasing flexibility.

Common features of Finnish residential interiors and interior product market

Around the world, architecture is shaped by natural forces (geography and climate), cultural forces (housing traditions and local habits) and material forces (wealth, economy and resources). As Finland is one of the Scandinavian countries in the north of Europe with long cold winters, it is inevitable that heat and heating plays a major role in all construction. Most Finns feel that a dwelling is defective if it is not warm inside during wintertime. Similarly we feel that a house is imperfect if there is no sauna in it. We also tend to personalise our dwellings ourselves - do-it-yourself interior decoration is especially common.

To meet the needs of do-it-yourself interior construction, there are many do-it-yourself stores (rautakauppa in Finnish, literally translated as “iron store”) in Finland. In these stores there is a large selection of surface materials of various types. Also the range of colours and tones for paints is very wide compared to those available in many other countries. The consumer may purchase materials, products, equipment and even small buildings such as garden cabins in rautakauppa. Kitchen cabinets are a common merchandise too - most kitchen manufacturers have either a nation-wide chain of representatives or have their products sold in various do-it-yourself stores.

Structurally, the residential interiors in Finland are usually built in a set way. Partitions, storage units and equipment are fixed and piping is often placed in situ within the reinforced concrete cast structural parts. Bathrooms and saunas are usually built fixed. However, a more sustainable technology relating to building services is becoming more and more common in Finland - for example, double piping made of polyethylene has become a common means of delivering heating and water supply, and an electricity system based on quick connectors is now on the market.

Adaptable interior products & concepts

In the following chapter there are some examples of adaptable Finnish interior products.

Bathroom units

Parmarine Oy, a manufacturer of bathroom units for the construction and shipbuilding industries, produces bathroom units with reinforced concrete floors and steel wall structures. The residential units, weighing 2.000 - 4.000 kg, are fully equipped rooms in which interior furnishing and mechanical and electrical service installations are made at the factory. The units are manufactured as ordered according to specific plans. In the 1980's, the company developed a panel bathroom type called "Entra 2000" that consists of floor, wall and ceiling panels. The type was delivered to the construction site as panels that can be brought into an apartment through the door opening.

Unit saunas

Unit saunas that can fit into small spaces are a new product group on the market. Apartment saunas became common in the 1980's in the newly built housing; these days it is relatively common to renovate old apartments and add a sauna if it can be made to fit into the overall room layout.

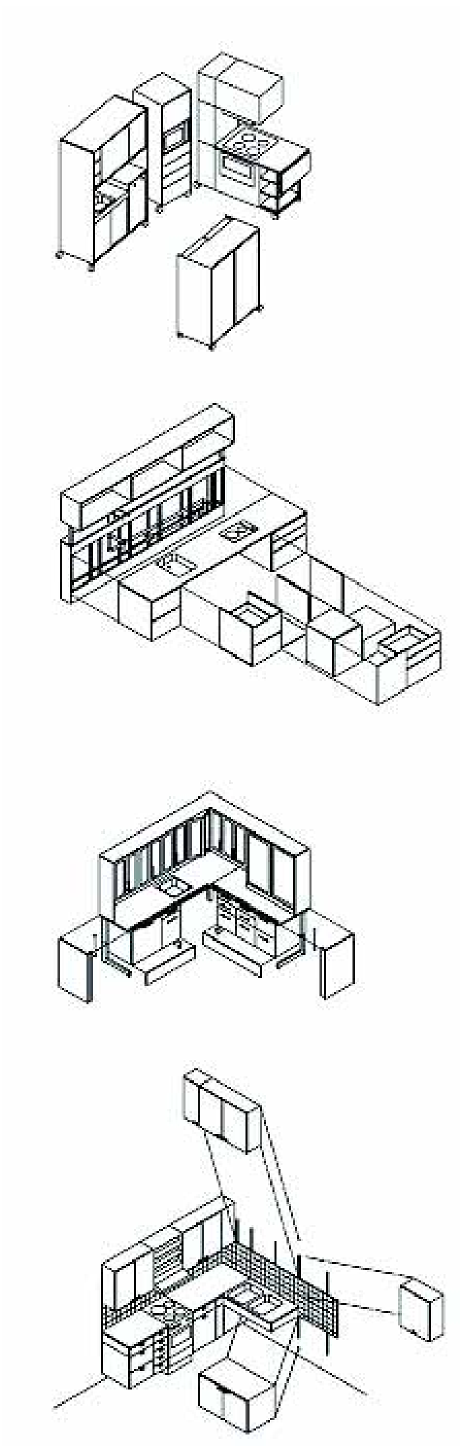
Half a dozen unit sauna manufacturers have entered the market with various solutions. The common denominator of these products is that they are delivered to site as ready-to-be-assembled sets, consisting of corner, wall and ceiling elements with a heater. They are assembled on top of a waterproof surface in the same manner as shower cubicles. Some manufacturers use a wooden structure with insulation, while others apply wooden panels to compound plastic materials with insulation. The units range from existenz minimum - Saunadusch Oy has a special, integrated, minisauna/shower cubicle with hinged sauna benches - to large custom made special deliveries. The design varies from traditional aesthetics to trendy geometric minimalism.

Adaptable kitchen sets

Commonly the kitchen manufacturers offer modular dimensioned cabinet frames and a large selection of materials, designs and colours are available for cabinet doors. The customer may choose a combination of modules and doors himself, or he may use design services available at most retailers. The outcome is customised, but not very adaptable during its use. The following kitchen sets are designed to have good adaptability.

A design based on independent movable units

A kitchen based on independent movable modules on wheels, designed by the interior architect Juha-Pekka Kinnunen, was presented at the Finnish Housing Fair of 2000 in Tuusula. The kitchen set consists of water, heat, cold and storage modules. A sink, a dishwasher and some storage space form the water module; a stove, a stove extractor fan and some cabinets make the warm module; a freezer and a refrigerator are combined to form the cold module. A microwave oven, for example, can be integrated into the storage modules. The module frames are made of steel and equipped with wheels. The surfaces



are made of high-pressure laminate or heat-treated birch, and there are quick connectors for electricity, water and drainage in the modules. The first version of the kitchen set was tailor-made for Villa 2000 House of the Housing Fair.

A design based on an installation wall and units integrated to a modular worktop

A kitchen design by the interior architect Esa Vesmanen based on an installation wall and units integrated to a modular worktop was first introduced in a design exhibition in May 2000. Its overall idea is based on its designer's studies and remarks on contemporary food culture. The installation wall with a steel structure - with surfaces of glass and subdued lighting inside the structure of the original version - semi-conceals the piping. The worktop is installed next to the installation wall. It contains built-in taps, a basin and a cooker. Various "space modules", for example, a two-sided refrigerator, home compost, recycling centre or dishwasher can be integrated under the worktop. The upper shelves in the original design are made of a lightweight veneer structure. The set can be installed as an independent space divider within a large living-dining-eating area or facing walls in a separate room. When installed as a space divider with a free-standing installation wall, the kitchen set can be easily updated with future technological innovations via the wall.

Height-adjustable kitchen cabinetry, adjustments as whole

The Keiski kitchen is an adjustable kitchen set designed by the interior architect Sirkka-Liisa Keiski. Aesthetically the kitchen matches the common taste, and functionally is especially designed to meet the demands of the senior citizen and the disabled. It contains several special features. The kitchen can be integrated or free-standing. There is a steel pillar and pedestal mechanism that enables the kitchen set to be height-adjusted as one unit to a desktop height of 730 mm to 900 mm. The unit consists of lower cupboards, refrigerator and dishwasher that are hung from the worktop, and of upper cabinetry. The upper cabinetry is supported by plate walls installed on top of the worktop. The whole unit can be raised or lowered by sliding the pedestals within the steel pillar and locking it at the desired height. In L-shaped applications, some horizontally sliding lower cupboards are included to make legroom for wheelchair users who wish to use the worktop area. Handrails to help the disabled are integrated into the worktop in an aesthetically pleasing manner. The Keiski kitchen set is manufactured by Lahden Mittaovi Oy.

Height-adjustable kitchen cabinetry with independently adjustable modular frames
Some manufacturers offer height-adjustable cabinetry based on modular dimensioned frames and vertical installation mouldings. Upper cabinets, worktop and lower cabinets are installed independently into perforated metal mouldings that are screwed into the walls. The lower cabinets have adjustable pedestals and their plinth boards are renewed after height-installation. Modular metal cassettes with a tiled surface are used between the worktop and upper cabinets. The upper cabinets can be independently height-adjusted to a limit of 300 mm, and the worktop and lower cabinets to a limit of 200 mm. The modular cassettes can be removable, or dimensioned according to the highest and lowest cabinetry positions, to cover all of the wall area between the height-adjustment limits.

Conclusions: The main factors pushing towards an adaptable infill industry

The dwellers' needs and wishes in respect to their houses in contemporary society are becoming more and more difficult to predict and fulfil. Special dweller groups, be they cultural or demographic, have emerged, and they demand to be taken into account in housing design. Elderly citizens, with limitations to their bodily movements, need special functional solutions, for wet spaces, for example, which are not necessary for the younger age group. These various needs cannot be properly met with a good-for-an-average-family design mentality or by using only standardised equipment and spaces.

In Finland there is a tendency to build larger wet space areas with more water-using appliances within apartments. In many cases this tendency has caused problems with moisture. One way to reduce these problems is to use more factory-made integrated components in the wet areas; these would help improve technical quality by reducing the workers' need to improvise with various electrical and mechanical piping component joints on construction sites. If these integrated parts were designed with reversible joints3, they could be replaced and changed later on to meet the occupier's changing demands as to design or function.

In addition to some new functional needs and problems with moisture, the state support for open building developments via Tekes funding is one of the main driving forces towards industrial infill technology in Finland. The open building approach is recognised by Tekes by placing it as one of the key development issues.

In Finland there is advanced construction technology available at the support level of open building at present. At the level of residential infill, the situation is more controversial. It is interesting to note that adaptable interior systems did become relatively common in the 1990's in Finland - in the field of office development.4 However, systematic access floor structures, for example, suitable for residential use, entered the market as late as the year 2000. So far, the co-ordination of the parts and the demands for mechanical and engineering components and interior parts for adaptable buildings have been lacking. These demands will soon be met, when the second report of the "Infill Systems for Open Building in Housing" R&D project of the Department of Architecture in Helsinki University of Technology comes out at the end of 20015. In it, the recommendations for residential total infill systems and product concepts suitable for Finnish housing culture and the Finnish building industry will be given. It is very likely that new product and method development programmes will be started subsequently, based on the recommendations of the report.

References

Astikainen, Riitta. 2001. "Ensin suunnitellaan uusi asunto - ja sitten alkaa muutosrumba" -article in *Helsingin Sanomat* on the 20th of March 2001.

Li-Chu Lin, Ming-Hung Wang. 2000. "Technological Change of Infill Construction for Continuous Customization" -article in *Continuous Customization in Housing - Proceedings of the Conference of CIB W104 Open Building Implementation*, October 16-18, 2000 Tokyo Japan, ed. Yashiro, Tomonari. CIB Report Publication 254.

Martin, Bruce. 1977. *Joints in Buildings*, George Godwin Limited, London / John Wiley & Sons, New York, 1977.

Tarpio, Jyrki - Tiuri, Ulpu. 2001. *Infill Systems for Residential Open Building - Comparison and Status Report of Developments in Four Countries*, Helsinki University of Technology, Arkkitehtiosaston julkaisuja 2001/75, Gummerus Printing, Saarijärvi 2001.

Tiuri, Ulpu - Hedman, Markku. 1998. *Developments Towards Open Building in Finland*, Teknillisen korkeakoulun arkkitehtiosaston julkaisuja 1998/50, 2. Painos Gummerus Printing, Saarijärvi 2000.

Mass customization and Agile Architecture

Consumer-oriented industrialisation and interactive decision-making.

ir. Caspar van den Thillart
Ministerie van Volkshuisvesting Ruimtelijke Ordening en Milieubeheer
Postbus 20951
2500 EZ Den Haag
The Netherlands
Phone: +31 70 3391954

Mass customization and Agile Architecture

Consumer-oriented industrialisation and interactive decision-making.

Caspar van den Thillart

It is widely believed that the rapid developments in ICT applications and the ongoing process of industrialisation will drastically alter current housing construction practice. Other changes have also followed from the government's withdrawal from the sector as happened e.g. in Europe. By virtue of its very nature, a private market has no choice but to pay more heed to the demand side: to satisfying individual consumer requirements. This paper examines the possibilities offered by agile architecture for consumer-oriented industrialisation.

