A Modular Construction System.
How to design its Production Process

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KEYWORDS
Modular Construction, Adaptable Building, Decision Support Tools, Design Management

Abstract

One type of architectural construction is a modular building. Specific requirements may motivate clients to opt for a modular building. However, designing such a system is a highly complex process and demands a systematic approach. This paper presents a brief introduction to this field of design management.

Introduction

When acquiring a new building, clients sometimes have specific demands, such as a short delivery lead time, a particular location, special financing or limited duration of use. In most cases, they opt for an adaptable building based on a modular construction system. The designer and builder of such a system have to bear these specific demands in mind. Moreover, they encounter the following challenges:

- There is no personal client, but a largely poorly defined market.
- The establishment of a production plan involves a substantial number of assumptions.
- The term for the amortisation of mechanising or robotising investments is unknown.
- The client and society want safe, sustainable and attractive buildings, not a semi-permanent solution.

To manage these challenges during the design process can be one of the tasks of the (architectural) design manager. Gray (2001) describes the task as follow ‘to make sure that the organization of the design process is structured appropriately for the task at hand, and to ensure that there are sufficient integrative and co-ordinating mechanisms for the work to progress meaningfully’. We think that in future one of the tasks of the design manager will also be to design the production process. Especially by modular building objects may play this an important role. The design scope of such objects includes long-term views and the involvement of a wide-range of design expertise. Also the influence of the client is important.

A method for the builder to design a modular construction system would be useful. This paper proposes one such method, which is based on the experience gained by the first author in designing three different Dutch modular construction systems.

Modular construction system

The Modular Building Institute (MBI 2006) defines modular construction as a method of construction that ‘utilizes pre-engineered, factory-fabricated structures in three-dimensional sections that are transported to be tied together on a site’. This definition, however, focuses solely on the production
Modular construction involves modular parts assembled in the factory, transported by road and installed on the building site to create a modular building.

- Modular parts have established grid dimensions.
- Parts just small enough to be transported by road are called modules.
- The modular buildings are assembled, transported and installed by specially trained professionals.
- The modular parts are connected using convenient dry-point and like connections.
- The components of the modular parts and modules are kept in stock at the factory.
- The point at which an order can be broken down into its individual components precedes the assembly of modular parts.
- Modular parts and modules are manufactured according to customer specifications.
- A modular building can be taken apart and then reused to create the same or another type of building.

See Figure 1 for a production scheme.

![Production Scheme](image1.png)

**Figure 1. Modular construction system production scheme.**

All over the world, modular builders have developed their own systems, based on the needs of their clients and on their own production skills and facilities. See Figure 2 for some examples.

![Examples of Modular Buildings](image2.png)
A design method for the builder

When designing a modular construction system, a modular builder has to manage four processes, viz. market research, product development, production and sales. The method ensures that those designing the four processes constantly exchange information and feedback. The process designers should work together, taking a multidisciplinary approach. Feedback tools make sure that co-operation runs as smoothly as possible.

This paper only addresses the production process perspective of a design method. The method’s description will consist of two parts: the structure and the content.

Method’s structure

Three design feedback tools are developed:
- *an object tree*: a structured description and detailed explanation of the system
- *a guideline*: a four-step system analysis approach
- *a ranking system*: definition of the decision-making criteria and of the qualitative levels, presented as a coloured filter

The object tree schematically presents the interrelationship of all building parts and shows where the parts will be assembled. See Figure 3. The diagram resembles a ‘product-tree’ with boxes representing the building parts. Individual components are presented on the lower end of the object tree. Higher up, the modular parts resulting from the assembly of individual components are presented. Even higher, the modular parts are combined into a three-dimensional object. This can be part of the resulting building, a building module or the completed building itself. The assembly locations are categorised as: assembly at supplier, assembly at the factory or on-site assembly.

A step-by-step guideline is used to monitor the entire design process involved in creating the modular construction system. It takes into account the limitations of each of the four processes determining the modular building’s design.
Each step of the guideline is divided into four parts:
- Part 1: input – the limitations that the final product must bear in mind
- Part 2: process – the elaboration of all input parameters
- Part 3: output – the changed product model
- Part 4: evaluation – a check is performed to confirm whether the output model takes all limitations into account.

If the evaluation is positive, it will be necessary to determine whether the output model also takes into account the limitations identified in the previous steps. If this check is positive as well, the product continues to the next step. If the product fails one of the checks, it has to be modified as part of the current step or by going back to an earlier stage of the process and continuing from there.

See Figure 4.

Figure 3. Two object trees. The configuration depends on the production strategy.
In addition, a decision tool is created. This tool is actually a ranking system designed to be superimposed on the object tree. Coloured fields (i.e. filters) correspond to the assembly location level. The colour codes represent:

- **red**: The boxes in the red field will negatively impact the production system and should be placed in another assembly location.
- **yellow**: The boxes in the yellow field will have a neutral impact on the production system. Replacement is not necessarily required.
- **green**: The boxes in the green field positively impact the production system. As many boxes as possible need to be placed in this field.

The six criteria to be decided are on-site construction time, costs, on-site labour, transport risks, dimensions with respect to transport and freedom of choices for the client.

**Method content**

Different priorities and criteria can be defined as part of the method’s structure. This may vary depending on the modular builder’s strategy. For example, achieving the highest level of cost-efficiency and industrial production may be the top priority, while fulfilling the needs specified by clients may be less of a priority. For this research, we opted for a ‘mixed’ strategy, striking a balance between freedom of individual choice and optimising industrial production.

The market research, product development, production and sales processes each have their own priorities and limitations that the resulting construction system must bear in mind. In four steps, the method decreases the solution spaces. The descriptions or the decisions to be taken within the steps include:

- **Step 1**: Production typology (from traditional to industrial construction processes)
- **Step 2**: Client choices (from such production strategies as pure, segmented or customised standardisation to tailored or pure customisation)
- **Step 3**: Client choice (levels such as construction, shell, installation, infill or finishing)
- **Step 4**: Production systems (flow, job-shop)

(Van Gassel and Roders, 2004).

**Discussion**

Some researchers already developed some types of methods to design building products, such as Quality Function Deployment (QFD) (Sarlemijn, 1995), Lichtenberg (2002), Austin et al (2001), Oostra (2001), Van den Thillart (2002) and Rutten (2004). These methods are mainly focused on the needs of the clients. The method described in this paper is more based on the characteristics of modular construction.

**Conclusions**

Modular builders develop building systems, elaborating on their market and production experience with other systems or building products already included in their portfolio. This reduces the risk of failure. They rarely begin from scratch. One of the pitfalls of this approach is that a building system may be developed that will compete with another of the modular builder’s own systems. The application of the design method can reduce this risk by increasing the transparency of a large number of choices and by improving communication with others.
Acknowledgements

We would like to thank PRC Bouwcentrum in Delft for the commission to develop this method as part of the IFD Buildings European study project. Special thanks goes to Geert-Jan van den Brand for his guidance and support.

References

The Multispace Adaptable Building Concept and its Extension into Mass Customisation

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KEYWORDS
Design Adaptable Customisation Building

ABSTRACT

UK government Policy Planning Guidance promotes optimum use of the existing building stock through mixed use in urban centres and encourages conversion of redundant office and retail space into leisure, service or residential uses. Whilst social pressures are evident in the push to more effectively utilise existing building stock, new building stock also has to meet the commercial requirements of the client, which often translates into maximum occupancy of the building. This is encouraging greater innovation in the design of new buildings to allow change of use throughout the structure’s lifetime. This paper describes the concepts surrounding an adaptable design for new buildings, along with a review of factors influencing the mode of use. The major physical parameters of storey height, building proximity, plan depth, structural design, services, fire safety, cladding and noise abatement are evaluated in the context of adaptable building use.

In addition to improved building utilisation, the UK government has identified a weakness in the productivity of the construction industry. The report ‘Rethinking Construction’ (Egan, 1998) suggested that up to 80% of inputs into buildings are repeated and that parallels should be drawn with the designing and planning of new cars in the automotive sector. This suggests that improvements in quality, cost and delivery time of new structures could be achieved through mass-customisation incorporating a significant element of pre-design.
1 BACKGROUND

The requirement for building adaptability is becoming increasingly relevant from both commercial and sustainability perspectives. The UK government has identified, in Policy Planning Guidance notes, the need to optimise the use of existing building stock therefore encouraging the conversion of redundant office and retail space into leisure, service or residential uses. There are several reported international examples of building adaption [Geraedts 2002][Omi 2005].

It is also apparent that the construction industry is exceedingly wasteful in the way that it supplies building space to the UK commercial market. It is common to have a temporary excess of empty office space whilst striving to meet market demands for housing, and vice versa. This is inevitably encouraging clients to look at alternative methods of designing buildings in order to minimise the consumption of construction resources and losing potential rental value. Mixed use developments offer a client both diversified risk and the ability to adjust to changes in market demand for building usage. Recent data from the UK commercial property market demonstrates the rapid change in demand, with activity in the private office sector rising from 3.3% in August 2005 to 12.6% in December 2005 – over the same period activity in the private retail and leisure sector was static at 5.4% in August to 5.7% in December [Savills 2005].

The additional capital cost of incorporating adaptability into a building design remains a barrier to adoption. However, there is data to show that the cost of the built structure is small in comparison with the cumulative cost of services and space plan changes over the life of the structure [Arge 2005]. Environmental benefits of adaptable office buildings have been examined by Larsson [Larsson 1999]. Using data from previous studies relating to embodied energy and energy expended in office buildings, Larsson estimates a 15% reduction in (a) air emissions and (b) demolition solid waste [Environmental research group 1994][M. Gordon Engineering 1997].

This paper details an adaptable building design concept called Multispace, developed by Reid Architecture [Gregory 2005]. The intention of this study is not to develop the ultimate flexible building, but is to explore the differences between flexibility and adaptability, and to make recommendations for adaptable building design that can be fitted out, with minimal changes, to achieve a variety of uses. Our thinking is strongly aligned with that of Brand, who’s seminal work on building adaptation put forward key exemplars and principles [Brand 1994]. The common features identified in the design facilitate the movement from bespoke to mass customised construction.

2 HISTORICAL CONTEXT

2.1 Reid Architecture Offices

Many of us still live, work or meet in buildings that were built over the last 200 years or even earlier. It is unlikely that anyone living in 21st century Britain can avoid using historic buildings in some part of their daily lives. Although there is an element of sentimentality, the reality is that we would have demolished the majority of Georgian and Victorian town houses by now if they did not allow us to use them successfully.

Reid Architecture originally occupied a Georgian terraced town house on Portland Place, London. The building served the London practice well during its growth period but Reid has recently moved to a remodelled 1960’s office building. The role of both buildings is very relevant to this study. The Georgian town house was built about 200 years ago for the purpose of accommodating a wealthy family with servants. Over its lifetime it has been adapted to serve small and medium sized consultant businesses and been subdivided to provide small single or two bed flats at the same time. Opposite these premises similar buildings have become embassies, headquarters for professional organisations or hotels.
With the expansion of Reid came the requirement to move into larger premises (called West End House). This building was built as offices in the 1960’s and was seen as unattractive and unsuitable for modern office specifications: low storey heights on the upper floors, relatively narrow floor plates, no air-conditioning, poor quality single glazed windows, no reception space and only one lift. A number of significant improvements were made without major alteration to the building shell, which allowed conversion into a high quality, fit for purpose, office building.

The crucial idea to learn from these examples is the concept of ‘loose fit’. The storey heights and relatively generous room sizes of the Georgian town house at Portland Place allowed it to be used as:

(a) High quality residence, (b) Flats, (c) Office space, and also (d) Hotel premises.

West End House did not have high ceilings or big floor plates by modern office design standards, yet it was capable of becoming a high quality office space for an expanding consultant business because the floor layout was relatively simple and open plan and the narrow floors actually benefited the desire to use natural ventilation.

This example demonstrates the potential efficiency of an adaptable building design that would cater for medium to large sized developments, and would accommodate new comfort demands. With buildings that are purpose built and difficult to adapt the cost of refurbishment can be as high as new build. It is more sensible to design buildings that can serve a variety of needs with minimal work to the shell and freedom for the fit out.