I first propose to discuss briefly the changes in the industrialisation process accompanying the transition from a government-dominated market to a private market (I). My views are based on my experiences on the market in the Netherlands. I will then explore the concept of 'mass-customization' (II) and continue with the aspects of mass customization in relation to the structure of the sector (III). I close with some guidelines how agile architecture can attribute to mass customisation and shed a light on the concept of 'interactive decision-making' in construction (IV).

In conclusion, I intend to demonstrate that the building industry, because of its structure, is particularly suited to mass-customization and has the potential to achieve results in this areas that could far surpass the possibilities offered by other industrial sectors.

Industrialisation in the building sector

The characterics of the building sector

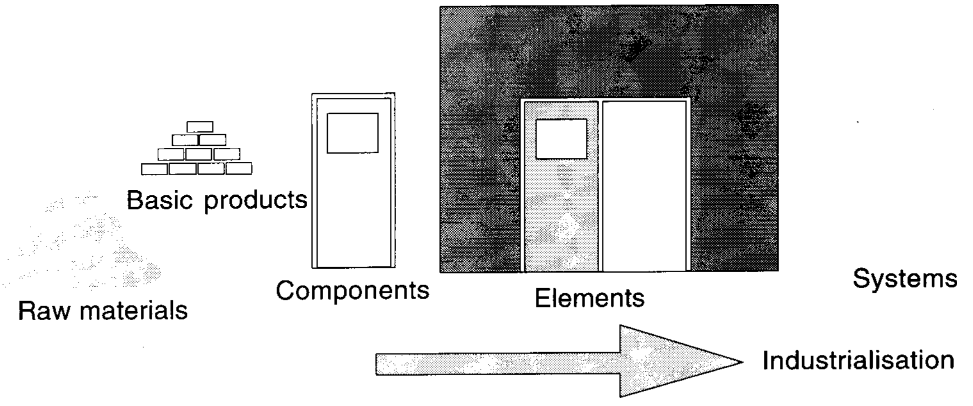
The building sector has an image problem. It is a branch of industry that is associated with rough work in bad weather, wind and mud. Traditionally, the sector has typically exhibited the characteristics of a craft rather than an industry. Industrialisation dominates, for more the most part, in the production of basic building products, such as cement, bricks, wooden beams, roofing tiles, pipes etc. These materials are generally manufactured and stocked according to a fully automated, well-controlled production process. At the construction site, however, where all these building materials and semi-finished products are brought together and to be incorporated into a final product, by and large traditional methods are still commonplace and quality control generally below standard.

Despite numerous attempts in the past to achieve full industrialisation, the craft aspects have proven stubbornly resistant. The question is why the construction industry lags so far behind other industrial sectors. However tempting, the construction sector cannot simply

be compared with the auto industry. Prefabricated components tend to be heavy, take up considerable space and have a limited action radius. A perhaps even more important reason for the slow development of industrialisation is the fact that unlike cars, buildings are immobile: they are bound each time to different environments with other limiting conditions. These limiting conditions strongly affect the sales possibilities. Numerous such restrictions are conceivable: planological limitations, re-housing problems, expropriation, to name but a few.
The capriciousness and the project-specific character of the production sector strongly impacts on the structure of this industrial branch. In a private market, without government sponsorship and lack of harmonization, the sector is mainly made up of small and medium-sized enterprises. A good example is Western Europe. In many European countries, industrialised housing production developed after the Second World War within the scope of a centrally planned economy. After the initial urgency of the housing problem had been solved, the public sector withdrew from the arena and housing construction declined, just as the demand for differentiation started to rise. Not even the building sector can escape this economic reality: ongoing industrialisation has, due to diminishing returns, increased the importance of differentiation of the product range. Differentiation of the product assortment will act as a market pull, which will lead to a technology push in production that is fuelled by the competitiveness between companies seeking to survive in a saturated market.

Upgrading industrialisation in a private market

A not unimportant question for countries was the construction industry shifts towards a predominantly privatised market is: can the sector survive without government funding and even go on to expand the process of industrialisation? My observations of the Dutch market have shown that further industrialisation is possible during the transition to a private market, although the risk of casualties is considerable[1]. The sector will have to turn to flexible ‘just in time’ production and at the same time strongly decrease the projects’ scale. Despite the logistic complications and the high investments in flexible production equipment required, the share of prefabricated components continues to expand gradually. Because this industrialisation process has developed in a private market from the bottom up and is therefore not imposed from the top down by government plans, I see this development as ‘upgrading’. Upgrading in this context refers to the ongoing process of industrialisation at ever-higher levels in the building products chain. The term building system - the final phase of prefabrication - may be viewed as a set of building components that is marketed by a manufacturer. Such building systems are generally manufactured to order and fulfil a specific function in the building under construction. Examples are the prefab units for the body, facade and roof elements, components for installation and build-in elements. The most plausible explanation for this upgrading process in the private market is that the building sector is being pulled along in the wake of developments in other, more advanced industrial sectors. Earlier, I referred to the poor image of the building industry. Few people today are prepared to work for a contractor in bad weather, wind and muddy conditions[2]. Hence market conditions are forcing contractors increasingly to opt for more prefab construction elements.



As the above shows, during the transition from a public to a privately driven market, the nature of the industrialisation process will also change: from production and maintenance of stock on hand to just-in-time production with flexible production equipment. The classic definition of industrialisation...'*The replacement of manual labour by mechanical labour in production processes with the object of realising a lower cost per unit of product*' is not adequate in today's demand market with individual consumer desires and a growing quality demand. Companies unable to respond to this problem will simply perish. A more contemporary definition of industrial building which stress the quality aspect in a private market should be: ...'*The marketing and assembly of building systems of which the production process is characterised by project-specific delivery, quality control and the striving to substitute manual labour by mechanical labour.'*

Mass-customization

In the transition from quantity market to quality market, construction companies active in housing construction often find themselves wrestling with the new consumer-oriented approach. After all, they had been used to a building culture comprising large-scale, uniform projects and focussed on obtaining volume discounts for the building materials bought in bulk. Only a few different variants in finishing materials were offered to the consumer, such as the colour of the tiles in the bathroom. Consumer desires tend, therefore, to be considered in the first instance as a nuisance by builders. The same applies to architects, who were not accustomed to having to listen to consumers. Even now, as

---

1 I am referring to my experiences in the Netherlands, a small member state of the European Union with a relatively high population density. After the second world war, the Dutch government energetically addressed the housing shortage. A huge number of inexpensive dwellings were needed in a very short period. Production was standardised and new factories produced prefabricated building units. Within a few short decades, such large-scale production had yielded millions of new homes. The turning point came during the eighties. The government called a halt to the production and financing of large numbers of rented dwellings. The market for owner-occupied dwellings overtook that for rented accommodations and the housing projects became smaller and more differentiated.
2 In the Netherlands, many skilled construction workers are self-employed as building contractors working in the private renovation sector, which has become booming business since the market for owner-occupied dwellings took off.

project developers become increasingly consumer-oriented, it is proving very difficult to fulfil individual consumer demands at random. If a consumer takes an option on a dwelling that has already reached the finishing stage and decides that all sorts of alterations such as additions, bay windows, conservatories, dormer windows, etc. are to be made, the logistics process of the contractor will suffer a considerable setback. Obviously, therefore, individual consumer desires should be input in the production line at the earliest stage possible. If, for example, a consumer desires to have a solar collector installed, it is better to ensure that this is input in the production line prior to the prefab roof element, as the contractor will otherwise have to saw a hole in the roofing sheet at the construction site. Subsequently having to make all sorts of changes on the construction site also means a risk of higher failure costs due to construction defects. This need to plan in advance in order to be better able to realize consumer desires has given rise to the current interest in what is termed *mass-customization*.

By *mass customization* it is possible to reduce the time of delivery for tailor made products by splitting up the product in component variants which can be produced independently in different production lines. The decisions of a consumer are split up at the same time and related to the component level. The changing combination of component variations will cause a large number of product variants to develop that are composed of these component variants.

> *Take the following theoretical example: A company comes up with a concept for a product that is able to be put together from ten choice levels of components. Each component level represents 10 variants. The variants of each level do not suppress the variants of the other levels. This concept is therefore able virtually to generate some 10 10 product variants.*

If this theoretical example were to be translated into a construction situation, this would mean that structures could be built in 10^{10} different variations. Obviously, producers in the housing market neither can nor wish to manufacture anywhere near this number of variations. The geometric structures of buildings nevertheless are highly suitable for generating numerous configurations. After all, simple geometric shapes easily fit together, unlike the complex forms of an automobile. This sheer profusion invokes questions such as:

- How can consumers decide given the abundance of choice available?
- Will such plenitude not lead to an uncontrollable number of connections with a corresponding risk of failure?

Before taking a closer look at the structure of decision processes in mass-customization let us first examine the way in which the organisation of the building sector should be geared to the phenomenon of mass- customization

The structure of the building sector and mass-customization

In the Western model, the building sector is one that is highly competitive. Design and implementation are strongly segregated and the sector is characterised by a relatively high number of small and medium-sized enterprises. In its most extreme form, the Western model is a cutthroat market in which financial haggling can at times cause the quality to suffer. Mistrust is the dominating culture in this competitive world. A different, more integrated approach to design, implementation and supply in large, quality-conscious companies is seen in the countries of Asia. The disadvantage to this approach, as the West sees it, is - apart from the subsequently unavoidable effect of price regulation - the risk that such large companies run in the event of drooping sales and, vice versa, the negative impact that downsizing such companies will have on the economy of an entire country. Western companies are, notwithstanding, starting to consider their position in the chain in a privatised market ruled by the consumer. They are aware that an open model can lead to communication problems and corresponding risk of construction defects. In the search for better quality assurance, models were experimented with featuring both forward and retrospective integration in the chain. Retrospective integration refers to the practice of contractors who buy up production companies to gain a firmer hold on the logistics process when fulfilling individual consumer demands. Forward integration is in the direction of the client and refers to the integration of the design discipline with the actual construction. This enables the design to be closely geared to the contractor’s building method, thus lowering the risk of construction defects. I shall refrain from expressing any opinion as to what the best model is. Companies seeking either forward or retrospective integration should consider whether future market sales justify the necessary larger scale. Another aspect is the question of whether increasing the scale a company’s scale will indeed result in a stronger hold on consumer-oriented demand: the higher logistics costs must still be able to be met with a profit. A small company is flexible and does not have the same problem with overhead. Let me illustrate: a craftsman who builds customised kitchens in the traditional method is scarcely any more expensive than an industrially manufactured kitchen. Competitive small companies able to respond to market demand and who handily take advantage of the possibilities offered by ICT are currently doing booming business.

Doubt is openly expressed in the literature about mass-customization as to whether the classic instrument of marketing will still work in the future ICT era. After all, marketing is nothing more than searching for similarities between groups of consumers in order to be able to supply specific groups with specific products, In the ICT age, consumer desires are extremely capricious or interactive, as this may also be termed. Consumer preferences have been found to be dynamic and strongly dependent on context. Companies depending on marketing tend to be in the rearguard of new developments. They are better off taking a pro-active stance than seeking alleged similarities between consumers. Why not completely reverse the approach and focus on the differences between consumers. In construction, an instrument offering this possibility is interactive decision-making. I will examine the possibilities of this new market perspective later.

Just one last comment regarding the structure and size of commercial organisations in relation to a demand market. A larger scale, achieved either through forward or retrospective integration is not necessarily the way to offer the client adequate service. The same holds for horizontal integration. In Western Europe, mergers are more common in the supply industry and are less prevalent between actual construction firms. These mergers,- however, often prove to concern financial holdings of operating companies that lead a relatively independent existence rather than tightly managed enterprises. Hence the operating companies would appear to be in the best position to operate profitably in their local market domains and should be given room to operate flexibly.

Next to the formation of financial holdings with relatively independent operating companies, the ICT era also offers opportunities in particular to enterprises in the small and medium-sized business sector. The alternative to a financial holding is voluntary cooperation. Increasingly, references to such occasional collaboration between the construction parties can be found in the literature. This refers in fact to an organisational model that makes competition possible on the one hand (which has a favourable effect on price) and collaboration on the other (which is good for quality). This could be regarded as a paradigm. Why would a company want to collaborate with the competition? The answer is that competitiveness and cooperation occur at different stages of the building process. Besides horizontal integration collaboration involves vertical integration; the error-free transfer of information between the three disciplines of construction supply, execution of construction and construction preparation. The communication between these disciplines is increasingly supported by ICT, which functions as the information carrier. The integration concerns strategic (temporary) alliances between building partners (regarding execution, design and supply) who join forces to provide the necessary expertise to handle one or a series of projects. At the end of the project(s) everyone goes their own way once again.

In ICT terms this could be described as a virtual organisation, which enters into changing alliances and modifies its performance to meet the specific conditions of projects. In fact, this is how the construction industry has always worked. In the west, however, the scale has dipped too far towards segregation and competition. Communication between the parties has become inadequate, leading to failure risks and a multitude of construction defects. By using ICT as a data carrier to improve the communication between the building parties the cooperation between the building partners will also be improved. However, temporary coorporation would not work if the building parties cannot benefit from it. The question is if virtual organisations are able to realize error-free virtual product variants. I propose to show that collaboration between suppliers and construction preparation can lead to excellent results. Let us apply our previous example of the 10^{10} virtual product variants to the building sector.

Suppose a building consists of ten building systems supplied by ten suppliers. Together, the number of possible variants totals 10^{10} virtual building states. The ten suppliers are obliged to maintain only 10 variants. The ten variants must be made possible on each level. This is relatively easily accomplished in construction, where flexible dimensioning is common practice. Take, for example, a building frame with 2 spanning options and 5 for the depth. The producer of façade X and the producer of façade Y adapt their dimensioning and details to these without any problem. In some cases, interfaces are needed in order to make the variants independent of one another. A wiring system with 10 connection options can be realized independently from the building frame by means of a lowered ceiling, matrix floor or double wall system. By splitting up the building in independent components (I call them systems) the building proces on the construction site is not necessarily hampered by late consumer decisions. Hence the huge number of virtual variants of a concept does not have to lead to an uncontrollable growth in the number of connections. Even more to the point: this flexibility is inherent to the building sector, which can deliver a far better performance in this respect than, for example, the automobile sector. However, this latter sector performs better as far as connection technology is concerned. Upgrading in construction will therefore have to be specifically directed at developing more industrialised connection and assembly techniques.

The foregoing is intended to demonstrate that full industrialisation which is aimed at mass-customization does not necessarily need to lead to large-scale enterprises in order to achieve maximum quality control. Such organisations are vulnerable because of the costs of logistic modifications resulting from the changing client demand. The model of the virtual organisation composed of a temporary combination of collaborating companies holds the advantage in that respect: the companies can compete when necessary, but can also work together when the situation demands. In case of coorporation there ought to be a common base: a concept where mutual agreements for the production of the different components is settled. This concept of mutual agreements concerns a set of systems that is brought to the market. Here I arrive to the issue of agile architecture and mass-customization.

Agile architecture and mass-customization

Open building systems

Opposite to open systems is closed systems. The latter refers to a situation with a unique design and a building system that brooks no change. In a closed system, a developer launches the specific type on the market at his own risk. This in contrast to the open building method that aims to offer consumers as much influence as possible during the design phase. Next to the consumers' advantage of being able to choose from a variety of options, open building naturally leads to the individual diversity so commonly lacking in contemporary new housing. As the illustration shows, not only consumers, but also other actors (as a rule, local authorities) can influence the choices to be made. A major difference between the closed and open building methods is that in the former case, consumers are unable to choose between different suppliers. Producers of closed systems neither can nor wish to supply a different bath or kitchen if a consumer should indicate a different preference. An open building process specifically aims to maximise the market scope from which to choose. Everyone can compete, but agreements must be made about the interconnections between building components. It is beyond the scope of this paper to explore the technical possibilities of universal compared to a limited set of connections between building components available on the market[3]. I would like to take a closer look at the structure of the decision-making processes for mass-customization.

- *How can we structure the decision-making process in a more logical fashion for consumers and how can we review plans in the light of their consumer performance?*

In the above, I used an example of a system concept that could generate 10^{10} building variants on the basis of assembly. Imagine a building as a collection of building systems, which are influenced as far as possible by the consumer. As I said earlier, the variants of the different systems should be as independent from each other as possible in order to arrive at a maximum system performance as regards possible variants. Such independence has been achieved if a system can adapt with the help of flexible production automatisation: the options of the one system must not displace the options of the connecting systems. In a concept of this kind, a logical path of choices should be organised for the consumer: the level of the difference decisions. Open building distinguishes:

- The level of the environment (shell) and
- The infill level.

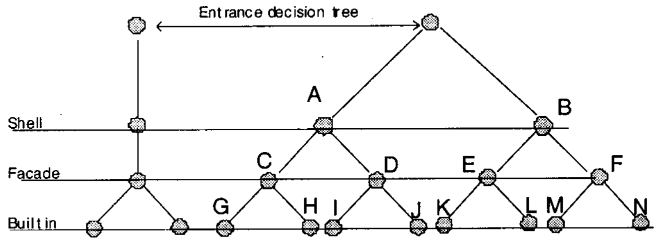
Infill features are entirely the domain of the consumer. Next to the consumer, both the sector of the commissioning authority and the municipal authorities also influence the shell. The above diagram represents a building viewed as a collection of building systems. The decision path runs from the support level to finishing work, while the variants (states) representing the different systems are as independent as possible from each other. A ranking according to priority is given in the below:

- Sys (a)	Support systems:	decision level environment	actors municipality/ consumer
- Sys (b)	Facade / roof systems:	decision level environment	actors:municipality/ consumer
- Sys (c)	Installation systems:	decision level dwelling	actors: consumer.
- Sys(d)	Fit-out systems:	decision level dwelling	actors: consumer.
- Sys (e)	Finishing systems:	decision level dwelling	actors: consumer

The diagram illustrates how variants are stacked by the different sub variants at system level. As the number of variants per system increases, the 'openness' of the plan increases. The performance of a set of building systems can be measured using formulae from information science [4].

The performance of a system variation of a dwelling (Sys perf$_{dwel}$) or of a plan (Sys perf $_{plan}$) stands for the number of system states able to be realised by actors based on previously known options offered by a project developer.

As the number of planning decisions to be made by the consumer grows, the system becomes more specifically tailored to that consumer. The concept of '*state of the system*' refers to the different forms, which are assumed by the system following a choice made by the consumer. Take the following simple example:



A shell is available in widths of 5.4 m and 6m. After the consumer has made his choice, this option is fixed, entering, for example, the state 6m. The top-level options in particular impact strongly on the total number of options open for consumer decisions. If, for example, only one shell is available, one façade + roof, one installation system and two built-in packages, the consumer has two options and will need to make a decision only once (built-in package variant 1 or variant 2). However, if there are two (independent) options on each level, this will yield a total of 8 system states for which he is required to make only 2log 8 = 3 decisions. This can be illustrated in the following simple decision tree.

The above figure is obviously a simplified representation of reality. The trees make it clear, however, that with only a few decisions on the part of the consumer, a great many system states can be generated at the expense of the builder. The system states are namely exponentially related to the number of decisions. This phenomenon also reflects the relations of the market parties (purchaser and contractor). Simple decisions, from the point of view of the consumer, create a high potential of system states for the contractor, with all the corresponding, different connections and failure risks. As I already indicated above, this risk of failure is acutely present if consumer requirements are expected to be realized in retrospect, at the construction site. If, however, the variants and their connections are able to be predicted in advance and to be split up in independent levels, the building sector will perform outstandingly in the area of mass -customization.

> *The building sector should regard the increased number of variants, not as a threat but as a challenge, as the market of the future lies in developing answers in the field of mass-customization. The strength of a consumer plan (and hence its market value) is the minimum number of decisions required to be made by the consumer and the maximum number of variants able to be offered on the part of the producer.*

In my country, concepts are already being developed offering consumers maximum choice. I call these consumer plans. An interesting phenomenon in consumer plans is that the less preference displayed by the choices between system variants, the higher the probability in variation of the final structures realized via these. The greater the variational power generated by a system (number of potential variants and high equiprobability[5]) the greater the chance of realising numerous building variants. There is little point in offering a set of systems able to generate hundreds of building variants, that continually lead to a single preference for the majority of consumers. The equilibrium between competing systems can also be driven by the cost factor. Concepts whose range of variants exhibits a high degree of equiprobability are extremely suitable for introducing diversity into the environment, which also serves a public interest. Finally, a higher equiprobability between systems demands more attention from the consumer and closer supervision for meticulous consideration processes.

Interactivity

In conclusion, a brief note on interactivity. Interactivity is a decision method that can be used to tailor a consumer plan to the individual. As I pointed out in the foregoing, it is wiser to offer the consumer an instrument by which his individual choice can be expressed rather than attempt to assign him to a group for marketing purposes, to which he may well no longer belong next year.

In interactive decision-making in construction, the choice process is made contingent on the environmental context. In this way, a consumer can distinguish himself from his close environment. This natural desire of the consumer is immediately recognizable in the fashion industry. No one wants to wear the same clothes as his neighbour. Uniform clothing is prescribed as a rule in organisations which have a public function and which must therefore be able to be identified by all. This simple principle has not (yet) been absorbed by the building industry. Dwellings in a particular area tend to be identical in appearance. However, there is no strong community bond that justifies this uniformity of appearance. The majority of consumers will seek to underscore their individuality by means of slight differences and will make their decisions on the replacement of parts of their dwelling as independently as possible from the neighbouring dwellings. This desire will benefit the building industry itself in a privatised market: if I decide to replace my tiled roof, I am not required first to consult with the neighbours or even the entire neighbourhood.

Mass-customization can function as the instrument to serve this need for identity, because the splitting up of decision levels allows for a relatively short just in time delivery and fixing of different components. Interactive decision-making causes the individual choice of the consumer to become dependent on what other purchasers may possibly already have decided. If my neighbour chooses a certain brick colour or perhaps a bay window, I can respond by choosing a different brick colour or even a different element from the project developer’s toolbox. Interactivity can be a wholly virtual process. Buyers are known to have difficulties reading drawings and translating 2d drawings to a 3d reality. This can even present problems to architects. A practical solution is the model dwelling, which relieves buyers from the need to visualise their dwelling from the drawing on paper. However, a virtual model, with an almost infinite number of variants far exceeds the feasible number of physical model dwellings. The future lies in economic virtual reality tools, which will allow prospective buyers and renters to walk through their virtual house. Interactivity must be firmly grounded on realistic decisions. The producer must be certain that a consumer will confirm a chosen option. Consumers are offered more differentiation, but on the other hand must surrender their freedom from commitment.

Interactive decision-making is not only suitable for detached homes, but also for row houses or multi-family dwellings. Obviously, each category sets limits of its own on the possibilities of interactivity. The instrument reinforces the probability of varied choices of the consumer. I would like to close with the following proposition from my dissertation:

> *Proposition Interactivity*
> *The variational power of a concept is vigorously boosted by making the consumers' decision-making dependent on the environmental context (inteactivity). The number of options able to be made available to the consumers via interactive decision-making increases the more independent the options of the constituent building systems of a dwelling or residential building are from one another.*

A brief elucidation:
The proposition states in the first place that the consumer-oriented performance of a consumer plan becomes increasingly powerful the more dependent the decisions of the (individual) consumers have been made on the environmental context. In the light of the behaviour of consumers in the fashion industry, so much at least is obvious. The consumer is offered the possibility of making a different choice from his neighbour.
The second part of the proposition indicates that a high interactive performance can be accomplished by ensuring that the various system options of building systems are independent from one another. In other words, in order to realize a highly consumer-oriented performance, the recipe is as follows:

- Make consumer decisions as dependent as possible on the direct environmental context
- Make system options of the constituent building systems as independent as possible from one another.

---

3 An entrepreneur can decide to have the connection to other building components depend on the market opportunities. In many cases, making arrangements via E-commerce increases the action radius of building systems.
4 The openness of a system can be described per level with the help of the classic formula used in information science
$I = K \log n_i$,
in which n is the number of possible states of a system per level i . In information science, I is a quantity indicating the information value of the system, 'n' stands for the number of system states; K is a constant that remains to be determined and that is related to the number of branches of the decision tree. In the case of a choice between 2 options at level i : $I = {}^2\log n_i$.
5 I have used the term equiprobability in this context in the sense that the options offered must all have virtually the same chance of being selected by the consumer.

The building envelope - last barrier in Agile Architecture

Leo G.W. Verhoef (assoc. prof.)
Delft University of Technology
Faculty of Architecture
Department of Restoration, Renovation and Redesign
Berlageweg 1 (room 6.01)
2628 CR Delft
Tel: +31 (0)15 - 278 4179
Fax: +31 (0)15 - 278 4178
Email: lg.w.verhoef@bk.tudelft.nl

The building envelope - last barrier in Agile Architecture

ABSTRACT

In the last 100 years mayor developments took place in residential buildings. The most striking the amount of square meters per person which increased from 4 till 40.