2.2 Loughborough University Centre for Collaborative Construction Research building

Few of the existing ‘modern’ buildings have been intentionally designed for adaptability which makes it difficult for us to assess the effectiveness of that adaptability over time. However, one such building is the Civil Engineering building on Loughborough University campus which, when built in 1970, was designed with structural redundancy to allow for the addition of an extra floor at some time in the future. Its tartan grid with a 14.3m clear span resulted in only four internal columns in its 1000m2 floor plate and all rooms were created with a partition system. This building has recently been refurbished (and extended) with the former including removal of all the original partitions to create a landscaped office to encourage research communication and collaboration.

The ‘loose fit’ approach is again demonstrated as being advantageous in allowing a level of adaptability. It is interesting to note, however, that the ceiling void allowance for services in the original building was 1.5m in depth; the substantial changes in services provision equipment has made much of this void space redundant and demonstrates the difficulties associated with predicting the future design requirements for buildings. The type of changes in the 21st century are likely to be very different to that seen in the past – telecomms and computing technologies will undoubtedly change significantly and requirement for building space will change accordingly [Russell & Moffatt 2001].

3 MULTISPACE

Mixed use urban developments are becoming increasingly common. Adaptable space allows landlords to be able to alter the mix of use to respond to market conditions without altering the shell construction, thus maximising the return at all times and minimising construction time and costs. A recent research document for the British Council of Offices states: “Office dominated mixed use buildings benefit from higher returns and are associated with lower risk when compared to a single office use alternative.” [Jones Lang LaSalle 2004]. The logical next step is to design buildings that can accommodate a variety of uses without predetermining their location or extent. Multispace offers the potential for developers to maximise commercial returns and reduce risk associated with mixed use schemes without having to predetermine which parts of the scheme perform a particular use. An adaptable building design meeting the potential requirements of office, residential and retail uses can be defined. The technical requirements of each building design parameter, for each building use,
were compared. Acceptable (or minimum) values for each parameter could then be identified, defining an outline adaptable building specification. The key design parameters are:

3.1 Storey height (the heart of the problem)
3.2 Building proximity, form and plot density
3.3 Plan depth
3.4 Structural design
3.5 Vertical circulation, servicing and core design
3.6 Fire safety design
3.7 Cladding design

### 3.1 Storey height

One of the focal issues for any generic design proposal is to achieve a storey height that is high enough to accommodate all proposed uses, yet low enough to avoid waste. The normal storey height for offices is in the order of 3.75-4m, whereas high quality residential and hotel (bedroom) storey heights are of the order of 3m. The storey height is determined by:

- Ceiling height required for the use
- Structural zone
- Services zones
- Planning height restrictions
- Short term economic pressure

The most important technical design aim is to provide a truly adaptable building shell within the lowest possible storey height - for a building of ‘normal’ width (i.e. between about 13.5 to 18m) a notional target in the range of 3.3 to 3.5m is suggested. (Table 1)

<table>
<thead>
<tr>
<th>Use</th>
<th>Min internal Ceiling height</th>
<th>Max economic ceiling height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>2.65-2.75m</td>
<td>3.0m</td>
</tr>
<tr>
<td>Residential</td>
<td>2.4m</td>
<td>2.7m</td>
</tr>
<tr>
<td>Hotel (Bedrooms)</td>
<td>2.4m</td>
<td>2.7m</td>
</tr>
<tr>
<td>Retail</td>
<td>3.5m</td>
<td>4.0m single storey to</td>
</tr>
<tr>
<td></td>
<td>Single storey</td>
<td>7.0m if mezzanine etc inserted</td>
</tr>
<tr>
<td>Generic Limits</td>
<td>3.5m on GF</td>
<td>7.0m on GF</td>
</tr>
</tbody>
</table>

**Table 1 – Summary of building ceiling heights [Gregory 2005]**

The preferred slab technology would utilise two way post-tensioning incorporating bonded tendons, which offers the following advantages:

- Fast site erection
- Very slim slab depth with no projecting beams
- Integral fire protection
- Safe construction and demolition
- Reasonable flexibility for additional riser penetrations between tendons

Typical post-tensioned concrete slab depths for an office building (highest design loads) would be:

- 250mm thick slab for 9x9m structural grid
- 330mm thick slab for 9x12m structural grid

The potential useable space per floor is also defined by service zone requirements, such as HVAC, power, IT services and pipework. The greatest technical design challenge resulting from this is to accommodate varying floor zones with the widest possible variety of ventilation solutions. The greater the storey height, the greater is the range of service solutions possible. A great deal of choice can be achieved within a storey height of about 3.5 to 3.6m, which can be reduced to 3.3m provided...
that under-floor servicing systems are acceptable (assuming use of thin slab technology).

3.2 Building Proximity

Proximity of building blocks is generally determined by:
- Natural daylight penetration
- Views and privacy (particularly for residential/hotel uses)
- Spatial proportions
- Space required for access roads, car parking, communal spaces and gardens.
- Space separation to prevent fire spread and access for fire fighting
- Economy: ratio of built area to plot size.

Previous research [Martin] has proven that courtyard or atrium forms are most efficient when the depth of building is restricted to a dimension smaller than the overall plot size. In a recent study of relative development efficiency, Multispace achieved the same development area or more, within a given height limit, because of the lower storey height, despite the Multispace floor-plate having a lower area than the office floor-plate designed to the maximum allowable BCO recommendations [BCO 2005] for floor depth.

3.3 Plan depth

Plan depth is generally determined by: (i) Natural daylight penetration, (ii) Proximity to views, (iii) Spatial proportions, (iv) Space required to accommodate the smallest internal room component/component group, (v) Economy: ratio of envelope area to floor area enclosed.

If retail, with its greater plan depth requirement, is restricted to the ground floor, then the generic limits would be 13.5-21.0m on the upper floors. The deeper the floor plate the more efficient the development will be (area of envelope to internal floor area ratio). However in large developments a variety of floor plate depths will bring benefits of diversity when attracting potential tenants. The benefits and methods of ensuring good daylight penetration into office floor plates has been detailed elsewhere [Gregory 2004]

3.4 Structural design

The structural grid must ideally co-ordinate with all uses so that they are fully interchangeable, without the need for significant transfer structures or uneconomically long spans. Generic limits for span in an adaptable structure would be 6-12m, dependent on structural system and cost constraints.

3.5 Vertical circulation, servicing and core design

The most onerous requirement for lift design is likely to be mixed use requiring separate lift services for office, residential and/or hotel uses. The issue to consider is whether the cost difference between providing for offices and other uses is so great that we would need to alter the number and type of lifts to suit each use. If lifts need to be inserted after the shell has been erected then the core must be designed to accept additional shafts without loss of floor plate efficiency. Security and separate lift shafts for each use must be considered when more than one use co-exist in one building. In the same way plant size and location must be considered. Again offices are often more heavily serviced than residential or hotel buildings.

3.6 Fire Safety design

Travel distance between stairs has a major impact on optimum floor plate efficiency for any building. Generic design limits for an adaptable building define limits on occupancy (1/6sqm), no of people (150-180), maximum travel distance (30m two way), no of stairs (2) and stair width (1.4m).
3.7 Cladding design

In addition to cost and appearance (including planning constraints), choice of cladding is also determined by thermal, acoustic, ventilation and natural light requirements.

A summary of adaptable building requirements are shown in Table 2.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ground Floor Condition</th>
<th>Upper Floor Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity of blocks</td>
<td>Determined by fire regs</td>
<td>18-21m min between habitable rooms</td>
</tr>
<tr>
<td>Plan depth</td>
<td>13.5m (preferably 15m) to 45m</td>
<td>15 to 21m</td>
</tr>
<tr>
<td>Internal ceiling height</td>
<td>3.5m single storey; 5-7m double storey</td>
<td>~2.7m</td>
</tr>
<tr>
<td>Ceiling zone</td>
<td>0-500m</td>
<td>0-500mm</td>
</tr>
<tr>
<td>Floor zone</td>
<td>Preferably 100 to 350mm</td>
<td>Preferably 100-350mm</td>
</tr>
<tr>
<td>Structural slab and spans</td>
<td>Min 7.5m span</td>
<td>Min span; max 12m span</td>
</tr>
<tr>
<td>Fire design occupancy</td>
<td>260mm slab @ 9x9m; 330mm slab 12x9m</td>
<td>260mm slab @ 9x9m; 330mm slab @12x9m</td>
</tr>
<tr>
<td>Travel distances for fire</td>
<td>30m 2-way (12m 1-way)</td>
<td>30m 2-way (12m 1-way)</td>
</tr>
<tr>
<td>No. and size of lifts</td>
<td>N/A</td>
<td>Design for mixed use as worst case and offices as worst case for single use</td>
</tr>
<tr>
<td>Cladding spec.</td>
<td>Maximise glazing within fire, noise and cost constraints</td>
<td>40-100% glazing, NR 20-30; 1.5m module &amp; option for opening casements</td>
</tr>
</tbody>
</table>

Table 2 – Summary of adaptable building requirements [Gregory 2005]

4 CUSTOMISED BUILDING SOLUTIONS

As a pre-designed adaptable building solution, Multispace also offers the opportunity to exploit the production benefits associated with a mass customised solution, with improved pre-design resulting from a better understanding of the production process. Reviews of the construction industry consistently identify the need to eliminate inefficiencies in the construction process [Egan 1998].

The Multispace concept impinges on some of the potential benefits of a mass customised solution. A generic design limits the time (and cost) associated with ‘up-front’ design. The certainty associated with a repeat ‘unit’ allows greater certainty in terms of cost, build time, quality and planning. The supply chain will benefit from defined repeat materials requirements.

Indeed some of the features of Multispace have already been incorporated into a ‘Customised Office Solution’ [Laing O’Rourke 2005]. This design has now been used on eight office developments, with appreciable benefits in terms of cost certainty, minimised construction time and potential adaptability being gained by the clients.

5 CONCLUSIONS

This paper has presented an insight into building adaptability and detailed an adaptable building concept. It can be concluded that;

1. Existing buildings can offer adaptability of use.
2. An adaptable building design can be developed which facilitates rapid change of use of new structures – design criteria are summarised in Table 2.
3. The identification of common technical design features and appearance in relation to building usage allows the development of a platform for mass customisation. Cost, quality and time certainty benefits would be gained from the improvements in procurement and construction consistency.

6 ACKNOWLEDGEMENTS

We wish to thank Chris Gregory, EPSRC, Reid Architecture, Buro Happold and Laing O’Rourke.
The Multispace adaptable building concept and its extension into mass customisation

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The Problem of Communication in Construction

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KEYWORDS
construction, projects, demand-supply communication, communication process

1 Introduction

Communication is an important topic in the construction industry, as also reported in the literature. Often problems in construction are referred to as communication problems [Emmerson 1962]; [Higgin and Jessop 1965]; [Latham 1994]; [DETR 1998]. Due to its specific characteristics, the industry forms a complex communication environment. Construction is a fragmented and dynamic sector with a project-based nature. This makes that many stakeholders operate in frequently changing sets of relationships which are contractually driven. The culture shows a reality of conflicts and lack of mutual respect and trust [Dainty et al 2006].

The goal of this research project is to improve communication in construction. To define the problem in more detail and to define a more specific research goal, the project started with two studies. Literature on communication in construction was studied, and interviews were held with experts in the Netherlands. This provided a first impression of the situation in the practice and literature of construction. This paper reports the first findings (in Section 4), including a more focused problem definition, the main research goal and a possible research set-up to tackle the problem. The literature study is reported in the next section; the empirical data from the expert interviews are discussed in Section 3. The paper ends with some conclusions.

2 Communication in construction

Since the early 1940s, literature on communication in construction has appeared, mainly based on the situation in the UK [Emmitt and Gorse 2003]. Many problems concerning communication have been reported, with a focus on intra-supplier communication within the construction sector; demand-supply communication during the design phase; and communication between and within single demand and supply side parties, during whole the construction process. In this division the demand side contains (representatives of) principals, users, investors, etc. and the supply side architects, (sub)contractors, advisors, etc. Based on an overview of this literature, the importance of improved communication in construction and the main factors influencing communication are discussed.