In addition to the developments in residential building, there have been many demographic changes; such as fewer children per family, fewer one and two-parent families, increased life span and greater financial capacity. These changes are expressed in other requirements, with the general desire for different types of housing, larger rooms, greater luxury and increased comfort. Therefore it is necessary to adapt houses to meet these demands and up to the present, the shell of the building has been seen as the boundary within which alterations can be made. To some extent, this is understandable because the original new houses were suited to their purpose and they were kept in good repair by maintenance. Because over the years, there have been great changes in the demands and regulations have been added relating to energy, noise, social safety and sustainable building, maintenance measures are no longer adequate and renovation and even stronger redesign must be carried out (figure 1)

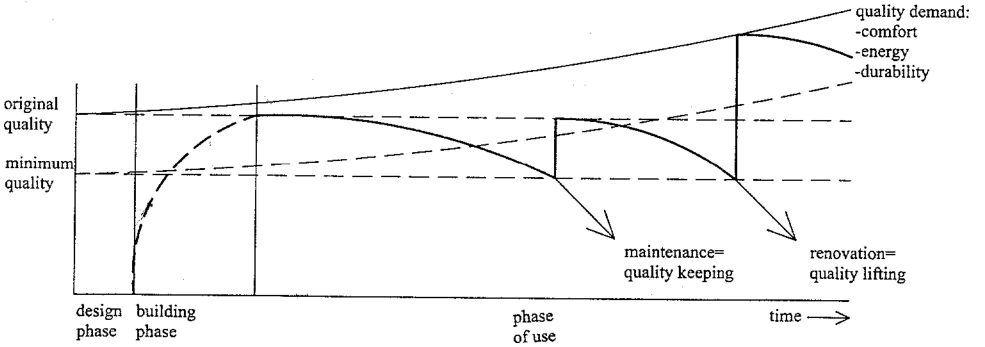


Figure 1:

From the maintenance period, we have learnt that it is the shell itself that affects the cost of maintaining the building. For this reason, it is no longer logical to see the shell as the boundary within which changes can be made. Indeed, from now on it must be a condition that the integral costs and yields can be related to the changed model, which permits alterations to be made within the shell and extensions beyond the present limits of the shell.

From the 1970, the renovation of dwellings and more especially entire residential neighbourhood came into prominence. A characteristic renovation technique was to combine dwelling units and in this way to increase their size. Within the shell of the building, three adjacent units could be converted into two dwellings. The costs of this exercise were limited but there were only two tenants to pay them in place of three and the total cost of the renovations must be divided over two dwellings. By adding the desired extra living space outside original building volume it is possible to keep every dwelling unit intact, the total cost is spread over three units and there are three tenants. The calculations for a project show that in comparison to the combination of dwelling units, .the extension of the shell by placing the necessary new facade brings lower costs and higher incomes per unit.

In the proceeding possible changes on a basis of redesign for the so-called non-traditional buildings will be given to reach an economic life time closer to the technical life time as one of the mayor profits for the environment.

The building envelope - last barrier in Agile Architecture

Leo G.W. Verhoef

Common points

In themselves, buildings may still be functionally satisfactory, but there are external factors, such as the dullness of the image that they summon up or their poor technical quality that require that attention should be paid to the shell of the building. There are many reasons why buildings may no longer be adequate. Failure to satisfy current demands may be expressed in lack of occupancy and further deterioration of the neighbourhood. This establishes a vicious circle, which can and must be broken. All too quickly discussions turn to demolition and new development, without first an investigation of the reasons for the situation. From an economic point of view, renovation and the reuse of buildings, taking into consideration the technical and spatial functions and also the architectural aspects often appears to provide a better solution.
There are elements in the building stock that the countries in Europe have in common, such as:

- Most of the buildings in Europe were completed after 1950. For a country like the Netherlands this means 75% of the existing buildings.
- The maintenance costs are mainly incurred in urban building envelopes,
- The renovation of buildings and reconstruction to provide an improved or different range of use will influence the building envelope,
- The quality of the building envelope very often fails to fulfil current demands and will certainly not meet future demands.

An important conclusion deriving from the ‘common points’ mentioned above is that however important maintenance may be, it does not lead to a higher quality of urban building envelopes that is desired. Improvement of the quality of urban building envelopes must be the real task. Of course, this improvement will incorporate the necessity for maintenance. Such an improvement requires the development of new and suitable strategies for local authorities, housing corporations and owners on one hand, and for architects and civil engineers on the other hand.

Until now engineering aspects on an integrated scale have been disregarded in this process. In many European countries new technologies have been developed, but these have either not yet been translated into practice, or have been only locally used to achieve a higher quality in urban buildings. This results in a limited impact on urban environments. Therefor it is essential to bring all kind of local solutions together, to learn from it and to come to a more general approach that can be used for building systems. Often problems and their solutions are approached in isolation. The wish to improve the quality of an individual building envelope usually leads to a local, project-based solution. Solving the specific problems of this renovation-project becomes the sole target. To reach maximum value for money, it is essential to integrate all the factors influencing urban building envelopes and look at it in a broader scope.

The main factors involved are:
1. Quantitative technical demands;
2. Qualitative aspects;
3. Social aspects;
4. Safety aspects;
5. Environmental aspects, including energy use;
6. Aspects relating to sustainability;
7. Modifications in the use of the building.

Two general movements to change the way of thinking and have to lead to an integral approach are:
1. The resolution of the UN: Dwellings have to be designed in such a way that they are a part of the ecological, social, cultural and financial sustainable society.

   This sentence has to count also for redesign and renovation, what is basically new.

2. The SUREURO project with the target to develop methods and means for the renovation of determined housing areas in Europe; until now no real improvements can be found for improvement of urban building envelopes.

Blocks of gallery flats

For all type of buildings the change of the ‘envelope’ will be a future renovation task. In this paper the attention will be directed to gallery flats. Blocks of gallery flats constructed by using the in situ concrete system have been built in large numbers in The Netherlands and throughout Europe. Such a block has been chosen to provide an example of making changes within the shell of the building and by changing the shell of the building to demonstrate the ideas mentioned above. The area between the buildings is usually large because the residential development was designed on the basis of the garden city idea that was associated with ‘the modern movement’.

In the flats chosen as demonstration model, the in situ poured concrete walls provide the stability of the building in both transverse and longitudinal directions, while the cantilever beams often made of prefabricated concrete are bearing the gallery slabs.

Figure 2: Existing situation before renovation

Very generally stated, the problems of the existing blocks of gallery flats arise from:

- The massiveness and uniformity of the blocks of gallery flats, which lack human scale;
- The lack of social control so that in and around the flats there is more criminality than near other types of dwelling;
- An extreme form of uniformity so that even from a short distance ones own dwelling cannot be identified;
- In consequence of this, the residents are not proud of their home and vandalism is accepted;
- Passages through the flats are dark and narrow, which create an atmosphere of danger;
- No clear area of transition between private and public area so that the private area starts behind the front door and little attention is paid to the public area;
- The plans of the dwellings, with bearing partition walls that do not permit the flexibility that is needed for changes to meet the new wishes.

In the chosen example, an attempt is made to achieve presence human scale by leaving out the gallery on the first floor. By making this constriction, a different zone is provided on two storeys that can serve to create human scale. The disadvantage of this solution is that the lack of supervision in this area provides opportunities for undesirable activities to take place precisely the zone where there is no possibility for social control from the galleries. To solve this problem it is necessary to make changes. Social safety, especially at the ground floor level, can be improved by including dwellings at this level. The residents then acquire the function of become the 'social eyes', which leads to a reduction in criminality. There is people's behavior is under social observation.

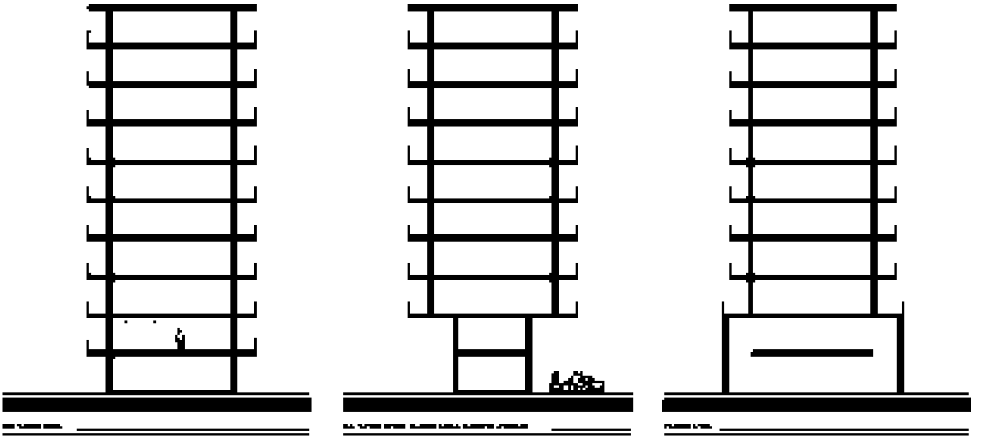


Figure 3: Social safety at the ground floor level

Figure 4:
Top: Original design and new situation (F. Verheyen, executed) of the “hoogoord flat”
Bottom: Original design and proposed new situation for the Bijlmer (ANA-architecten)

Having dwellings on the ground floor, while at the same time maintaining the storage space of the residents in the flats on the upper floors requires extra space. The most obvious solution is to let the two lowest storeys project beyond the walkways.
From the technical point of view, there are two options for this:
- The independent construction of the new extensions on their own foundations. This solution is simple but attention must be paid to possible pipelines lying in front of the flat. The extensions add so little load on the subsoil that a shallow foundation suffices for them. If the subsoil has little bearing capacity, as is usually the case in the west of the Netherlands, the extension must be constructed on piles. The changes in the concrete structure involve the removal of the galleries and balconies on the second storey and replacing them by a concrete floor with insulation and a finishing layer
- The suspension of the extension from the bearing walls. In this case, no extra piles are needed. The reinforcements of the consoles that support the galleries can be retained and taken up in the new extension of the walls.

By suspending walls on the existing construction, there is an important increase in the range of options. The forces that must be taken into account are shear forces along the old concrete, which create relatively small stressed, and the tensile forces and compression forces to transfer moments from the newly added part to the existing concrete. The tensile force that needs to be taken up is equally small, despite the relatively large mass of the extensions.
The present constriction is the same width as the galleries, which are usually very narrow. With a few exceptions, they vary between 1.35m and approx. 1.5 m. wide. If a relatively wide extension is desired, for example up to 3 meters we must investigate whether the assumption that the forces and stresses remain relatively small, is true.

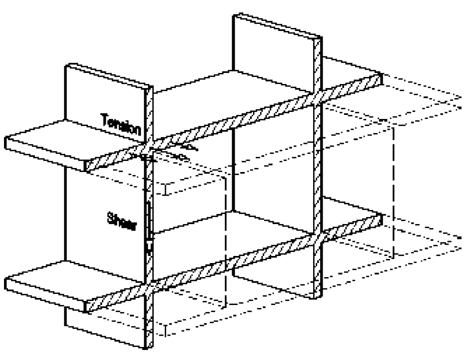


Figure 5: Extension in existing concrete structure

The suspension option for the extension of the ground floor causes the greatest loading that we can imagine. If the extension continues to a greater height on the facade surface, the loading and the moment per unit area will decrease.
These tensile forces can be transferred to the existing bearing construction in two ways. It can be concentrated, with only joints such as long or short adhesion anchors in the walls or

spread, in which case part of the tensile force is transferred via the floors.

Naturally, the additional load on the foundation system must also be taken into account. In view of the stiffness of the walls the so-called calculable value of the additional loading, if it is suspended symmetrically on the building must be equally distributed over all the piles, a load this type of building can support that up.

For placing dwellings on the ground floor, the suspension of walls on the existing structure provides a valuable addition to the range of possible options. Nevertheless, other possible means of doing this such as the addition of piles and the independent construction of the extension. The financial aspect determines whether the addition of piles or the drilling in of anchors is more economical.

If on the other hand, we want to make extensions on the higher floors, we shall quickly come to the choice of suspension as the most direct manner of transmitting forces. In principle, the walkways are a type of suspended structure. The only change is the increase in the shear force and the moment.

Change of galleries

Galleries are often draughty and poor options for private use since they mainly serve as walkways for people who want to reach their homes. For greater privacy, to prevent people from walking very close to the windows of the flats there are three possible variations for the widening of walkways. The first is to make a big inside corridor behind the new facade, which always provides access for three flats. An example of this has been executed as ‘new building’ in the residential building “DWL of the architect Pi de Bruyn, in Rotterdam. Every third floor is extended out to the facade. The part above this is a space extending over two storeys that can be considered as a semi-private area. Because the kitchens look out over this private area, permanent social control is possible so the flats can be considered safe. From the point of view of construction, it is very easy to find solutions and is fully in accordance with the approach to extension at ground floor level.

A second variant assumes that only some of the flats are extended, together with the addition of a lift. In this case, vertical divisions are created to counterbalance the strongly horizontal character. In consequence, the appearance of the block of flats is greatly changed. Part of the gallery disappears, so the access system is one with porches. It is now possible to recognize ones own home from street level. The extra lifts make this option very expensive.
If a different method is chosen to construct the extension, the extra lifts are not required. The second escape route must then be via the balconies on the rear side of the building the existing staircase must be adapted in such a way that the stairs run from floor to floor.

Figure 6: Internal view (DWL, Pi de Bruyn

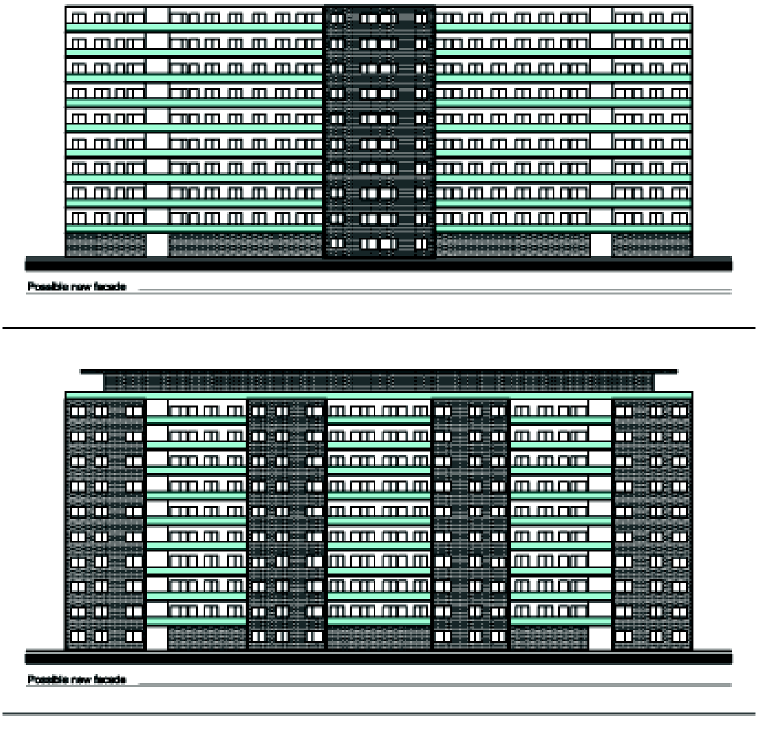


Figure 7: Two possible solutions with change of facade

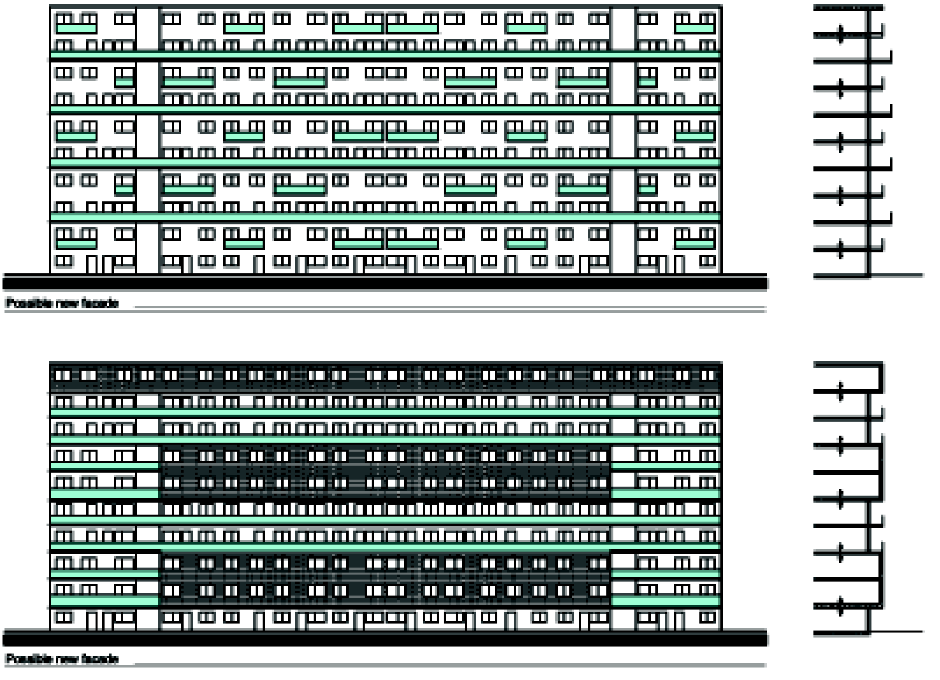


Figure 8: Making maisonettes

A third variant widens the galleries on every second floor. The dwellings become maisonettes. The bedrooms continue under the extension and are thus less exposed to direct sunlight, which in any case is not desired there. By building an extension on the access part, a semi-private area can be created. Because the in situ concrete part of the wall is much higher than the original consoles, the upper reinforcement of the console can be used for the new wall. Extra anchors and the roughening of the walls are necessary to ensure good joints. Here too consideration can be given to letting the tensile force be transmitted not only through the walls but also via the floors. The monotony of the block of flats is now clearly broken up and these measures have given it a stronger character. Maisonettes can contribute to the desired variation in the types of dwelling available and naturally, that such a solution need not necessarily be used for the entire building.

It is necessary to make holes in the floors, raising the question of whether the remaining part of the floor can function with the reinforcement that is in it. If that is not the case, the addition of reinforcement by using adhesive bonding is an obvious option.

4. Postscript

From this paper it appears that to date there are still untried ways to adapt concrete structures to meet the desire for new uses. Naturally there are also impediments or extra points that need attention. Walls that were added later without reinforcement form such an impediment. It may then be necessary to reinforce these walls at a later date by using bonded laminates of steel or other material. Probably it is easier to make the tension connections directly with the floor elements next to the wall, although the wall must still bear the shear forces. Some further research into this is certainly needed, because owing to the variation in deformation between the old floor and the new one, some shear forces will also have to be borne by the floor. Apparent impediments can thus be removed. Extra attention must be paid to the shrinkage of the new concrete. It may be assumed that the existing construction is worked-out in terms of shrinkage and creep, so temperature and humidity deformation can be neglected since the construction is subject to inside climatic conditions. The fresh new concrete will shrink and creep owing to hardening and time effects. Two alternatives are needed for this. The first is to provide the new walls with finely distributed shrinkage mesh reinforcement in such a way, that cracks remain small. The second is to use a so-called ‘shrinkage reduced high performance concrete’ so that the maximum degree of shortening remains as small as possible.

The implication of IFD from international perspectives

Tomonari Yashiro
Professor, Institute of Industrial Science, University of Tokyo
4-6-1 Komaba Meguro Tokyo 153-8505, JAPAN
tel: 81-3-5452-6400 fax: 81-3-5452-6402
yashiro@iis.u-tokyo.ac.jp http://www.iis.u-tokyo.ac.jp/~yashiro

The implication of IFD projects from international perspective

ABSTRACT
The author had the chance to visit the example of IFD project in the Netherlands and found similarities and uniqueness of the project from international perspective. The paper discusses the implication of IFD project in international context, by comparing with the situation and the related projects in UK and in Japan. IFD has two outstanding points from international perspective.
The first outstanding point is the combination of paradigm of 'demountable' combined with that of 'industrial' and 'flexible. In UK and in Japan, the combination of paradigm of 'industrial' and 'flexible' is getting major status in R&D project for developing innovative housing, though both countries have different historical background. In Japan, 'demountable' building R&D project is also undergoing. However, at the time of writing, there is no R&D project in both countries to combine 'demountable' with 'industrial' and 'flexible explicitly. By reviewing those related projects in UK and in Japan, the paper discusses how IFD project hit the point in the context of growing concern to sustainable built environment in post-industrial society.
The second outstanding point is the methodology of encouraging technology development. The paper focuses on the discussion why IFD project could stimulate such a various kinds of technological developments in relatively small size domestic housing market in the Netherlands. By comparison with R&D projects in UK and in Japan, the paper points out that IFD project generate effective incentive of technology development to suppliers and clients by less-specific requirements and method of giving financial incentive.
In concluding comments, the paper lists lessons of IFD project from international perspective.

KEY WORDS; IFD, open building, flexibility, demount-ability, performance based, industrial ecology

The implication of IFD from international perspectives

Tomonari Yashiro

Introduction

Building related economic activities occupy some 50 % of material resource use in developed countries (OECD 2000). Respecting on that fact, open building approach is quite significant in the sense that natural resource input into ‘support’ (=base building) are well conserved for longer duration of time than ‘ordinary’ building with poor adaptability performance. However, it needs to be reminded that open building has a nature of double side effects; if the frequently replaced infills are disposed away without, or with low degree of, reuse and recycling, total ‘consumption’ of natural resource in life cycle basis could be increased than ‘ordinary’ building. To restrict resource consumptive nature, there is a need to facilitate to reuse the replaced infill components Weng, 2000.
To enhance reusability of elements, building elements needs to be easily demounted. However, generic building methods today apply complicatedly mixed composition of different kind of materials to comply with users’ requirement. In another word, contemporary building methods are filled with ‘spaghetti’ compositions. There is a need of fundamental innovation of building methods to improve resource productivity in building related activities.
In this context, IFD project, demonstration program in the Netherlands, involves significant lessons as a pioneering attempt to enhance demount-ability of building. It is quite suggestive to exchange knowledge and lessons at the meeting opportunity of international circle. In order to facilitate global scale discussion among building professions and agents in building related industry, this brief note tries to offer outsiders’ aspects to identify the implication of IFD from international perspective.

Implication 1: Design for Environment (DFE)

In manufacturing industry, new paradigms of product design are emerging; These are called as Design for Environment (DFE) and/or Design for X (DFX). Here X represents several related terms such as disassembly, recycling, remanufacturing and environment. Thus, DFX includes the idea of design for disassembly, design for recycling, design for remanufacturing and design for environment, The design of major industrial products like automobile, electronic equipment’s, photocopy machines and furniture’s are being dramatically changed based on the principle of DFE/DFX.
Design of buildings as assembly of industrial products is inevitably affected by these paradigms shift of products’ design. However, partial changes of elemental products do not assure considerable improvement of the performance of DFE/DFX in building methods. It needs the comprehensive and integrated innovation of building system.

IFD project, especially the type of short cyclic real estate, is the attempt to realise the idea of DFE/ DFX by comprehensive and integrated innovation of building system.
Not like the age when industrial product are perceived to be far from individual customisation because of the constrain by mass production, recently many building professions believe that 'industrial' and 'flexible' lie on the same vector rather than opposite directed vector. For instance, in UK and in Japan, several 'industrial and flexible' projects are undergoing; The situation in UK can be overviewed at the web site of the housing innovation site (http://www.rethinkinghousebuilding.org/). As it is already reported, various open building projects are undergoing in Japan (such as http://www.openkugahara.com/). These projects certainly demonstrate breakthrough that 'industrial' methods provide potential to realise highly degree of 'flexibility'.
However, only combination of 'industrial' and 'flexible' tend to focus its scope onto the initial production stage from design, construction to hand over, while there is a need of whole life cycle based approach. Addition of the word of 'demountable' to 'industrial' and 'flexible' promote to extend the scope to whole life cycle; improved demount-ability enhance the life cycle based flexibility of building.
Hence the implication of IFD from international perspective is that it is a pioneering attempts where governmental body in developed country take initiative to facilitate the integration of the idea of 'demountable' with that of 'industrial' and 'flexible'. In another word, IFD is primary attempts to demonstrate DFE/DFX principle in industrialised building system.

Implication 2: Encouragement through performance based criteria

Pilot/experimental projects led by governmental or public bodies tend to set precise and detailed technological requirements in order to assure certain achievement. However, precise and detailed setting of requirements often could be obstacle factors against creative and innovative invention, and could lead to less-innovative achievement by restricting realisation of various solutions.
It is notable that various technological solutions are proposed through IFD project by introduction of performance based requirements. Respecting on the scale of building market in the Netherlands, the number of varieties of proposals are surprising.
Though the amount of subsidies offered to successful clients whose newly constructed buildings are approved to comply with IFD requirements is certainly one of significant driving forces, the authors has the impression from interviews to building professions involved in IFD project that the most effective driving force to facilitate architects' trials for various technological proposals in their housing projects is less-tight requirements defined by performance based criteria.
In addition, it seems to be also significant that the Dutch architectural education involves building technology modules. These educational backgrounds enable Dutch architects to manage issues relating to design-production interface that is essential area to prepare technological solutions to meet with performance based criteria.
As Steven Groak noted, innovation of building is generated through project based activities (Groak 1994). Feasible technological solutions that meet with 'industrial', 'flexible' and

‘demountable’ performance criteria can be invented through specific context of actual project.