The efficiency and effectiveness of the construction process strongly depend on the quality of communication. In literature four reasons are mentioned why improvements in communication are needed. The first reason is that an improvement in the communication within the building team [Higgin and Jessop 1965], in project teams [Thomas et al. 1998] and between project manager and contractors [Franks 1998], [Somogyi 1999] could reduce failure. Second, more open communication at all levels could lead to innovations [Lenard and Eckersley 1997] and better technical solutions [Sörensen, in Atkin et al. 2003]. Third, communication improvements in early phases of projects would positively influence the quality as perceived by all stakeholders involved [Emmit and Gorse 2003]; [Brown 2001]; [Usmani
and Winch 1993]. Finally, improved communication during the briefing might lead to better decision-making, for example less haste in moving to solutions and better ways of looking at the requirements first [Nutt 1988]; [Barrett 1995]; [Salisbury 1998].

Communication is influenced by several factors; an overview can be derived from literature. The first type of factors is related to the organization of the construction process. Main aspects are the difference between formal and informal communication routes during the design phase [Mackinder and Marvin 1982] as well as during the phases of development [Pietroforte 1992], [Higgin and Jessop 1965]; and the divorce of design and production [Hill 1995]; [Emmerson 1962]. The second type of factors is related to the stakeholders themselves. Opposing interests could lead to hidden agenda’s, often leading to restricted communication [Richardson 1996]; [Brown 2001]; [Cuff 1996]; [Preiser 1993]; [CIB 1997]; [DETR 1998], and all stakeholders’ (assumed) frames of reference are found of great influence on communication as well [Moore and Dainty 2001]; [Salisbury and White 1980]; [Gray et al 1994]; [O’Reilly 1996]; [Usmani and Winch 1993].

Over the years, several studies concluded thus that the construction sector could benefit from improved communication. Although the studies highlight several aspects of communication in construction, no literature overview has been found on demand-supply communication in construction. Studies focus on intra-supplier communication (between head- and subcontractors for example) or intra-demander communication (between principal and end user for example), or study just one phase of the building process. In the cases where communication between demand side parties and supply side parties was studied, the focus was on just a few stakeholders instead of taking into account many parties of each side.

3 Practice of communication in construction

The structure of the Dutch construction industry does not differ so much from the UK, except for the fact that Dutch industry is highly regulated in comparison with the UK [Bosch and Philips 2003], and that the UK subcontracting system (as opposed to the Dutch) allows for principals to contract directly to subcontractors [Atkins 1994]. Communication problems seem to be similar as well, as for example shown by the attention paid to this topic by PSIBouw – the Dutch network of innovators in construction – in their program ‘Rethinking Construction’. Open interviews with all kinds of stakeholders within the Dutch construction industry have provided more insights. Their ideas on communication problems in construction in the Netherlands are reflected in this section. The section starts with describing the research method used to perform the empirical study.

3.1 Research methodology

To obtain more insight in communication problems, seven experts on the practice of communication in construction were interviewed. The interviewees were selected based on their profession (constructor, consultant or professional principal); the type of projects they were procuring or working at (Infrastructure, public utility building or housing); and the domain they were working in or building for (public or private).

The data were collected in semi-structured, in-depth interviews. The format was that of a conversation with a structure and a purpose. To further ensure the richness of the method, the interviewees were first informed about the aim of the study, the financier, what their participation involved, and how the results would be disseminated. Then they were asked to think of one or more specific projects that they were currently working on or had recently completed. Open interview questions based on the purpose of the study allowed interviewees to talk about their experience.

During the interviews notes were made, which were transcribed directly after each interview. Remarks of all kinds were put into one of the three categories characteristics of the Dutch construction industry; the importance of communication; and factors influencing communication. The interview method chosen caused that not all of the interviewees’ remarks were comparable. For example: some interviewees focused on the organization of the construction industry as a whole, while others went into

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detail about contractual aspects. Despite these differences (mainly in scale), there were lots of parallels and opposed views, drawing a clear picture of the communication environment as formed by the construction industry. After the analysis, an overview of main topics was presented to the group of interviewees, sitting together. A discussion took place, during which nuances, additions and clarifications were made. Interviewees explained their views to each other, providing more insight in the background of opposing ideas. Based on this meeting, conclusions were drawn.

3.2 Results

Characteristics of the Dutch construction industry
The picture of the Dutch construction industry, as painted by the interviewees, is one of an industry made up of conservative, poor communicating stakeholders. Even more than in other industries, human factors seem to determine most whether construction projects develop in a good way or not: there needs to be some kind of “chemistry” between the individuals involved to make the process go well. Because of the small margins, the hierarchy within the supply-side is rigid and stakeholders behave in both strategic and calculating ways. This behavior results in a mutual lack of trust, reversely discouraging stakeholders to improve their communication. Interviewees point out that when something goes wrong, it results in pointing fingers on both sides, the claiming of extra efforts (and thus costs), coupled with a decreasing level of trust. According to the interviewees, trust is the main cause for principals’ wishing to be involved in the entire process. Because of their will to control every little detail, lots of consultants are involved. In infrastructure projects executive parties just seem to get involved in the latter stages of the building process only, whereas in public utility building or housing projects their input is being asked more and more in earlier stages of the process. Nevertheless, they still have little experience with it. As a result, executive parties only think about the product to build, and not about the problem it should tackle. Conversations therefore tend to be about product specifications and project plans rather than about functional requirements, wishes and needs. Despite the fact that communication has been organized in much the same way for a long time, interviewees state that a dialogue is starting: constructors are rethinking their professional relationships with clients, and government realizes that procurement should be less detailed. Over all, interviewees praise the industry for its commitment, hard work and competency.

The importance of improving communication
In general, the interviewees do not perceive construction communication as problematic; however, they admit that communication processes are far from optimal. As a main consequence of poor communication, a waste of time was mentioned. For example, errors from early stages have to be solved later. Moreover, making adjustments in latter stages of the building process usually costs extra money. Interviewees think that improved communication would probably lead to less delays and lower expenses. In addition, all stakeholders’ satisfaction about both the process and the quality of the product could rise when they would communicate in a better way.

Factors influencing communication
According to the interviewees, the main problem of communication in the Dutch construction industry lies in the lack of stakeholders’ ability to empathize with the other parties involved. This is especially the case between demand side and supply side parties. Since designers and constructors do not experience how their choices affect the use and maintenance of the product, it is difficult to communicate about these topics. This results in constructors who do not think along with the principal; principals who are not open-minded to the constructors’ input; and designers who design objects that do not always match the wishes and needs of their principals. In addition, the stakeholders’ perception of their roles in the process is not always perceived as professional. Interviewees feel that principals do not always think thoroughly about their wishes and needs, and do not take charge in order to enforce their will. Neither are constructors as mature as interviewees think is necessary: too often they behave in strategic and calculating manners. The interviewees agree that the preparations of the project are important. Principals need to get their requirements more clear and therefore enough time should be spent on the brief. Interviewees argue
whether the brief should be detailed or not. Some think the brief should contain mainly functional specifications (in order to optimally use the supplier’s knowledge on possible solutions); others think that specifications should be unambiguous and detailed (in order to prevent misunderstanding about the desired product). However, interviewees share a complete consensus that the principal’s view of his or her own role is crucial. The best base for clear communication is when principals actually see themselves as chiefs and also act like this by being straight about the requirements and making clear the do’s and don’ts. Finally, interviewees talk about an imbalance in stakeholders’ power and about poor (mainly financial) agreements, especially in the public sector. Openness about the budget available and mutual responsibility could positively affect communication.

**4 The problem of communication in construction and a research set-up**

The expert interviews, conducted in the Netherlands, reinforce the findings in literature. The communication influencing factors as mentioned by the interviewees do fit into either the organization of the construction process or the interests of stakeholders involved or their frames of reference. Looking at the interview results, interviewees seem to focus on the communication between stakeholders at the demand side and stakeholders at the supply side. This is where they reported most problems and demand-supply communication seems thus worth to be studied in more detail.

In the literature, communication in the construction industry is studied quite extensively; however, the subject of demand-supply communication has not yet been looked at thoroughly. Because of this lack in literature and because of the relevance of the subject to the construction industry, the objective in our research project is defined as obtaining insight in the organization of demand-supply communication processes in construction and developing an approach to improve the effectiveness of this organization.

We define communication as a process in which the participants create and share information with one another in order to reach mutual understanding (according to Rogers and Kincaid [1981]). Main research questions that need to be addressed are “How is demand-supply communication organized in construction?” and “How to design effective demand-supply communication processes for construction projects?”. To answer these questions, we designed the following research set-up.

**a) Literature study:** As the aim is to contribute to the fields of communication (contributing to the knowledge on group communication, since stakeholders in construction are part of different working groups), management (defining how the organization of demand-supply communication works in construction) and construction (improving demand-supply communication), the previous literature study in the field of construction will be expanded with an overview of relevant studies on demand-supply communication in the fields of designing and management. Several tools are already available with an influence on demand-supply communication. Since there is little scientific base on the working of these tools, in addition an overview of demand-supply communication influencing instruments and methods will be made (not necessarily in construction).

**b) Theoretical framework development:** Dainty, Moore and Murray [2006] combine several communicational [Shannon and Weaver 1949]; constructional [Walker 2002]; and organizational [Handy 1999]; [Banner and Gagne 1995] theories and ideas into a model for group communication. In this model both formal and informal communication routes have their place. Group members are seen as individuals, yet acting from within a group. Factors of influence in this model are members’ roles (formal and informal); their levels of maturity and expertise; and all kinds of noise (language differences; varying frames of reference; physical noise (like plant and machinery), etc.). This model seems a good starting point for studying demand-supply communication. In construction, stakeholders’ representatives are both part of their employers’ team and cooperate with representatives of other stakeholders in working teams. All communication influencing factors as identified from literature can get their place in Dainty, Moore and Murray’s model. The model could be further developed and adopted to the goals of our research.

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c) **Empirical study**: In order to study problems with demand-supply communication in the practice of construction, the organization of demand-supply communication will be studied in several building projects, including tools used to enhance this communication.

d) **Organization of demand-supply communication processes**: The empirical findings will be analyzed within the theoretical framework to obtain insight in the organization of communication processes and factors that influence this. The effects of methods and instruments on this communication will be studied.

e) **Development of approach**: The insights gained will help to make recommendations for the use and/or development of methods and instruments to improve the organization of demand-supply communication in construction.

### 5 Conclusions and recommendations

A project for improving communication in construction was defined. Based on a first literature study into communication in construction and some expert interviews in Dutch construction industry, it was possible to define the problem of communication in construction in more detail. It turned out that most problems were reported in the communication between demand side and supply side stakeholders. The strong interaction in construction projects between stakeholders on the demand side and on the supply side seems to make construction projects very vulnerable to communication problems. Based on this problem definition, the main research goal and research set-up could be defined.

Although a limited amount of experts in the (Dutch) construction practice were interviewed, the interview results give already a quite good impression of communication (problems) in construction. A more extensive empirical research and a comparison with the communication practice in other countries should be performed to get a more detailed and complete picture.

Based on the lack of literature on demand-supply communication in construction, it can be stated that more research on demand-supply communication is needed. As it seems that in other industries interaction between the demand and the supply side is much looser, this offers an extra argument to study the peculiarity of this kind of communication in construction and to compare it with that of other industries, in order to learn from them.

In this paper one way of approaching the problem is proposed. Other possibilities would be, for example, participant observation [RAI, 1951] or surveys [Cicourel, 1964]. The difficulty with participant observation is that it would be a big challenge to remain independent. When one would choose to conduct this kind of research, one would have to strive to participate with several stakeholders, perhaps in different cases. Surveys may result in socially desirable answers.

### Acknowledgements

We would like to thank all experts who participated in the interviews of this first study for their time and commitment to the research project. Furthermore, we like to thank PSIBouw for their funding of our research project.