The implication from international perspective can be summarised that IFD is a good example where various solutions are generated by encouraging project based innovation through performance based criteria.

The next step: Promotion of industrial ecology

IFD created various examples of ‘industrial’, ‘flexible’ and ‘demountable’ buildings. Though these realised buildings represent pioneering achievement, it needs to be noted that these building only have better potential performance of ‘flexible’ and ‘demountable’ over their life cycle. In another word, beyond IFD project, there is a need to prepare driving force to facilitate continuous customisation by utilising better ‘flexible’ and ‘demountable’ performance.

Generally contractual relationship between suppliers and users terminates at the stage of hand over of buildings. There are poor contractual incentives for industrial sectors to commit in the process of continuous customisation to comply with ever changing user’s need. Thus, to utilise better ‘flexible’ and ‘demountable’ performance, there is a need to create incentives that facilitate industrial sectors’ commitment into the individual process of continuous customisation.

In addition, though technological solutions by IFD projects provide potential for reutilization of components and/or material resources, probability of reutilization is affected by inter-firm and/or inter-industrial reverse supply chain of demounted components and materials. Without feasible reverse supply chain, potential of demount-ability of building by IFD project can not realise better resource productivity.

Needs of continuous commitment by industrial sectors and need of feasible reverse supply chain indicate the need of fundamental restructuring of building related industry. It can be termed as ‘industrial ecology in building related sectors’. The author already presented the scenario to promote industrial ecology in building related sectors; it is a restructuring of building related industry from product provider to service provider (Yashiro, 2000a and 2000b, Yashiro, 2001). It is expected open building implementation has a rightful position in the movement of industrial ecology.

Concluding comments

From international perspective, IFD project provides valuable lessons.

First, IFD demonstrates feasibility and potential benefit to combine the idea of ‘industrial’ ‘flexible’ and ‘demountable’. Special emphasis should be put on the significance of demount-ability in the sense that it enhances whole life cycle based approach.

Second, IFD indicates the way to stimulate various technology developments by ‘loose’ requirements with performance based criteria. It needs to be noted that the simplicity of approval procedure and educational background of Dutch architects enhanced the integration of design-production interface to create various technological solutions to comply with the requirements.

Third, in order to enjoy the benefit of achievements of IFD projects, there is a need of restructuring of building related industry that enables life cycle based commitment for continuous customisation as well as that promote the establishment of inter-industrial reverse supply chain.

These lessons are expected to be considered to create driving force for open building implementation in specific contexts in different countries.

Acknowledgement

Mr. Hans Vingerling at SBR kindly provide worthful information and introduced potential people who are involved in IFD project. Mr. Vries Robbe at Stcicil kindly guided the site visit of steel house project (Smart House project) in Zoetermeer. Without their kind arrangement, the author could not have knowledge about IFD project.

References

OECD, (2000) Achieving sustainability and energy efficiency in buildings, OECD/IEA Joint Workshop, 2-3 November 1999, ENV/EPOC/PPC(2000)3/PART1

Weng, C., and Yashiro, T. (2000), The Benefit of Open Building System to Recycled Use of Resources, pp207-pp212, Proceedings of CIB W104 Open Building symposium in Tokyo ‘Continuous customization in housing’

Hendriks, N., and Vingerling H., (2000), Industrial flexible and dismantable (IFD) building technology: a key to sustainable construction,_Proceedings of the RILEM/CIB/ISO International Symposium, Integrated Life-Cycle Design of Materials and Structures ILCDES

Groak, S.,(1994) Is construction an industry? Notes towards a greater analytics emphasis on external linkages, Construction Management and Economics, vol.12 pp287-pp293, 1994

Yashiro, T. (2000a) Construction sectors as ‘service providers’, Alternative business model for sustainable construction, Proceedings of CIB W55/65/82 TG23 joint meeting, Univ. of Reading

Yashiro, T. (2000b) From product provider to service provider - Relevant industrial change for sustainable building implementation, Proceedings of international conference sustainable building 2000, 22-25 October 2000, Maastricht, The Netherlands, Aeneas Technical publishers (ISBN: 90-75365-36-5), pp79-81

Yashiro, T. (2001), Incentive for industrial ecology in building sector, contribution paper to the workshops of ‘OECD and IEA Joint workshop The design of sustainable building policies’ in Paris on 29-30 June 2001

Development of Infill Remodeling Technology of Condominiums

Kenji YOKOYAMA
Senior Manager, Tokyo Gas Co., Ltd.
3-13-1, Minami-Senjyu, Arakawa-ku, Tokyo 116-0003, Japan
Tatsuo OKA Professor, Utsunomiya University
2753 Ishii-cho, Utsunomiya city, Tochigi-Prefecture 321-0912, Japan

Development of Infill Remodeling Technology of Condominiums

ABSTRACT

Tokyo Gas started the total remodeling business for existing condominiums based on the following technological development: systemization of infill structural components, integration of work types, and reorganization of process planning. Since the business began in January 2000, we have received 38 orders as of August 2001. The average order is for \9,500,000 (us$80,000) and construction takes about 1 month. In this report, we discuss the condominium remodeling market in Japan, expected to expand; the status of infill technology Tokyo Gas has been developing; analysis of shortened construction terms; and evaluations by customers.

Development of Infill Remodeling Technology of Condominiums

Kenji YOKOYAMA

Condominium market in Japan

The postwar housing policy of Japan focused on quantity rather than quality. The housing and land statistical survey of 1973 first showed that the total number of houses exceeded the total number of households. The number of houses continued to increase. In 1998, the total number of houses (50,250,000) is larger than the total number of households (44,360,000) by 5,890,000, indicating a shift from new housing construction in compensation for the quantitative disadvantage to constructing high-quality housing from existing housing.

For condominiums, 100,000 or more units built for sale have been constructed every year since 1979; the total was 3,519,000 in 1998. About one-fourth were more than 20 years old; the number of units more than 20 years old exceed 100,000 every year only in condominiums built for sale. To cope with the increasing number of old condominiums including rental condominiums, the Urban Development Corporation started the remodeling project for totally remodeling about 560,000 rental houses supplied between 1955 and 1980. Tokyo Metropolitan Government and many other local governments have started or discussed remodeling to improve the quality of existing housing.

Private enterprises of many types of industry have started various remodeling businesses, so this market is expected to expand in the near future.

Application of infill technology for existing condominiums

Background

Tokyo Gas has been developing the infill system suited to comfortable housing conditions, including facilities and interior structures. Tokyo Gas, a gas company, has been developing the infill system for the following reasons:

First, changes in housing inevitably entail changes in facilities. Constructing skeleton-infill condominiums (open buildings) has been vigorously discussed in Japan. In the infill system, “facilities” serve as the basic lifeline and as part of housing providing comfort and convenience. Changes in the construction of housing and housing production and provision will naturally lead to changes in facilities and it is important that Tokyo Gas, which provides facilities, examine the future of facilities in the infill system.

Second, we are developing the infill system, including interior structures because, while facilities play an important role in housing, they should do so without being obvious. Integrating them as part of interior structures promotes better spatial design, cost, and construction.

Third, infill technology is expected to serve as renewal technology for existing condominiums. In the Tokyo metropolitan area, the number of condominiums 20 years old or older is increasing rapidly. According to a survey by the Ministry of Land, Infrastructure and Transport of Japan, the percentage of condominium residents wanting to continue living in the same condominium in 1998 exceeded that in 1993 by 8 points, indicating those wanting to live permanently in condominiums is increasing. This further points to the need for large-scale remodeling of existing condominiums. For realizing comfortable living environment, it is important to increase the facility of these condominiums to that of newly built.

For 20 years, Tokyo Gas has been remodeling detached dwellings, centering on bathrooms, kitchens, etc., where water is used. In 2000, the number of orders was more than 1,300 and total orders \2 billions (us$17 millions). Tokyo Gas started total remodeling business of condominiums in 2000 using its proprietary infill technology. Here, "total remodeling," means that the existing infill (interior and facilities) is removed completely and new infill is installed inside the existing skeleton. The number of orders received so far is 38; the average order is \9,500,000 (us$80,000) per condominium.

Significance of total remodeling

The significance and advantages of totally remodeling existing condominiums are as shown below.

(1) Advantages for residents

It is possible to change the layout according to the life style and life stage.

Many condominium residents lives in condominiums the layout was designed and determined by the developers. Many layouts do not match the life style and life stage of individual families sufficiently. In many cases, they endure such layouts or purchase another condominium to cope with the change of their life stile or life stage. Now there is an increasing need for changing the layout according to life style by total remodeling.

It is possible to replace old piping, etc.

Piping for water supply, hot-water supply, and drainage is often laid under the floor. In condominiums 20 to 30 years old, problems such as water leakage occur due to outdated piping. Such piping can be replaced by removing all existing interior structures and total remodeling. Replacing old piping with resin piping ensures durability of several decades.

(2) Advantages for construction contractors

Improved profits

Housing remodeling market is crowded with competitors from small-scale building contractors to large-scale remodeling companies and the competition is increasing; they try to keep orders as low-priced while meeting customer needs. The profit is therefore low in spite of the time-consuming nature of the work. Total remodeling entails a large order volume, which enables construction contractors to make better profits.

Promising market

As stated above, the number of condominiums in the Tokyo metropolitan area is expected to increase. Because of the resulting increase in the number of old condominiums and of residents wanting to live permanently in condominiums, the condominium remodeling market will grow to be a more promising market.

(3) Social meaning

Remodeling old condominiums contributes to the society in terms of “Resource saving” through using housing for a long time and “Residential environment” to prevent slumism. For public rental housing provided by the Urban Development Corporation, local governments, etc., the remodeling of 30- to 40-year-old housing was started due to societal considerations.

Application of infill technology

Tokyo Gas has been making technological developments such as systemization of infill structural components and the simplification of construction work. By applying these technologies to total remodeling of existing condominiums, it becomes possible to remove the infill of which variable and renewable properties are required while retaining the skeleton that has durability and remaining value. This enables infill renewal based on social (changes in family composition, etc.) and functional (livability, etc.) requests that change with the age of housing. In construction work, this system provides advantages such as shortened construction term, cost reduction, and reduced construction noise compared to conventional remodeling. Construction contractors can expect improved profits through cost reduction.

Overview of infill technology

Systemization of infill structural components

In conventional remodeling, specialists work on structural components on site and make the infill. In this system, the percentage of prefabricated components is made as high as possible, simplifying construction work on site. The standardization of structural components into modules and the commonalization of construction (installation) have improved installation versatility.

Panels with prefabricated framing and base sheets have been developed for the wall and ceiling system. The base construction is expandable and contractible to cope with existing skeleton dimensions. This has lightened the processing workload on site, increased work efficiency of the interior finishing and reduced construction noise and waste.

The floor system has base unit into which resin pipes for floor heating is integrated, which enables simultaneous floor and floor heating construction.

The water and hot-water supply piping, electric wiring, etc. are unitized at the factory according to the remodeling plan. On site, installation is easily completed by supporting and fixing.

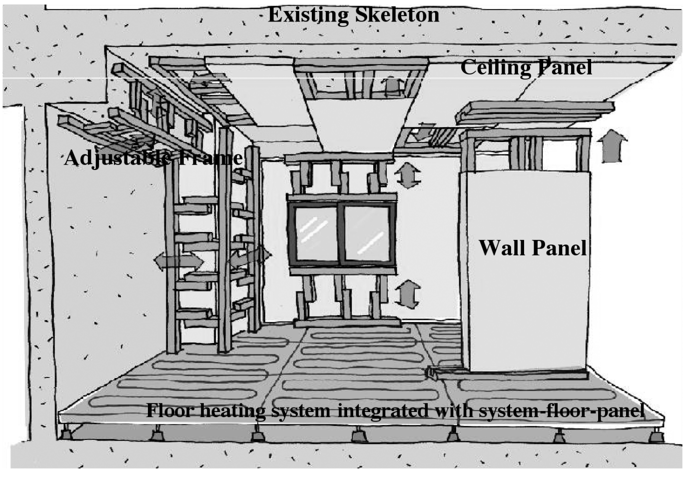


Fig.1 Interior system — modular ceiling, wall, floor and furnishings

Construction work by multi-skilled workers

Some 15 to 20 specialized skills are required for total remodeling condominiums. Because some are conducted in a narrow workspace, time may be wasted in coordination between different work and processes. Using multi-skilled workers means integrating work to streamline construction. It is relatively easy to integrate water and hot-water work and gas fitting conducted using similar skill, but may be difficult to master conventional construction methods. For consistent construction work by multi-skilled workers, it is important to develop simplified constructing technology through the above systemization of infill structural components.