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**The problem of communication in Construction**
Soft Computing Case Based Reasoning as a IT support for the initial briefing stage of a construction project

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KEYWORDS
project brief, project definition, architectural management, case based reasoning, soft computing

1 Introduction

There is a great need for IT support for the initial briefing stage of a construction project, that will allow greater access to information required in briefing and will improve the process of identifying client needs. The problem of poor conversion of project brief into project definition, due to the poor business analysis and facilities management, could be eliminated by an improved business analysis and standardisation of information requirements. IT support at the early stages of briefing is weak in the transitional period handing over to design (Betts et al. 1999a).

According to the British Airport Authority (BAA 1994) study, core processes in construction, which make an important contribution to the production process in building, in order of importance, include: construction and manufacture, design, project definition, business analysis and facilities management. Sub-processes of project definition process are: client needs identification, briefing, scope definition and formation of consulting team. A detailed study of of these different processes enables the identification of inhibitors against smooth process flow (hereafter called blockers) and provides suggestions for their elimination (eliminators). This is accompanied by a workplan aiming to create a IT supported innovation strategy. Suggested IT supported workplan for elimination of project definition blocker are: code of practice for briefing developing, external and internal best practice benchmarking and a Case Based Reasoning - CBR and Knowledge Based Systems - KBS as a IT tools.

The main goal of this paper is to create a CBR model for discovering and retrieving historical project definition solutions - HPDS stored in integrated project databases (data from the conceptual, design, construction, operational and renewal project phases) and Construction Knowledge-Base – CKB (basic element in national IT strategies for construction). In that way it is possible to provide responses in cases where similar project definition solutions in the past do not exist. One of possible solutions is in application of soft computing, for overcoming the problem of imprecise, unreliable and indefinite data.

2 IT Support In Project Definition Process

According to the many research studies from the Construction IT Forum (1995), The Technology Foresight: Report of the Construction Sector Panel (OST 1995), Bridging the Gap report (DoE 1995) and Construct IT Centre of Excellence (1995), specific information technologies that are research priorities in construction are Virtual Reality - VR, CAD, Knowledge Based Systems - KBS and Integrated Databases - IDB.
There is a great need for marketable software for the initial project definition stage of a construction project, which will allow greater access to information required in briefing, will improve the process of identifying client needs, and will be linked to an effective facility for future design visualization. The emphasis on the need for improved project briefing and partnering reflect issues raised in the influential UK Building 2001 studies (Centre for Strategic Studies in Construction 1998). The emphasis on project information integration, knowledge-based engineering systems, and the adoption of virtual reality as a key technology also support mayor recommendations that emerged from the Technology Foresight in Construction report implemented by the UK office of Science and Technology (OST 1995). Latham Report (1994) and Egan Task Force Report (1998) also lend particular support to IT supported process change and integration of design and construction processes in construction. These initiatives are part of an effort to substitute a highly integrated production line process in construction (feasibility, concept, prototyping, manufacturing, logistics and site assembly) for the traditional system of producing buildings (feasibility, concept, design, tender, construction) (NCE/NB 1995). In comparison to world class practice in car manufacture, IT support at the early stages of briefing is strong, but very weak in the transitional period handing over to design.

3 Industry Knowledge Base in Construction

Globally speaking in recent years emphasis has been put, through great efforts, on deriving a national IT strategy for construction. One example of this is found within the UK, where in Construct IT: Bridging the Gap (1995) report a technological vision is specified towards which a series of implementation efforts are currently being directed. The central elements of this vision are an Integrated Project Database – IPDB and an Industry Knowledge Base – IKB. IPDB is an integrated database containing all data from the conceptual, design, construction, operational and renewal project phases of construction project life cycle (Betts 1996).

In order to preserve, spread and manage the knowledge accumulated in previously realized construction projects, all IPDB can be gathered and stored in a newly created Construction Knowledge Base – CKB. A CKB presents an example of Industry Knowledge Base – IKB, at the construction industry level. The need for an Industry Knowledge Base – IKB (in construction industry it is CKB) was identified in the Construct IT report produced by British Telecom and Andersen Consulting (Construct IT 1995). The basic concept of the CKB is that of "Construction Information Gateway" acting as a single entry point to a set of distributed databases. Current KBS usage in construction includes design synthesis, cost estimation, fault diagnosis, failure prediction, and indeed, most of the construction processes.

4 Case Based Reasoning Applied As A Decision Support In Project Briefing Phase

Contemporary IT application in project briefing is very scarce. This is the result of the very specific nature of briefing. On the other hand, different applications of CAD technologies in next main design phase of building project are very important and fully acceptable in construction companies. To change this situation it is necessary to include decision-making processes from previous projects, in order to capture Tacit Knowledge of those projects.

This paper presents a CBR model based on Rough Sets Theory for discovering and retrieving adequate and quality historical project definitions - HPD stored in IPDB. Using this model, it is possible to describe present problem with its salient characteristics. CBR system based on RST matches salient characteristics of present project definition problem with salient characteristics of HPD from historical IPDB stored in CKB. One of the HPD whose salient characteristics best matches salient characteristic of present project definition problem is retrieved. CKB should preserve developed and rare knowledge in such form that can be efficiency distributed to anyone who needs it. The aim is to realize more robust, more general, more efficient and more effective CKB that perform more complete reasoning cycles and cope with deficient data. Data from CKB can be interpreted using the Rough Sets Theory - RST, which is one of the latest mathematical approaches to definition and analysis of imprecise, unreliable and indefinite data (Pawlak 1982).
In project definition phase it is necessary to make decisions about some of project solutions, which are most suitable to meet client needs. Considering the client needs, it is necessary to develop salient characteristics for the bridge project (working example in paper) that have to be matched with salient characteristics of historical project definition - HPD for previous bridge projects. Similar problem description and CBR system make it possible to retrieve historical project definition - HPD with the best match of salient characteristics with the existing problem. Criterions stated in this example are: (1) Fast Construction, (2) Low Construction Cost, (3) Possibility for Prefabrication (assembling)

These criterions represent **conditional attributes**. Applicability of HPD for present project definition problem represents **decision attribute**. Values of attributes are presented linguistically. In this example it is assumed that there are four HPD of similar previous bridge projects in CKB: (1) **Pre-stressed concrete structure**; (2) **Composite steel and concrete structure**; (3) **Reinforced concrete structure**; (4) **Steel structure**

Conditional attributes and decision attributes are presented as four variants of HPD in Table 1. This table represents **attribute value table** or **decision table**. Columns in the table represent attributes (characteristic). Every row of the table is considered as information about particular HPD. For example, HPD 1 (Pre-stressed concrete structure) is characterized with the following set of attribute-value: (Fast Construction, Yes), (Low Construction Cost, No), (Possibility for Prefabrication, Good). This set of attribute values represents the information set about solution 1.

<table>
<thead>
<tr>
<th>Historical project definition - HPD</th>
<th>Fast Construction</th>
<th>Low Construction Cost</th>
<th>Possibility for Prefabrication</th>
<th>Applicability of HPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Pre-stressed concrete bridge structure</td>
<td>Yes</td>
<td>No</td>
<td>Good</td>
<td>Yes</td>
</tr>
<tr>
<td>2) Composite steel and concrete bridge structure</td>
<td>Yes</td>
<td>No</td>
<td>Good</td>
<td>No</td>
</tr>
<tr>
<td>3) Reinforced concrete bridge structure</td>
<td>No</td>
<td>Yes</td>
<td>Poor</td>
<td>No</td>
</tr>
<tr>
<td>4) Steel bridge structure</td>
<td>Yes</td>
<td>No</td>
<td>Excellent</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Table 1. Attribute value table (decision table) for HPD**

Solutions 1, 2 and 4 do not differ from each other compared to attributes Fast Construction and Low Construction Cost, while solutions 1 and 2 do not differ from each other compared to attributes Fast Construction, Low Construction Cost and Possibility for Prefabrication. Attributes Fast Construction and Low Construction Cost generate two elementary sets \{1,2,4\} and \{3\}, while attributes Fast Construction, Low Construction Cost and Possibility for Prefabrication generate three elementary sets \{1,2\}, \{3\} and \{4\}. Solution 1 represents applicable solution, while solution 2 represents inapplicable solution, although these solutions do not differ from each other compared to attributes Fast Construction, Low Construction Cost and Possibility for Prefabrication. That means that it is not possible to characterize applicability of solutions 1 and 2 compared to attributes Fast Construction, Low Construction Cost and Possibility for Prefabrication. Following conclusions can be drawn:

- Solutions 1 and 2 are **boundary cases** (situated on boundary line) and could not be correctly classified according to accessible knowledge.
- Remaining solutions show characteristics according to which they can be classified. It is obvious that solution 4 is applicable. It is also obvious that solution 3 is not applicable. For solutions 1 and 2 it is not possible to exclude that they are not applicable.
- Lower approximation of "Applicable Solution" (solution that can be retrieved during the work on present project definition problem) is set \{4\}. Upper approximation of these sets is set \{1,2,4\}. Boundary cases are solutions 1 and 2.
- Solution 4 is applicable and decision is to retrieve it, while solution 3 is not applicable and decision is not to retrieve it.
- Lower approximation of notion "Inapplicable Solution" is set \{3\}. Upper approximation of this notion is set \{1,2,3\}. Boundary area in this case is set \{1,2\}. 

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**Soft Computing Case Based Reasoning**
It is possible to eliminate excessive attributes with **reductors** \{Fast Construction, Possibility for Prefabrication\} and \{Low Construction Cost, Possibility for Prefabrication\}. Rules that have the same conditions but different decisions:

- IF (Fast Construction, Yes) & (Possibility for Prefabrication, Good) ⇒ THEN (Applicable Solution, Yes)
- IF (Fast Construction, Yes) & (Possibility for Prefabrication, Good) ⇒ THEN (Applicable Solution, No)

These two rules are inconsistent, or indeterministic. Other rules are consistent, or deterministic. Inconsistent rules do not permit definite answer and decisions. **Factor of Reliability** for above inconsistent rules is 0.5. **Partial Dependency** is 2/4=0.5.

### 5 Discussion

CBR offers a different slant to the more conventional KBSs, e.g. **Rule-Based Systems-RBS**, and may overcome some problems associated with rule-based systems. Thus it would appear that CBR offers the potential to develop true 2nd generation expert systems which employ multiple representation and reasoning methods (David *et al.* 1993). Presentation of created model is shown in Fig. 1.

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**Figure 1. Application of Created CBR Model based on RST as a Decision Support in Project Definition Phase**

Result of the application of CBR model based on RST is one potential solution for the current problem. Solution suggested by CBR system could be considered as IT support for decision-making in project definition process. Selection and retrieving of quality project definitions included in IPDB, which are stored in CKB, facilitate the shortening of project definition process. HPD suggested by CBR system sets the Standard of Quality, which should be maintained or exceeded during the briefing.
Although the application of created model is in the project definition phase, the results of this application are far-reaching and continue in the next phases of project life cycle, like the design and construction phases. There are numerous examples of building designs, which need to be modified, or completely changed in order to correspond to the adopted construction technology. This is the consequence of one of the biggests problems in construction industry - separation of design and construction processes. In historical IPDB stored in CKB all data and corresponding knowledge about construction technologies are included, as well as explanation of different problems that have been shown during construction phase. In that way a lot of potential problems, which can arise during the construction phase of project, can be eliminated.

Created model can also make improvements in operational phase of the project. All data related to built-in equipment and its maintenance are also stored in IPDB. In that way it is possible to include some of the existing knowledge in present project, during the briefing phase, in order to exceed problems corresponding to built-in, function and maintenance of equipment.

6 Conclusion

The reasoning model, based on the application of Rough Sets Theory in Case Based Reasoning system, enables IT support for project definition phase and should discover and retrieve previous quality project definitions, which could be found in historical IPDB, stored in CKB.

The main advantage is that model does not require previous or additional information about data, as is the case with possibility degree in Fuzzy Sets Theory or probability of events in statistics. The main shortage is that in any possible case of decision analysys it prevents getting all determining rules.

Direction for further development of the suggested model is in the further expertise of the existing project definitions, which has to adopt previous experience to the current needs, since CBR systems could not rely only on the historical cases of project definitions. That can be achieved using the general rules, models, etc. In that way it is possible to provide responses in cases where similar project definitions in the past do not exist. One of possible solutions, which can provide further development of CKB, is in application of Rough Sets Theory in CBR systems, for overcoming the problem of imprecise, unreliable and indefinite data.

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The Communicational Aspects of the Building Process

– A Necessary Expansion of the Scope

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KEYWORDS
Building process, communication aspect, external client consultant, project management, Denmark

Abstract

Co-operation, coordination, and clear communication are aspects of the building process related to human interaction, which are now gaining priority within the field. The growing interest in the human interaction aspect of the building process can be seen as a sign of recognition of the need for adjusting to the change in the marked conditions. On these grounds a study of the communicational aspects of the building process in the form of a preliminary study of the organizational structure where the client chooses to include an external consultant in the building process to function as the client’s representative - a structural choice departing from the tradition and now becoming a trend in Denmark. The objective was twofold: firstly, to reach a better understanding of the reasons for and implications of this – now common but sparsely studied – structural choice and specifically the role of the client consultant, and to examine whether there is basis for a further study of this role and its conditions, and secondly, to explore the potential in doing such a study through a communication theoretical approach and method. The study was based on a selected case study of a building project, which is now under construction, with completion due in the autumn of 2007. The study points to a potential lying in applying a broad conception of the communicational dimension of the building process as to include communication at a strategic level when organizing and managing the building projects.

Expanding the scope - introduction

Judged from the focus of current initiatives to improve the building process what seemed hitherto to be a widely accepted assumption that it is within the sphere of theses processes’ technical characteristics that lie the biggest challenges for the building industry in the future, seems finally being challenged. Both researchers and practitioners within the field have tried to draw attention to issues regarding organization and management, not only as central elements of the building process but as areas where challenges facing the industry can be identified and action should be taken. Co-operation, coordination, and clear communication are elements mentioned as crucial for the functioning of the building process - e.g. by Emmitt [1999], Saunders [1996], Fisher [2000], Werborg [2001]. These aspects of the building process related to human interaction now gain priority partly as a result of the success obtained by experimenting with the methodical principles of partnering and lean construction [Erhvervs- & Byggestyrelsen 2002, Bertelsen & Høgsted 2003, Andersen 2004, Christensen 2006, Jensen 2001].
The growing interest in the human interaction aspect of the building process can be seen as a sign of recognition of the need for adjusting to the change in the marked conditions. As in other fields marked by the intensified globalization it continuously becomes harder to operate in the building industry, or put in another way, the growing competition demands of the building professionals to change, to renew their perceptions and adjust their conduct [e.g. Fisher 2000, Ockman 2000, Saunders 1996]. Recognizing the heterogeneous and complex character of the building process can be seen as an initial step in this indispensable adjustment process. On these grounds a study of the communicational aspects of the building process becomes highly relevant. Not only can it unfold a hitherto neglected dimension of the building process and thereby provide knowledge of great importance in regard to developing the methods, which can account for the changed conditions. This is needed since the widening of the scope on the building process, which the recognition of its multidimensional character represents, demands a corresponding match in the methodical approach. This means an approach, which can assure that the multidimensional character of the building, is accounted for in the way the process is handled.

Also a communicational study can show that the communication represents a complex dimension in itself since communication is both a part of the object to be improved by the various initiatives – the building process – and a part of the way of the very improvement process since handling the transition - changing habits and view and engaging in experiments with new methods - demands of the people involved to communicate. This duality represents a challenge in itself adding to the multitude of conditions which one needs to bear in mind and consider when working improving the building process. In this way introducing new methods for structuring and managing building projects when given the prospect of better solutions concurrently unfold the building process, exposing seemingly new layers and thereby making the extension of the complexity of the process only more evident. This is why studies of the communication aspects of the building process are needed.

The role of the client consultant from a communication perspective – a preliminary case study

Within this contextual framework it becomes interesting to take a closer look at the organizational structure where the client chooses to include an external consultant in the building process to function as the client’s representative - a structural choice departing from the tradition and now becoming a trend in Denmark. Regarded from a communication perspective the client consultant can be seen as representing a bottleneck in regard to handling the flow of information between the client and the other parties involved which in itself can affect the coarse of the process. The inclusion of such a role in the project organization also changes the the participants’ organizational frame of reference which might have a detectable destabilizing effect on the process. A study of this specific way of structuring a building process is interesting not only because it will provide general knowledge of this hitherto only sparsely studied organizational structure. By focusing on the communication aspects of this organizational structure a neglected dimension of the building process will be rendered visible. At the same time, light will be cast on the role of the client representative and the conditions for its exercise – a role which has emerged from clients immediate need of a representative and is still in the process of consolidation into the existing practice.

The structural choice which includes a client consultant as representative in the organization is intriguing seen from a communication approach since it implies adding to the already considerable amount of managerial challenges by increasing the complexity of the organization as well as the communication structure [Walker 1998, Wilkinson 2001]. Thereby it enhances the risk of hampering the flow of the process. Including a client consultant in the organizational structure and placing it – as is often the case – in a mediating position between the client and the rest of the process participants can be seen as an indication of the client’s wish to simplify the relation to the rest of the project organization. The client consultant can function as the single channel of communication giving the client advantages in regard to control of the information flow, getting the sufficient degree of professional assistance and advise, making it possible for the client to decide the degree of his/hers involvement in the everyday procedures of the building process. At the same time bringing the client consultant into the organization adds to its
complexity and adds a link to the chain of communication. These reflexions have been the outset for this preliminary study.

In the autumn of 2005 a project was initiated in order to investigate the potential in doing a further study of the communication aspects of the building process when organized as above-mentioned. The objective was twofold: firstly, to reach a better understanding of the reasons for and implications of this – now common but sparsely studied – structural choice and specifically the role of the client consultant, and to examine whether there is basis for a further study of this role and its conditions, and secondly, to explore the potential in doing such a study through a communication theoretical approach and method. This has been done on the basis of a selected case study consisting of qualitative interviews with key individuals from the central parties in a building project, which is now under construction, with completion due in the autumn of 2007. Their statements have been treated employing a communication theoretical method.

The building process from a communication perspective – theory and method

The theoretic and methodical framework of the study is based on the French professor in communicational studies Alex Mucchielli’s formulation of a systemic communication theory which he names La théorie systémique des communication and its derived method. It represents a communication approach consisting in examining the communication aspects of the process as a dynamic systemic structure. Applied to the context of the building process this implies defining the building process as a dynamic communication system constituted and maintained by the interaction of its participants [Mucchielli 2000, Mucchielli 2005]. The basis for defining it as a system comes of the following hypothesis: the actors are interrelated through their communication interchanges, which in turn are interconnected through a circular feed-back systematic. This means that an exchange always implies a response reaction, which in turn implies a response and so forth, leading to what Mucchielli calls an action-reaction dynamics. Due to a certain degree of routine in the behaviour of the actors their interchanges take on a typical character that makes it possible to detect a pattern. This tendency towards typification equally becomes a characteristic of the structure in which the actors’ interrelations can be inscribed, giving the structure a certain degree of stability, which justifies defining it as a system.

Analyzing the building process in this theoretical context involves ascribing a certain degree of predictability and typification to its structure and functioning. This means that the participants – when stepping into a new building process - have a notion of what to expect in regard to both the organizational conditions that define their liberty of action and the actions of the other parties. These expectations have many sources including a conception of the function and position of each participant in the process. So what happens when the organizational structure of the process is changed by the introduction of a new or different role such as the client consultant? How do the participants handle the situation? Do the participants accord their perception of the roles and positions, their expectations and actions with the new organizational change? Or will they still – to some extent – act in reference to their former expectations though the foundation for these have changed? These are some of the questions, which have worked as leading threads in the current investigation of the functioning of the building process.

Summery of the results from the preliminary study

In the selected case the participants defined the role of the client consultant as the one keeping track of budget and costs during the process, seeing to it that things run on schedule, surveying that the other participants live up to their responsibilities as these are formulated in their separate contracts with the client. The goal of this being to assure the client gets the ‘best possible building within the given budget delivered on time’. In order to do this the client consultant needs to keep track of the flow of the process as a whole. This implies being well informed which in turn demands staying in continuously contact with the rest of the project organization. Apparently the flow of information had been successfully suited and systemized by specific and detailed procedures so as to make the flow of communication as simple as possible all while providing the participants with the information they need, when they need it. This could be the possible reason that the participants did not experience it as problematic that another link had been
added to the ‘line of command’ though it implied an increase in the distance between the client and the rest of the project organization. The communication aspect concerning the direct facilitation of information is not seen to represent any noteworthy challenge, as it does not affect the level of performance. So this aspect of the client consultant’s role did not – in this instance of practice – represent the challenge, which in a communication theoretical perspective had seemed to be the case. This must be seen in relation to the specific conditions for the process leading to an untraditional division of responsibility between client, user and client consultant.

As expert on the functionality of the building the user has been authorized to play a primary part in the decision-making regarding the design on behalf of the client. This means that in the given building project the client consultant has in fact not been the client’s single link to the project organization and vice versa. Or at least, seen from a communicational perspective the client consultant has shared the role as the client’s representative with the user who has in some way also represented the client by means of assigned authority. However, in practice the user does not participate in the process on the same practical day-to-day level as the client consultant and so, in relation to the rest of the project organization the client consultant still is still both regarded as and functioning as the rest of the organization’s main contact to the client. The high degree of user involvement does, however, pose a challenge to the client consultant since it demands of him to work in close collaboration with the user all while staying alert towards the users dispositions to ensure that these do not favour the users interests at the expense of the that of the client. This means that the client consultant – view not only from a communicational perspective – in fact rests the primary representative of the client in the sense that the client consultant’s primary objective is to ensure the client’s interests – satisfactory qua lity within the given time and budget.

Under the given conditions one could suspect the possible overlap between the responsibility field of the client consultant and that of the user give rise to conflict. However, this has not been the case probably due to the high degree of commitment and cooperativeness shown by the parties involved. In practice the collaboration between the client consultant and the user is marked by informal manners – as goes for the project organization as a whole – and a high degree of trust. This is interesting in relation to the points stated by J. R. Turner and R. Müller (2004) about the principal-agent relation between project owner and project manager. They find that medium level of structure and high degree of collaboration between project owner and project manager are key factors for obtaining the best project performance. The relation between the client, the user and the client consultant in the given project could be considered an example of such a combination. They define collaboration as ‘combining clearness of objectives and relation norms’ which they consider ‘reflects the clarity of the end deliverables and the nature of the working relationship’ [Turner & Müller 2004]. This is interesting in regard to the relation between the client consultant and the manager of the projection of the design in the given case. The study showed incoherence between their understanding of each other’s role and the boundary between the two. Constituting a grey area between them a responsibility void emerged which in after some time started to affect the other participants directly and the progress of the process indirectly. The analysis indicated that a clarification of the roles and the responsibilities assigned to each participant earlier on in the process could have ensured a mutual understanding between the two, removing the cause for the conflict and thereby preventing it. This is not only interesting in regard to solving or avoiding specific conflicts between to parties in the building process. Within the framework of this study the question becomes relevant in the examination of the role and position of the client consultant in conjunction with a critical discussion of how the communicational aspects of the process are handled.

The conflict springing from the apparent incoherence of each participant’s perception of each other’s roles gives rise to two questions. The first concerns the incoherence itself the essence being the question of empowerment in relation to financial authority. It lies beond the scope of this paper to elaborate this issue, however, it is relevant to point to as an essentiel part of any further study – not only because it playes an important part in the relation between the client consultant and the client cf. Turner & Müller [2004]. It must also be considered as relevant in relation to a general discussion of the roles and functioning of the building process. The second question springing from the analysis of the conflictous situation concerns how communication is viewed and accordingly handled as a dimension of the building
process. In the case studied communication is primarily viewed on a very concrete level as specific tasks having to do with the flow of information. The responsibility for communicating – understood as handling information - is assigned each participant as a part of his or her role. In opposition to this I propose – on the basis of this study – to apply a broader conception of communication in relation to the building process. This should consist in including a more abstract understanding of communication, not only as exchange of information but as human interaction being a much wider concept. By adding a structural approach to the expansion conception of communication room would be created for a more strategic use of communication and thereby exploiting the neglected potential in the conditions for the process. An objective of such strategic work could be to create optimal conditions for collaboration and good communication during the process. The study pointed to clarification of the roles and accordance of the participants’ expectations to individual and collective performance as a means to improve conditions for collaboration. In relation to a further study of the role of the client consultant as the client’s representative it would be relevant to examine the role in the context of the expanded scope as suggested above – where the building process as a whole and the communicational dimension in itself are view as complex structures. Given the role of the client consultant – bearing in mind that it is role still in the process of consolidation - consists in ensuring interests of the client ensuring the conditions for good communication approach on a strategic structural level could be seen as a natural part of the client consultant’s role in the future.