Reorganization of construction processes

Subject to systemization of infill structural components and construction work by multi-skilled workers, we have arranged complicated construction processes as shown below, simplifying interfaces between work types and sections.

Infrastructure work

Facility work for water and hot water supply and drainage, gas supply, power supply, ducting, etc., is defined as residential infrastructure work and conducted together during the first several days of the process schedule.

Infill interior finish work

Interior finish work for the floor base, partition wall, and ceiling, etc. is conducted consistently after infrastructure work.

Housing equipment unit work

In the last phase of the process schedule, kitchen, washing and dressing stand, furniture, etc. are installed together.

Streamlining of construction through infill technology

Through systemization of infill structural components, the integration of work using multi-skilled workers and reorganization of process planning, we have succeeded in construction work for 18 actual working days using the process in Fig. 2. Formerly, it took 1.5 to 2 months for similar work, now completed within 1 month including days for removing the interior structures and holidays. The average construction term of the 38 cases ordered so far (as of August 2001) is just 1 month. (Complete construction work by multi-skilled workers has not been actually conducted.) The prefabricated ceiling, wall and floor are effective in reducing the construction term.

Evaluations by residents (total remodeling)

We conducted surveys in questionnaires and interviews with condominium residents having total or large-scale remodeling. The questionnaire was conducted with 50 persons. Eight were interviewed in detail for about 2 hours. Main points are given below.

(1) Motive for remodeling

- Remodeling was urgently needed to cope with changes in behavior in the growth of the family.
- The used condominium purchased was remodeled before the resident moved in.
- The condominium was remodeled because it had not been repaired in 20 years and was dilapidated and dirty.
- The condominium was remodeled because serious trouble was caused by water-related facilities in the kitchen, bathroom, etc.

(2) Reason for remodeling instead of getting new housing

- Location

  The location is near the center of the city and therefore convenient.

  The resident has lived there for a long time and has many neighborhood friends.

  The parents of the resident live in the neighborhood.

Consistent construction work under the system using a small number of jobs

Itemize of work

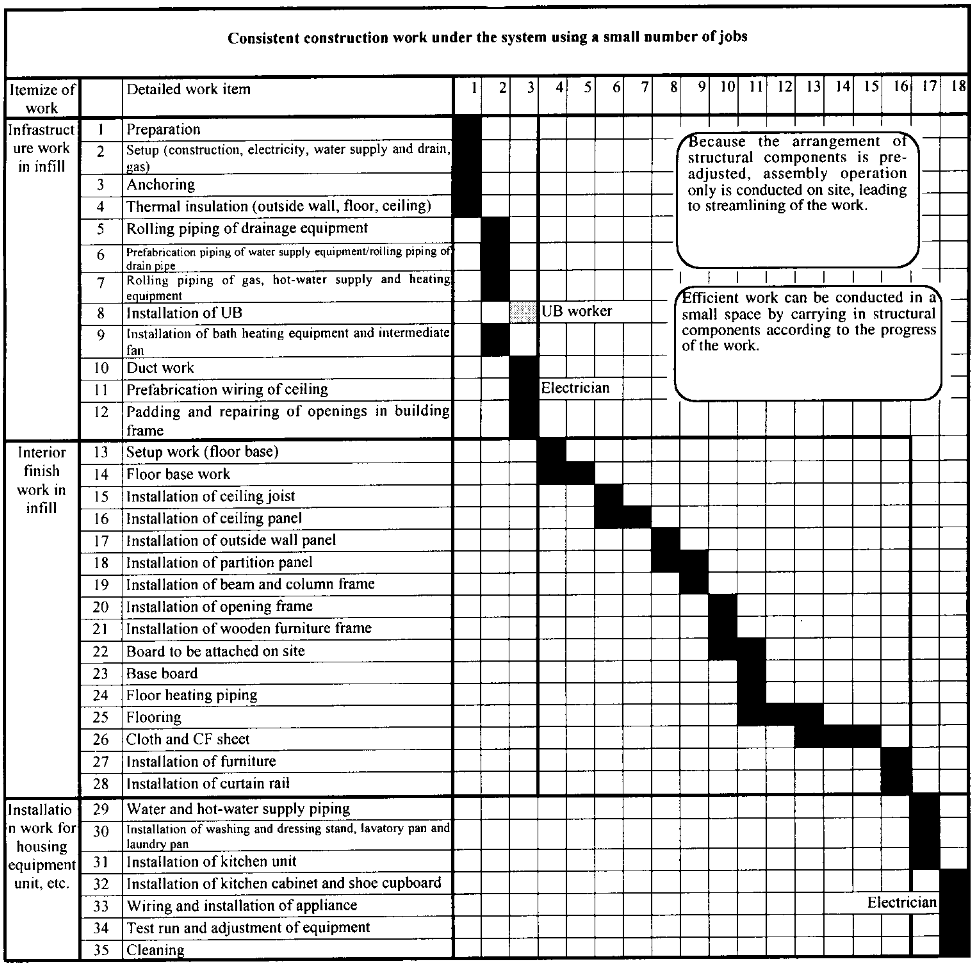


Fig.2 Construction Schedule by Systemized Infill and Multi-skilled Workers

- Condominium
  The condominium gets plenty of sun.
  The condominium has a wide balcony.

(3) Satisfactory results after remodeling

- Functions and usability of the kitchen, bathroom, etc. have been improved.
- Storage space increased and living space was wider.
- Costs for electricity, gas, and water were reduced due to introduction of advanced high-efficiency equipment.
- The condominium became bright and clean.
- The condominium is well ventilated.

(4) Unsatisfactory results after remodeling

- The impression of the finish was different from that expected at planning.
- Thermal insulation, sound insulation, etc., needs further improvement.
- There are few chances to use advanced equipment.

Summary and prospects

In this report, we describe the development of business that can, through systemization of infill structural components, the integration of work using multi-skilled workers and reorganization of process planning, complete construction work within a shorter term compared to conventional remodeling.

Using infill technology has just begun and the number of orders received is 38 (as of August 2001). As stated though the development of simplified structural components has been largely completed, consistent construction using multi-skilled workers still needs work. We must establish a system for efficient construction by multi-skilled workers and give training for such construction and further develop technology for simplified structural components

The condominium remodeling market is expected to expand rapidly. Using this technology, we will differentiate our system from those of competitors and promote business

Integral Design

Thoughts for tools rendering a methodical design framework

Wim Zeiler
TU Delft / Kropman B.V. Mechanical & Electrical Contracting
Verrijn Stuartlaan 36, 2288 EL Rijswijk, The Netherlands
P. 0031703401, F. 0031703999351, E-mail: w.zeiler@ry.kropman.nl

Emile Quanjel
TU Delft, Faculty of Architecture/ OBOM; architect
P.O. Box 5043, 2600SA Delft, The Netherlands
P. 0031152785400, F. 0031152788295, E. e.quanjel@hetnet.nl

Integral Design

Thoughts for tools rendering a methodical design framework

ABSTRACT

Good design control is the most cost-effective way to reduce plant size, save energy, reduce emissions and reduce maintenance costs all needed for an optimal LCA-design. Many software tools have been developed for building performance simulation. Still they are not very useful for the daily building design practice because of the many limitations towards use. An integral approach is needed to close the gap between computer experts, HVAC-consultants and building designers/architects. There is a need to develop a better understanding of building design and its necessary interaction with HVAC-design. A way to structure this by using a design methodology.

In order to develop appropriate tools for decision support in design processes, it is necessary to found them on an understanding of design. The framework of Methodical Design as developed at the University of Twente is extended to integrate the specific LCA aspects. The HVAC design process is being described in terms of several major phases, levels of abstraction and connected levels of modelling centred on layered design representations.

KEY WORDS

Risk management, design tools, methodical design, integral design

Integral Design

Thoughts for tools rendering a methodical design framework

Wim Zeiler, Emile Quanjel

Introduction and Background

"According to the Bible (Genesis 11:1-9), a tower was erected by people in Babylonia with the intention to reach heaven and God. Their attempts, however, failed because God interrupted the construction by causing among them a previously unknown confusion of languages and scattered them over the face of the earth."- Bedir Tekinerdogan.

Design and commissioning of HVAC-systems and controls optimised to the building are difficult to be accomplishing with ease. IA way to solve this complex interaction between building, environment, individual users and HVAC-systems is to look closely at the key-factors of design. Integral Design is essential to extend the view of the designers, architect and climate consultants to all the different aspects involved with building design.

Building Performance Simulation

To achieve efficiency goals, building designers require effective design tools for analysing and understanding the complex behaviour of building energy use. In the past decade, computer simulation and modelling has been used for providing a detailed appraisal of building energy design. Building energy simulation is an analytical method for building energy research evaluation of architectural design.

Risk management is the key aspect for using simulation. In the early stages of design there is little information, though nearly all the important decisions are made. In real-life, the nature of the building design process and the shortcomings of current simulation tools have made it difficult for the designer to use such tools efficiently. In the practice this often results in non-optimal, malfunctioning, or even wrong building/ installation system combinations There is a need to develop a better understanding of building performance simulation and to put into practice the techniques for achieving energy efficient buildings [Hui 1998]. The gap in understanding between software experts, climate-consultants and building designers/architects has to be closed.

Using simulation models for building design has its limitations as existing models fail to tackle issues regarding data preparation in the face of uncertainty in the design environment. Major shortcomings of simulation tools include [Hui 1998]:

- The program input is voluminous and scientifically detailed. Data, which is usually unavailable during early design stages, has to be assumed when doing the analysis.
- Program output consists of bulky computer printouts that confuse the user. Understanding and interpretation of the simulation results is difficult.
- Many detailed design tools are research orientated.
- The user interface of the tools is often neglected.
- Program validation and accreditation are lacking. People are confused and uncertain about which programs will give better simulation results.

While architects have begin to use design tools, at the present it is the engineer who will be most familiar with their use to assist in the design process. Until recently, the architect has been poorly served with design tools. Computer aided design (CAD) has been one of the few tools widely taken up in architectural practice. CAD is not a design tool in the sense used here [Extract EU 1995].
Similarly, users will bring to the tool their own assumptions and simplifications of the design problem.

Integral Design

To work effectively with the simulation tools, practitioners should learn to work within the limitations and understand the role of simulations in the building design process.
Energy efficient building are the result not of only a responsible attitude towards energy but also of how successful the designer has been in applying the technology and the building performance simulation tools during the design process. The building design process is characterised by Evolutionary, Multi-criteria, Multi-discipline and Multi-solution. Inappropriate modelling of the design process may result in ineffective design tools and solutions. In general, there are two main categories of design [Hui 1998]:

- Architectural designs that works on graphical images to determine the architectural form, shape, facade, etc.
- Engineering design that works on system schematics to perform thermal and HVAC calculations.

Architects usually develop their designs in drawing-based, graphical forms; prototypes are used to investigate the design concepts. What important here is that building design is a creative process based on iteration: it consists of a continuous back-and forth process as the designer selects from a universe of available components and controls options to synthesise the solution within given constraints. Understanding the design and performance relationships is essential and this can be facilitated through simulation [Hui 1998]. At the early design stages, only conceptual sketches and schematics, 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 most effective opportunities for improving the performance of a building occur early in the design process.

Many problems emanate from a lack of integration between architectural design and design of indoor climate. Building services consultants have difficulties adapting their methodical and arithmetic way of working to the artistic and intuitive characteristics of architectural design. A telepathic interface is needed in which the thinking of the architect designer is linked in the design process itself with the engineer. [Hartog 2000].

Supporting and stimulating an integration between architectural form and engineering analysis might enhance the performance of the architect and could facilitate the communication between architects and contributing building services consultants.
By using a design environment, which follows their way of working, architects are tempted to investigating the consequences of their design actions in the indoor environment [Hartog 2000].

Up to now the building design process is more or less sequential; first the building is designed and subsequently the heating/ cooling/ ventilating system. Thermal comfort requirements are commonly reduced to required air temperature, neglecting other important thermo-physiological environmental parameters like radiant temperature and air velocity. For system design, usually only extreme internal and ambient conditions are considered [Extract EU 1995].