Also consisting in testing a communication theoretical method the study proved fruitful in the sense that Mucchielli’s systemic communication method resulted in an unfolding of the relations of the participants in the selected building project. On the basis of the findings of this preliminary study there seem to be potential in exploring theories of communication in relation to studies of the functioning of the building process and the roles involved. However, being a preliminary study it did not give sufficient basis for evaluating the specific theory and method used in opposition to others.

**Topics for further study**

As illustrated above this preliminary study pointed to a potential in expanding the scope of the building process by exploring it’s communicational dimension. Thereby the study touched upon a range of topics bearing potential for further study. Some of the central topics being the following:

- Including communication on a strategic level in structuring and managing building projects:
  This could consist in exploring the potential and the possible ways of implementation e.g. by a detailed study of the conditions for the interaction between the participants in the process.

- The role of the client consultant:
  This could be in form of a more detailed study of the communicational dimension either by considering it in the context of a broader conception of communication integrated at a strategic level in the management of the building process, or by studying the process of consolidation of the role itself by means of a communicational approach

- Communicational theory and method:
  Consisting in experimenting with applying different communicational theories and methods in the context of the building process

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Understanding Value in the Briefing Process

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KEYWORDS

Value, briefing, product, process.

Introduction

In building projects, a frequent complaint is that the client’s brief as a document is ineffective for communicating the client’s wishes, needs, and requirements to the project participants. An effective briefing process is essential for achieving a successful building process where the outcome is a client satisfied with the structure delivered, and project participants who are satisfied with their contribution margin. To ensure this, value should be a main concern in the briefing process. In this context, value can be perceived both as delivery of a product to the client, and as the cooperative process of developing and communicating the client’s brief. This is typically carried out more or less successfully through Value Management and Value-Based Management, respectively.

Two value paradigms

When broadening the value concept, there is an important difference between value in singular and values in plural. “Value is what an individual places upon an object or an outcome, i.e. the value one places on pay” [Meglino & Ravlin 1998, p. 353]. What Meglino & Ravlin state is that value is related to assessments about a product and the price. An example of this view can be found in Lean Production, where Womack & Jones [1996, p. 311] define value as “a capability provided to a customer at the right time and at an appropriate price, as defined in each case by the customer.” Basically two types of the described value exist; utility value and market value. Utility value is associated with the technical and aesthetic construction and the use of the construction, e.g. brick type, top lighting, colour, usability, flexibility, etc. Market value is closely connected with the utility value. It describes the value of utility and quality in money and relates to demand.

Values, on the other hand, are the principles by which we live, or one might say that values are our individual bible or the paradigm through which we see the world [Covey 1989]. They are the core beliefs, morals and ideals of individuals and are reflected in attitudes and behaviours in society, like “At the bottom of all human activities are values,(…)” [Köhler 1966], and “Whether a behaviour is morally correct or not is determined by the values that lie behind the decision”, [Hauen et al. 1999, p. 45]. In the briefing process, and in the rest of the building process, values are the core fundament of successful interpersonal communication, coordination and understanding, e.g. cooperation.
In other words, values are personal guidelines like “It is against my values to lie”, whereas value relates to a product and its assets, and it is often connected to monetary relations like “The new Skoda is of great value” [Wandahl 2005, p. 56].

**Product and process value**

A transformation of the value concept into the context of building projects is not straightforward. Some suggest that the two types of values could be identified as product value and process values [e.g. BEC 2003; Wandahl & Bejder 2003]. A distinction between product and process is useful in construction, and this division has prior been debated in the Danish construction industry [e.g. EBST 2001]. To talk about a product viewpoint is mostly relevant as the purpose of a building project is to build and deliver a product (a structure) to a client. The client has requirements, wishes and ideas to the product, e.g. quality, usability, flexibility, design, price, etc. The architectural, economical, material and functional aspects of building are hence gathered in a **product value** paradigm. The product is determined, designed and erected in the building process. The building process is hence means to an end. In this process all the participants need to cooperate to fulfil the reasonable needs and requirements from the client. The success of this process is highly dependent of the personal values of the participants and the common values of the project. The second paradigm is, therefore, the **process value** paradigm.

The two value types are considered to be paradigms because they reflect two general but different types of value, and because all other descriptions of management concepts related to value can be embodied in these two paradigms, cf. Fig. 1.

![Figure 1. The two value paradigms prompt two different management positions, Management of value and Management by values.](Image)

Two meta positions of management (management of value and management by value) are derived from the two paradigms. They do not describe pragmatic and specific management tools, procedures, etc., and are hence considered to be meta positions within building management related to value. Finally, Value Management, Value Engineering and Value-Based Management are examples of management concepts derived from each of the value paradigms. Value Management is a name for practical management concepts aiming at defining what product value means to a client organisation within a particular context, and to ensure that the value defined by the client organisation is embodied in the design solution in such a way that it maximizes the client organisation’s value for money relation. This mainly entails workshop-alike-approaches in the briefing process and enforces a focus on the brief-design interface. Value Engineering is also concerned with the product value, but Value Engineering focuses on cost optimising the design solution and the manufacturing process. Furthermore, to ensure all elements in the design solution are buildable and carried out during construction. Value-Based Management on the other hand is based on the soft management approach of applying process values as means to increase the product value delivered primarily to the client organisation, and secondly to the other project participants. This involves a definition and description of common values for the whole project organisation, which unconsciously influence human behaviour in a more proactive manner, i.e. an empowerment of all the project participants to improve their background for decision-making and coordination of these actions mutually.

**Understanding value in the briefing process**
**Value(s) used in the briefing process**

In the briefing process the client’s reasonable entitled needs, requirements, and wishes should be explored, elaborated, and communicated in a dialogue between client and designer [Hudson 1999; Kamara et al. 2001]. Moreover, the aim of the project should be stated, and the needs should be uncovered and if possible weighed, and the desired quality level should be stated. This involves a range of activities and decisions, which have high impact on the subsequent building process. Many of the decisions taken in the briefing process have long term consequences. It is, therefore, important with high effectiveness, i.e. to determine the right product. Due to the dynamic conditions in the early phase of construction it is also important to aim at a high efficiency, e.g. the right briefing process. For that reason, both of the value paradigms should be in focus in the briefing process. The product value paradigm and the process value paradigm are subsequently discussed in the following two paragraphs.

**Management of value (the product value paradigm)**

Decisions in the briefing process about the product are a main activity, and the product value paradigm therefore plays an important role. Derived from the product value paradigm the management position ‘management of value’ occurs. Management of value is the traditional approach where well-known systems and structures are applied to ensure that the product value required and needed by the client organisation is realised in an efficient manner. It seeks maximization of the value delivered to the customer plus increased marginal profit for the project partners. Furthermore, it focuses on the goals described in the client’s brief, and the goals mainly belong to the product value category. The emphasis on “of” is because value is not used in the management, other mechanisms are applied to obtain value.

Value Management is perhaps the most known management discipline in the briefing process based on the product value paradigm. This Value Management process is critical for a successful construction. In the brief the project team and the client has great ability to influence the cost of the project, because most of the cost is allocated in the brief but not realized until later [Abdul-Kadir & Price 1995].

The purpose of VM is in other words to increase the effectiveness, i.e. to decide the right value. However, primarily the client decides what the right value is, and it is therefore vital to understand the client’s value system. This is not easy because all the client’s needs are not explicitly known, neither to the client himself nor to the project team. This situation is in the Johari Window framework referred to as the closed part of the window [Luft 1984]. An implicit client product value system will result in an incomplete design solution, not containing all the client’s requirements, which again will result in a finished building that does not fully satisfy the client (received < expected). Kano presents a model that classifies the client’s requirements with the purpose of achieving as high customer satisfaction as possible [Kano et al. 1984]. Kano presents three different types of requirements. Must-be requirements are basic criteria of a product, which the client takes for granted and does, therefore, not explicitly demand them. In construction an example of must-be requirements could be, e.g. doors and windows, correct sound insulation and plumbing connections. If these requirements are not fulfilled, the client will be extremely dissatisfied. On the other hand, as the client takes the must-be requirements for granted, their fulfilment will not increase his satisfaction dramatically. One-dimensional requirements are expected by the client and, therefore, explicitly mentioned to the project team. The client’s satisfaction is proportional to the level of fulfilment. An example of this could be: roof light, installation of kitchen range, parquet floor, etc. Attractive requirements have the greatest influence on client satisfaction. However, they are neither explicitly expressed nor expected by the client. If these latent needs are not met, however, there is no feeling of dissatisfaction. If the briefing process not is worked properly, there is a risk of not recognizing must-be and attractive requirements. Furthermore, there is also a risk of not recognizing all of the one-dimensional
requirements when the briefing process is not taken seriously. The result is a design solution and later a construction which gives the client a poor perception of “value for money”.

Several elements affect the briefing process and hence make the briefing process full of hurdles. Some of the well-known challenges are the client’s level of professionalism and the size and complexity of the building project. In Barrett and Stanley [1999] the ‘human dimension’ is mentioned as problematic in the briefing process, i.e. an insufficient understanding of the individual and lack of efficient cooperation is a major root to briefing failures. The process value paradigm is, therefore, relevant to stress when seeking an effective briefing process.

Management by values (the process value paradigm)

The briefing process is a phase characterized by a high degree of uncertainty, dynamic, and involvement of many different persons. In such an environment traditional systems and structures are often inadequate for managing the process. Both in theory and in practice it has been indicated that soft process values as basis for influencing the human behaviour (management) are more efficient.

Management by values applies commonly agreed (shared) values as a supplementary mechanism to manage and control human behaviour. It uses process values as means to achieve the main goal of the building project. The main goal is still the delivery of product value to the client organisation. It is called management by values because values are an element used in the management, not the goal. In other words, the purpose is to achieve an efficient cooperation. Cooperation takes place among individuals, and the cooperation is hence founded on the process value paradigm.

Theoretically, it is acknowledged that process values directly influence behaviour, because they encourage individuals to act in accordance with their values [Rokeach 1973; Williams 1979]. Values are, however, only one of a number of forces that effect behaviour, but in situations of absence of other task and situational variables (e.g. incentives, limitations) that influence behaviour, values should have great impact [Meglino & Ravlin 1998]. This is often the situation we are dealing with in the briefing process, i.e. a high degree of uncertainty and a chaotic and dynamic process. Human values have implications for the interaction between individuals because they influence each individual’s perception and behaviour. Moreover, when persons share similar values (i.e., interpersonal value congruence), they tend to perceive external stimuli in similar ways. Among other things, this similarity in interpreting and classifying environmental events serves to clarify their interpersonal communications. Individuals with similar value systems also behave in similar ways. This enables them to better predict the behaviour of others and more efficiently coordinate their actions. In effect, value similarity produces a social system or culture that facilitates the interactions necessary for individuals to achieve their common goals [Kluckhohn 1951].

Discussion

The connection between process values and product value is perceived as a means-end connection where the use of process values is a means to the delivery of a product containing the client’s values (whishes, needs, and requirements), cf. Fig 2.

![Figure 2. Process values as a means to the end goal, i.e. the client's product value.](image-url)
Process values are hence normally not in itself a goal. The use of process values to influence behavior in the building process results in a more proactive management situation compared to when traditional steering mechanisms are applied such as systems (quality, time, budget, etc.) and structure [Wandahl 2005]. In the briefing process a proactive focus is important because the client together with the project partners have to make decisions on several future concerns. In the beginning of a project life cycle, where the dynamics and uncertainties are highest, the use of process values is most efficient. Later in the cycle, when the production is in progress and high productivity is needed, the traditional systems are efficient. Hence, the use of mechanisms to influence behavior shifts during a project life cycle.

Conclusion

Value in building can be understood through two different value paradigms. Firstly, product value which views value as the product and associated functions, services, etc. delivered to the client. Secondly, process values, which views value is the personal values stating the foundation of interpersonal cooperation. Both paradigms are active in the briefing process. The decision about and communication of product value is the essence of the briefing process. However, to be successful in stating these product values(goals), process values should be in focus to nurse and facilitate the cooperation in this process.

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Dynamic Briefing for Active Roofing

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KEYWORDS
Active Roofing, Dynamic Briefing, Integral Approach.

ABSTRACT

Traditional roofs have primary, passive, functions such as protection against rain, wind, snow etc.. Nowadays, roofs are more and more used as preferred location for additional functions such as photovoltaic systems, roof lights and safety devices. New approaches, on designing as well as assembling the roof, are necessary; tools for innovative roofs or Active Roofs. New ways of exchanging knowledge is therefore neccesary. This research offers an integral approach for knowledge exchange which is dynamic – related to the specific situation. Based on a domain dependant design method, complemented with morphological matrices, a toolbox for dynamic briefing is developed. In order to implement and train the knowledge for the several users, ‘learning by doing’ workshops are proposed. The knowledge generated in this project will benefit the Building Services research and education at Technische Universiteit Eindhoven, Delft University of Technology and the TNO Building and Construction Research. The developed methodology will also be implemented in the 6th European framework program; EUR-ACTIVE ROOF-er, with partners in industry and professional organizations throughout Europe.

1 Introduction

Nowadays, knowledge as the “fourth resource” of organizations is crucial for the success of problem solving and task performance [BuckinghamShum 1997, Roth 1997, Sumner & BuckinghamShum 1998]. This is especially needed in situations where multidisciplinary teams work on complex problems in a team setting [Baumard 1996]. Empirical studies show that learning and integrating available knowledge from the surrounding organization are strongly connected with the task performance [Lave 1991, Roth 1997, Suchman 1987, Ackermann 1993, Argyris 1993]. Yet, in workplace learning, companies rely on traditional schooling for their educational needs and on separate knowledge management structures for their situated knowledge-needs. On the other hand there is the development of tools based on web-based or it-based technology. In the design-building industry the effectiveness of these tools, used mostly separately and by different kind of participants from design- or construction-phase, is rather poor. This is caused partly by: the differences in culture of participants from design or construction, there different positions in the total process and the differences related to knowledge, skills, organization and responsibility [Quanjel & Zeiler 2003].
The transformation towards a knowledge society causes structural changes in the learning and work demands of professionals [Nonaka & Takeuchi 1995]. Nowadays, knowledge is crucial for the success of problem solving and task performance [Buckingham Shum 1997, Sumner & Buckingham Shum 1998]. Knowledge work requires multidisciplinary teams to collaboratively solve complex problems.

Due to the dynamics in the knowledge economy continuous learning is expected of knowledge professionals [Tissen 1998, Wiig 1994]. Yet, in on-site workplace learning, companies rely on traditional schooling for their educational needs and on separate knowledge management structures for their situated knowledge [Weggeman 1997]. There is little understanding of what is required to design adequate on-site learn-work environments that directly facilitates learning integrated with the learning and knowledge resources of the organization [Senge 1990, Suchman 1987].

The architectural design process is complex and has a vague structure. The designer starts from an ill-defined problem and through different steps and stages progress has to be made up to a blueprint for a solution [Simon 1973]. The conceptual design stage is rough and with little information. As the design proceeds, more information and detail will be developed. Though there is little information at the early stages of design nearly all the important decisions have to be made at this time. There is an influence/information contradiction or design process paradox [den Hartog 2003, Ullman 1992].

2 Active Roof: challenge for change of culture, process and products

The current situation for the roofing industry is one of delivering a specific roof for a building, a position in the total building process at the end of the decision-chain, with limited influence on the design- and the construction aspects. Due to his role as deliverer and sub-contractor with many other participants, the roofer has a very weak position with restricted added value. In the meantime many new products and participants are added to the building design and building process. Adding new elements to a roof requires specific knowledge of both the behaviour of the product and its effect on the building envelope performance. Related to the design-process there are many aspects which frustrate a better use of the collaboration between the roofers or roof-industry with clients and architects. First there is a lack of diverse information, language and knowledge. Secondly there are different levels of technical sophistication in the design and building process. Third aspect, if there should be a possibility to innovate; there is a lack of knowledge about innovative roof systems and how to integrate them in the building design [EURACTIVE ROOFer 2005].

Referring to the current situation there is a need for change. The word Active Roof is the concept word related to these changes; the possibility or need to change the culture, process and product related to the roof. Active has in this context several meanings. Active roof as an innovative product, a more active role in the design- and building process, change of the organization. An active attitude is needed in order to design and construct innovative and better roofs; knowledge exchange within the roof-industry and with their possible participants in design- and construction-phase.

The integral approach needed for the development of these knowledge and skills is defined by Quanjel and Zeiler [Quanjel & Zeiler 2003]. Integral design is meant to overcome, during design team cooperation, the difficulties raised with the early involvement of consultants. This is achieved by providing methods to communicate the consequences of design steps between the different disciplines at the early design stage. Related to the specific field of the roofer this means the direct connection of construction /user- and design-related knowledge.

In this study we propose to design and study knowledge-exchange support. This scientifically based support for collaborative work and learning is integrated with the knowledge management cycle of the surrounding organization. As such, this study integrates findings from science-based engineering, and knowledge of situated learning in the design context.
3 Methodical Design and Morphological Matrices: tools for dynamic knowledge briefing

Design is the key discipline that brings knowledge into being. In the engineering sciences, a lot of approaches have been developed to structure and optimise design processes: concurrent engineering, value engineering, design for manufacturability, systems engineering, quality function deployment, strategic design, etc. To develop our required model of design support and referring to the research of Blessing, an existing model from the mechanical engineering, Methodical Design, is used [van den Kroonenberg 1992, de Boer 1989, Blessing 1994]. The proposed tool focuses on support rather than automation, and on supporting the whole design process. A primarily problem-oriented, process-based model of design is used. The tool model of design is the morphologic matrix, which acts as the knowledge structure for the team. The model constitutes generic knowledge of a system as part of a design process, i.e. possible steps; relationships between the steps (based on contents rather than on the sequence of execution); and possible means to support the steps. [van den Kroonenberg 1992].

There are some results on the effects on the use of Methodical Design and morphologic matrices in professional design teams. Due to the PhD thesis for an Integral Design Methodology and developed workshops with morphological matrices as design tool, first conclusions for the effects for the use of morphological matrices can be made:
- They structure communication, especially in more complicated design situations;
- They archive discussed proposals within design teams;
- They structure design activities within design teams, widen the field of new possibilities;
- In practice; for communication within the team, to increase the number of relevant and new design alternatives, to raise the awareness for contributions of other disciplines [Savanovic 2005].

4 Workshops: training the knowledge transfer

The impact of Donald Schön’s work on reflective practice has been significant - with many training and education programmes for teachers and informal educators adopting his core notions both in organizing experiences and in the teaching content [Usher 1997]. Although, working with experienced designers from different disciplines is not often done. Mostly the verification of a new methodological concept is done by experiments with student groups or with design groups within one company [Segers 2002, Blessing 1994]. The relevance is improved by using experienced designers, as there is a major difference in approach between novice and experienced designers [Kavakli 2001, Ahmed 2003, Kavakli 2003].

In the Integral Design project TVVL-BNA-TUD different concepts of workshops have been tested [Quanjel & Zeiler 2003]. Within the ‘learning by doing’ approach, within a recent PhD research, newly developed process models are applied, tested and evaluated with professionally qualified designers in a repeated series of workshops. There are a number of advantages that the workshops have regarding to standard office situations: the full line-up of design team, avoidance of a ‘laboratory setting’, the possibility to gather a large number of professionals in a relatively short time, repetition of the same assignment and comparison of different design teams and their results [Savanovic 2005].

To that effect, case studies that are complex and innovative enough will be selected, and a series of different type of workshops with experienced professionals from the ONRI (Dutch Association of Consulting Engineers), BNA (Royal Institute of Dutch Architects), IFD (International Federation of Roofing Trades) and HHD (Het Hellend Dak) will be organized to investigating the relevance of the approach.

A first set-up within a realistic setting and client is made: innovative solutions for pv-installations integrated with existing roof types. For each setting, three design teams (architect, structural engineer, installation consultant), are formed. In order to monitor the effect of the proposed tools, the three groups have to work with the use of different knowledge exchange. The first group (teams A-C) will work in the traditional setting, in the way they are used to work. In the second group (teams D-F), a
roof-advisor is added to the design team, but without guidelines and specific tools. The third setting (teams G-I) will contain design teams with a roof-advisor and the proposed tools / guidelines from the Methodical Design. The project has a realistic time-scheme for the concept design phase, three month, and will incorporate the role of the client related to the decisions to be made.

**Fig. 1 Workshop setting proposed within realistic project-client setting; teams G-I**

**5 Conclusions and discussion**

By monitoring the proposed workshops with the use of students, feedback by clients and participants with questionnaires, and screening of the results by specialists in the field; knowledge exchange will be fully optimized within the knowledge-triangle research-education-practice. With the results the workshop, as well as the tools, can be improved and used in the next type of workshops. A sequence of workshops can provide the needed information and data leading to validate it scientifically. The research is in a primary phase and first workshops will start at the end of 2006. The proposed tools will finally be effectively implemented as practical instruments for briefing participants involved in the design of innovative roofs.
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Adaptables and Performance Based Building Information

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KEYWORDS

Insight, overview, coherence, performance-capacities, data-mining.

0. Abstract

Real insight in the possibilities of adaptables of building constructions supposed that their is an overview in the coherence of “Performances” of sometimes many various “Elements” of the building construction. All these types of elements are (sometimes abstract) formulated in all kind of official Performance Determination Methods. Each specific element is compiled by building components (BC) and / or is a part of building components. The building construction as such is always constructed as a “Set” of BC’s of one / or many type(s) of BC’s. So sometimes “Elements” can have a more or less abstract character. Building Components (BC’s) are always physical tangible. As general problem can be defined that data-mining is inevitable in order to get that insight and overview. In large scale complex building constructions data-mining has to be organised on a systematic logic (mathematic) way. By doing this in this way a lot of juridical and technical practical problems can be solved easier. Performance Based Building Quality Information has to be organised in line with all the several above mentioned types of methods. These methods are mostly in line with the performance based national standards and / or building regulation. The input data (ID) and using conditions (UC) of the different standards (as result of data-mining) aren’t always “harmonized”. So it isn’t easy to get the above mentioned insight and overview. That’s the reason a study on Integral Building Quality Information Models has been carried out by author, based on a fundamental theoretic approach, using mathematical theory’s fit for IT tools.

1. Introduction

The paradigm of performance based building has been studied and promoted in NL, in EU and also worldwide. (See CIB-W60 and TG 11 and the results of the recent CIB Pebbu project). In public sector it can be found in the national building regulation of several countries (Visscher 1997) and b.e. in the construction product directive (CPD) of the EU and in private b.e. in a lot of National / CEN / ISO standards. (The NL building related performance based standards has an amount of ca 200; see the NEN 2000 [2006] of the NSB NEN Delft NL). The possibilities of adaptable of building are so much important that already in the program phase of the client-briefing and the design phase adaptable had to be taken into account. (Bakens 1995) See b.e. the so called “school dwellings” first destination in use: a primary school in a sub urb, second destination on long term: family housing. By doing this the life cycles of the building can increase and the final demolition can extended. This is most of the time from several points of view a benefit for the environment. (Klunder 2005).