The representation of the level of physical reality within the model is a key concept. One way to achieve the correct level of detail required for the various building sub-systems, i.e. constructions, lighting, etc. is to use a Design Methodology.

Methodical Design

"A problem cannot be solved at the same level of consciousness as it was created" - Albert Einstein

Communication between architect and building services consultants is based on abstraction, i.e., and the exchange of abstract descriptions of a design. With the rising use of product information models, it is now possible to incorporate multiple abstraction levels in the design representation. This enables the representation to take an appropriate (abstract) form to match the needs of the design specialist saving much time and confusion [Hartog 2000]. Through the different levels of abstraction, the building model is gradually described in an increasingly more detailed manner. The different levels of abstraction should be considered as a representation of a particular view on the total information available for a design.

This integrated building 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.

Design, as a solution-evolving process, involves activities of searching information, analysing, manipulating and structuring information about the problem to be solved. Generating new information and evaluating and communicating information is a major activity within the process. Design has normally a very dynamic nature, with a tendency to ad hoc actions, which should be supported by design aid systems. To develop the required model of design support an existing model has been extended: Methodical Design [van den Kroonenberg 1978]. The methodical design process can be described on the conceptual level as a chain of activities which starts with an abstract problem and which results in a solution.

Four main phases are distinguished, in which eight levels of functional hierarchical abstraction, stages, can be distinguished.. In system theory the same activities are proposed for decision processes as can be found for the design process.

System Theory	Activity	Methodical Design
Definition Demands	Generate	Problem definition
Synthesise Analyse	Synthesise	Working principle
Evaluation Decision	Select	Detail design
Implementation Application	Shape	Realisation

Functional Decomposition

"There are things known, and there are things unknown. And in between are the doors" - Jim Morisson

This classification provides means for decomposing complex design tasks into manageable size problems. An important decomposition is based on building component functions. The decompositions are carried out until we arrive at simple building components whose

design is a relatively easy task.
Hierarchical abstraction means the decomposition of information into levels of increasing detail, where each level is used to define the entities in the level above. In this sense each level forms the abstract primitives of the level above. These terms in the upper level, form condensed expressions of a given relational and/or operational combination of primitives from the level below.

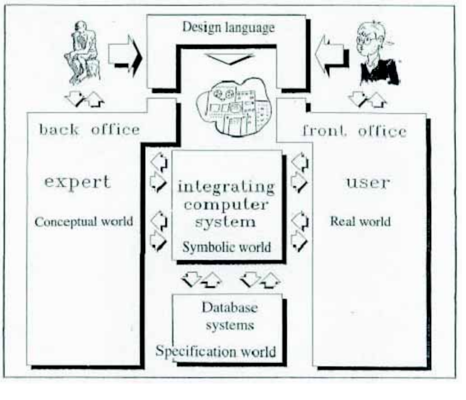
- Information level, knowledge orientated, representing the "conceptual world".
- Process level, process orientated, representing the "symbolic world".
- Component level, device orientation, representing the "real world".
- Part level, parametric orientation, representing the "specification world".

Information Level
This level deals with the knowledge of the systems by experts. This information processing is based on prior design knowledge. [Alberts 1993].

Process Level
This level deals with physical variables, parameters and processes. Modelling at the functional level involves deriving an abstract description of a product purely in terms of its functionality. This abstraction reduces the complexity of engineering design down to the specification of the products desired functionality.

Component Level
This level describes the hierarchical decomposition of the model in terms of functional components and is domain dependent. Generic components represent behaviours that are known to be physically realisable.

Part Level
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 of the consequences of certain design choices at the current level of abstraction for the final result.



The design problem as defined here is how to obtain a physical description of a technical system given a high-level (abstract) specification. In order to estimate what the restrictions imposed by generic components imply for the overall system, the resulting configuration has to be parameterised in terms of the form characteristics of the individual components. Throughout this process, the performance requirements serve as constraints on the possibilities for configuring generic components into larger structures and for assessing the physical characteristics.

With environmental aspects involved from the beginning of the HVAC design process for sustainable buildings, the number of uncertainties becomes overwhelming [Toxopeus et.al. 1999]. The topic of decision support systems, now approx. 15 years old has gained a lot of attention in research and application. Methodologies for sustainable building assessments and for design support regarding LCA are considerably new topics [Abu Sa'deh et.al. 1999]. Emphasis is put on often encountered inconsistencies, namely the set-up of LCA-system models, the representation of decisions and value choice of actors involved in a product system and the representation of changes within the economic and culture system. As the design process proceeds so the information about the building and its HVAC-system needed being designed increases. The HVAC design process may therefore be viewed as progressing from an information poor condition to one that is information rich.

Decisions made during design are known to influence the performance of other life-cycle phases. Ideally, designers should have an insight into how their decisions influence the different life-cycle phases. The main motivation behind the ideas presented in this paper is to provide designers with knowledge, which allows them to foresee the consequences in multiple life-cycle phases resulting from their decisions. One of the critical problems in engineering design is making early decisions to satisfy a host of total life-cycle phase issues. High costs and delays due to problems arising in manufacturing and other life-cycle phases from design phase decisions are the specific motivation behind this approach. This is evidence of the difficult which designers have in taking into consideration the life-cycle consequences (and their interactions) of their design decisions [Borg 1999].
There are a number of manual and computer based design tools which are employed to avoid the generation of life-cycle problems, such as DfE (Design for Environment), DfS (Design for Serviceability) and DfR (Design for Recycleability). However, they offer only a narrow view to the consequences and they are mostly employed towards the later design stages when major design decisions have already been committed. Most robust ideas come from applying Design for principles [Goulding 1997].

On the other hand Concurrent Engineering, or more correctly concurrent product development as a procedure for simultaneously integrated and provident thinking, requires, designers to take a multiple-life-cycle phases view towards their evolving design solution. An emerging problem to such an approach, is the generation of models of interrelated life-cycle consequences, as a means to life cycle providence during the early design stages. It is believed that life-cycle providence can be employed for supporting the exploration of the design phase without necessarily constraining it. [Borg 1999]:

- The identification of design decision factors which influence the consequences generated during the different life-cycle phases;
- The structuring of the knowledge which links design decisions to their consequences or behaviour;
- The modelling of the mechanism trough which design decision consequences propagate trough the different life cycle phases.

The need for the management of product life cycle, however, has not been recognised as much as the need for production. In order to manage the product life cycle, designers have to collect various inputs from specialists, because the environmental issue covers many disciplines. It is also important to let users know the design concept including life-cycle management so that they can use the product satisfactorily. It is a challenge for design engineering to provide a method to plan the life cycle of products better and easier [Kurakawa 1996].

The LCA methodology is described by SETA (Society for Environmental Toxicology and chemistry) and CML, the Centre of Environmental Science Leiden University.

1. Planning
- Definition of the product and its alternatives
- Choice of system boundaries
- Choice of environmental parameters
- Strategy for data collection

2. Screening
- Preliminary execution of the LCA

3. Data collection and data treatment
- Measurements, interviews, literature search, theoretical calculations, database search, qualified guessing.
- Computation of the inventory table

4. Evaluation
- Aggregation within the category (characterisation)
- Normalisation

5. Improvement assessment
- Sensitivity analysis

System Theory	LCA Methodology	Methodical Design
Definition Demands	Planning	Problem definition
Synthesise Analyse	Screening Data-collection	Working principle
Evaluation Decision	Evaluation	Detail design
Implementation Application	Improvement Assessment	Realisation

The four phases, with their specific level of aspect abstraction, have their own requirements for the descriptive model of decision making.

Design level	Main topic of abstraction	Output	Focus from LCA point On
Problem definition	Information "conceptual world"	Need Design problem	Environment
Working principle	Process "symbolic world"	Functional specification Physical solution process	Energy Exergy
Detail design	Component "real world"	Module structure Prototype structure	Re-usability
Realisation	Part "specification world"	Material properties	Resources

The goal of the building performance tools should be to create a software infrastructure that can be used for information sharing across disciplines and can be used to link interoperable software tools throughout the building life cycle. In the building industry, the goal of “interoperability” means collaborative access to project/building information and information sharing: a single building model that is shared by all participants in a building design, construction, commissioning, and use. An interoperable building model would assure data compatibility across applications and platforms.

When interoperability supplants the current piecemeal sequential data exchange, information will no longer be lost in the life-cycle process. Software users will benefit from enhanced communication among disciplines and across project teams and a resulting reduction of inconsistencies form decisions made by different disciplines. The industry could see major cost savings through more efficient information management, tracking of project/building decisionmaking, and the ability to clearly document the life-cycle performance of buildings.

Conclusion

"Indeed this subtle and complex freedom from inner contradictions is just the very quality which makes things live" - Christopher Alexander, The Timeless Way of Building.

The need for an integral approach of the integral, dynamic system consisting of a building and its building services systems such as its HVAC heating ventilation air-conditioning system is strongly felt. Methodical design is proposed as a theoretical basis for design of the building and it's building services systems. Design is viewed as a problem solving activity in which functional reasoning is central. It can form the basis for simultaneous generating the design and its simulation model

In order to allow a stepwise approach in which each design decision has well - defined implications, four different ontological levels have been distinguished for designing energetic - process;

- Information Model	- Conceptual World
- Physical Process Model	- Symbolic World
- Functional components Model	- Real World
- Parametric Model	- Specification World

To support architects more effectively in their tasks, a design methodology based Methodical Design and LCA Design should be developed for evaluating the performance life cycle characteristics of conceptual designs. This environment will be an important element in the strategy to integrate indoor environment analysis in the design process. In addition providing design information to simulation tools, the outcomes these tools generate should be presented back to the designer. Using this with a frame of design and analysis feedback will presumably increase the LCA consciousness of indoor environment characteristics of conceptual design.

Acknowledgements

This project is been supported by the TVVL, the BNA and the TUD. The Integral Design project has benefited from earlier work in the MetaView, EcoView projects, which were supported by Senter. The partners in de MetaView project were Kropman b.v., TUD, TNO-Bouw and Huijgen Elwako. The partners in de EcoView project are Kropman b.v., TUD, ECN and ATO.

References

- Abu Sa’deh A.J., Luscuere P.G. (1999), Ecological Assement of Building Designs, Existing Methodologies and Tool, TU Delft, Faculty of Architecture, DIOC “The Ecological City”, 1999.
- Alberts L.K., Wognum P.M., Mars N.J.I., Structuring Design Knowledge on the basis of Generic Components, Artificial Intelligence in Design, J.S. Gero (e.d.) Kluwer Academic Publ., 1992.
- Alberts L.K., YMIR: An Ontology for Engineering Design, PhD-thesis, University of Twente, Enschede, 1993.
- Borg, J.C. (1999), Knowledge Intensive Component Life Design Synthesis, University of Malta
  www.cad.strath.ac.uk/~jonathan/Home_res.html
- Building Performance Assurance - Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, Building Technologies Department (2000).
- Extract from EU commission, Thermic Programme Action No B184, Tools and techniques for the Design and Evaluation of Energy Efficient Buildings, UCD-OPTET, 1995, www.bwk.tue.nl/tago/hensen/courseware/class-tools/issues.htm.
- Goulding, J.R. (1997), Design Methods: Design for X, Engineering Management Program, Port State University, 1997.
  www.emp.pdx.edu/Searchable/Std_projects%20PDF%files/emp-9771/De.../DFX.ht
- Hartog P. den, Meta Design Environment, PhD-tesis research, Delft 2000
  www.bk.tudelft.nl/ugeus/hartog/internet/mdepage/topics.html
- Hui S.C.M. (1998), Simulation based design tools for energy efficient buildings in Hong Kong, Hong Kong Papers in Design and Development, Vol.1, 1998, pp.40-46, Department of Architecture, University of Hong Kong, 1998.
- Kroonenberg H.H. van den, Methodisch Ontwerpen (WB78/OC-5883), University of Twente, 1978.
- Kurakawa, K et.al. (1996), The Green Browser: An information staring tool for product Life Cycle Design, The University of Tokyo, 27 august 1996
  www.race.u-tokyo.ac.jp/~kurakawa/papers/dtm96.html
- Mc Gown, A.D. (1999), Green G., Recording The Design Process in Real Time: Innovate Design Concept Synthesis, Dept. of Mechanical Engineering, Glasgow University
  www.dmu.ac.uk/ln/4dd/synd1e.html
- Toxopeus, M.E., de Jong, J.J. (1999), Life Cycle Oriented Design, University of Twente, Faculty of Mechanical Engineering.