2. Balance between the building and it’s intended use

Prediction of all different types of use is a kind of telling fortunes. The fluctuation in the technical requirements (related to a specific use during life time) can also hardly been foreseen. To have a
Adaptables2006, TU/e, International Conference On Adaptable Building Structures  
Eindhoven The Netherlands 03-05 July 2006

good start of each building project it is recommended that all technical relevant information is formulated in a way that it is clear what the Performance Capacity (P Cap) related to a specific item of ( an element ) of the building really is. ( Scholten 2001 and Van Overveld 2003 ) When the building is “ in balance with it’s intended use” (than in that specific case related to that specific item) the Performance Capacity is “zero”.

( be See NEN 2916 ( NL) Energy performance on non residential buildings- Determination Method .
This system is introduced for complex building project. The relevant turning point is not “zero” but “1” Every complex building with calculated value’s under 1 is oke and above 1 is sub standard. For psychological reasons author promotes in general zero as turning point.)

When there is a positive margin there are technical possibilities for adaptable in use without renovation. In fact the building is flexible in use. In case the P cap is below “ zero” we have to renovate the building. The “maintenance” of a building means to take care that the Building Components keep in their right condition.( the original intended condition ). “Renovating” means that on or more Building Components are replaced by new one of more or less the same type but on the original or higher quality level.

In principal the reason to “adapt” building construction can be:

- the original intended (specific) Use asked a other (performance) quality level.
  ( time related socio/economic dynamic development of client briefing )
- the original type 1 Use changes in type 2. Use with consequences for the performance quality level.( “redestination”)

3. Definition of the performance capacity of an element.( P Cap )

The performance capacity (P cap) of an “element” is the difference of the reproducible performance (determined on a methodological way) and the minimal required performance. In case of a maximal required performance it is the difference of that maximum and the determined performance.

So from this view the total information about all kind of performance capacities of all the “elements” of a building can be seen as a “Set of information “ and can be arranged on a mathematics way.

4. From cacophony to symphony.

4.1 Adaptable is not only related to changing in Use. ( The Dutch Building Degree 2003 defined formally 12 main different functions in use and more than 70 sub functions and 60 specific detail rules in relation to determine functions.) The above explained P cap is strongly connected to the methodological type of determination of the performance as such.(PDM) ( Van den Bercken and others 1994 )Most of the time performance based standards are recommended. Several types of standards aren’t always fit for every phase of the life cycles. Testing ( in stead of calculation ) in the design phase without prototypes is quit a problem. Calculation in the using phase without correct ( un verifiable / out-of-date ) input data (ID) is an other problem.

4.2 During the lifecycles the state of the art in the field of building technology will change and in line with this, some times in principle other types of new standards [with demand other using conditions ( UC)] will take the floor.

So a the end we see there are possibilities in 4 time related Delta’s ( t2-t1 ):

- Use. Functional Use / Destination
- PDM. Performance Determination Method
- ID. Prescript Input Data
- UC. Using Condition of the Method.

Depending how many “cross sections” between inter related standards (see the ca 200 in par 1) exist the coherence between all kind of discussions and decisions on building solutions will surely increased. Data-mining, in an organized way, is in my view inevitable.

The situation can occur that redestination or to renewal a complex building project turns out a “ box of Pandora” in case you don’t manage this “cacophony” of building information to a “symphony” of harmonised optimal solutions.
No mistaken: If a Building Component is replaced by an other of the same type, than in my view this is no Delta. It says only something of the flexibility and / or the possibilities of disassembling of the Building Construction as such. Of course in a lot of situations replacing Building Components of an other type is a Delta and has relations to the PDM, ID and or UC. Flexibility and Disassembling on the level of Building Components turns out to be a good method to create adaptable buildings

5. Tools for insight and overview in coherence in problems and possibilities of Adaptable.

The philosophy how to get this insight and overview in the relevant coherence of adaptable related aspect has been published [ eds Ang & Prins 2002 pag 327-349 ] under the name: BBasys (Building Balance Audit System) by author. In line with the above under chapter 3 mentioned mathematical Set theory in 2001 the combined formula was discovered that "catches" the performance capacity of all the building ( constructions ) of mankind that there was, is and will be: Pcap tot = { Alevel Pcap I [Aspect Pcap I ( Pcap IP cap{ 1,...,..} ) ] ] } For Adaptable on abstract level ( A level ): 10 "levels" are relevant.( see annexe 1: In the NL situation 66 other Aspects at least had to taken into account and for renovation b.e. on “new build quality level” more than 700 different P cap’s of elements can be found in the NL building regulation. They all has been published in professional literature (Van Zeeland 2003-2004 ). By the way: The local government can give ( under certain conditions ) exemption to reach the obliged quality level for new buildings in case one wants to create new destinations in old existing buildings. So for the building permit the case can be easier, but for the private client / owner can still demand quality on new build level. In several adaptable related projects this system has been tried-out for some aspects.

6. Triple A Quality Rating.

For Total Quality not only the quality of the Project is relevant. If all the essential Pcap’s of a existing project are known this Project can get a such called “A “ status. But this Pcap information is only trust worthy if the Partners ( responsible for that information ) are qualified also on “A “ level.( See be. the EPBD 2007 of the EU: Quote: “.. people had to be certificated.. “ and the certificated asbestos investigation ) And at the end, it is some times very essential that the P cap is determined on the right moment in the building process. ( A Qualified Process ) So Project, Partners and Process ( those three to gather) had to get an “A “ status, in case Total Quality in the field of Adaptable makes sense from the view of performance based building. See Bouwbesluit Exact and Quality Rating [Van Zeeland 2003 ]

7. Conclusions ( C ) and Recommendations ( R ) :

For creating successful possibility ‘s for Adaptable Constructions in relation to performance based building information the two following theoretical fundamental conclusions can be drawn.

C.1. “ Data-mining” of all relevant information is essential ( Data-mining has to be organized on the philosophy of “ Building Balance Audit System” or similar “scientific techniques”. Author is very interested in information from colleague’s who have experience with other types of organizing: “data-mining “ in a systematic way)

C.2. The using of the philosophy of “ Triple A Quality Rating “ ( From which person comes which technical information and on which moment ?)

A more practical general third conclusion is:

C.3. 1. In order to promote large scale possibilities for Adaptable focused on avoiding juridical and technical problems it is essential the several Performance Determination Methods (for existing building constructions ) are standardized in Nat Standards ( NS )

2. In order to promote exchange of technical data in a specific project the Nat Standards, relevant for building quality, have to be harmonized. ( on Input Data level and on the level of Using Conditions )
3. Complex Nat Standards have to be computer-programmed on its own and to gather. (Integrated IT Tools)
4. Computerised Nat Standards have to be fully integrated in the 4 D Cad Tools of architects and technical experts.

For creating successful possibility’s for adaptable constructions in relation to performance based building information at least the following Recommendations can be formulated:

R.1. **In general confronted the juridical and technical practice.**
Take the three conclusions serious, but use the principle of proportionality (focused on efficiency and effectiveness)

R 2. The IFD philosophy (promoting: Industrial-, Flexible- and Disassembled - Constructions) has proved to be a very efficient and effective solution for it in practice. (Van den Thillart 2004)

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9. Annexe: 1 Abstract Level explanation.

Al 1: Building materials: building products, half components, raw building materials
Al 2: Building parts: construction parts, equipment parts, windows, doors, staircases.
Al 3: Separation construction: inside: project separating floors / walls outside: façade (outer wall) ,roofs, ground floor
Al 4: Inside spaces in case of a building: destination (type of use), shape, dimension, location
Al 5: Building construction- or the building as a whole: juridical destination, use in practice, client specifications, load bearing construction
Al 6: Building parcel / Project plot: geodetic situation, possibilities to build, the shape and
dimension, the use/destination of the un-build part: landshaping aspects

Al 7: Geographic: climate zone, continental situation, national / regional situation: local development / urban situation.

Al 8: Timeframe of the society: culture / historic, architectural opinions: (The personal responsibility of the architect, as a professional, how to manage all these items in one design concept as “specialist” in design and as “generalist” in the construction field)

social society, financial / economic situation, public / private juridical situation, the state of the art in the field of building technology

Al 9: Astronomical and biological reality: the world of the astrometry: The rhythm of short and long ice periods. climates declinations the biological world, human conditions

Al 10: Timeless world: the mathematic tools and the metaphysic philosophy
Determining future value of the existing houses by neuro-fuzzy system

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KEYWORDS

Redevelopment, transformation potential, neuro-fuzzy approach.

Abstract

In the housing market a shift from a supply-led to a demand-led market becomes more obvious. At the same time there is a miss-match between the existing housing stock and demand. A substantial existing housing stock which does not meet the user requirements. The main questions are: 1) what is the future of the existing housing stock and 2) is there an efficient method that can be used in practice to assess their future value? Comprehensive considerations are necessary each time the question of transformation versus demolition arises. It is both time consuming and recurring process. To facilitate this process, a systematic approach with the application of artificial intelligence (AI)-based information processing is described. In this approach, a human expertise is cast on a knowledge representation in a computer-based system, which is made available to external inputs for human-like decisions. Therefore, the outcome is consistent with the knowledge-base established within the system and the decisions made are instant, compared to comprehensive “human-deliberations”. Main aspects of transformation have been captured in a neuro-fuzzy model. The paper describes the method together with the practical application.

Introduction

One of the future qualities of the housing projects will be measured by their ability to transform acceding to the changing user demands. Taking into account the frequency of change within built environment, high transformation ability of structures could have environmental, economic and social benefits [Durmisevic 2006]. There were few attempts in a past to assess transformation of buildings or their parts: for example, the Capacity to Change (CTC) index by the OBOM research group presented in a report of OBOM research group in 1992 [Brouwer and Cuperus 1992]. The report suggested that the Dutch Real-Estate norm, which evaluates the quality of real-estate properties, should include flexibility aspects as well. It was proposed that the following three aspects should be considered: 1) separations of levels of decision making being site, support and infill, 2) evaluation of a load bearing structure in relation to building services, and 3) dependences between building elements. Although the CTC index was not developed further than that report, the idea has been found challenging for many real-estate investment companies in the Netherlands such as ING bank, Rabo Bank etc. Another model (Flexis) is developed by R. Geraedts to measure the flexibility of installation services. This
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model addressed aspects of spatial and technical flexibility that the installation systems deal with such as position, accessibility to services, and overcapacity of the installation systems. This was to allow for different spatial typologies [Geraedts 1995]. Another model is developed by E. Durmisevic to assess transformation capacity of buildings based on disassembly potential of building and its systems, considering efficient use of building systems and its materials during the transformation process. Taking into account the growing concerns about the efficiency of use of buildings throughout their life cycle coupled with growing demand for development of building systems that are adaptable to changing user needs, it becomes necessary to assess the transformation capacity of buildings, which is an indicator of their technical flexibility that has an impact on the spatial flexibility. Such assessment deals with the span of load-bearing construction, position of main installation net, position and replaceability of distribution installation net, and replaceability of partitioning walls. By doing this, one can better judge the capacity of the existing buildings to be transformed and the future value of design solutions with respect to its flexibility [E. Durmisevic 2006].

A housing corporation ‘Rondom Wonen’ together with the municipality Pijnacker-Nootdorp wished to redevelop the northern district of Pijnacker [Zoet et.al. 2003]. The required redevelopment was needed at three levels: 1) district, 2) street and 3) apartment level. EGM research (where S. Durmisevic was employed at the time) supervised decision-making process during project start-up and EGM architects integrated research results into a design proposal. This project includes 442 apartments divided over 16 housing blocks that were built in 1968. The flats lie in a beautiful, green district but look somewhat monotonous and dull (‘Fig. 1’).

![Figure 1. Current situation: five stories high apartment block](image)

The client (housing corporation) together with the architectural office (EGM) needed to decide whether to transform the existing housing or to demolish it. To facilitate decision-making process, a transformation potential needed to be assessed.

**Aspects Determining Transformation Potential**

In order to assess transformation potential of a dwelling, all its elements can be classified into two groups: fixed and flexible. Under the fixed elements the following aspects are considered:

a. **load bearing structure (support)**
   a.1. type and dimension
   a.2. type and material (T_{v1} value is obtained through consideration of a.1 and a.2).

When discussing load bearing structure the following aspects are of an importance: materials, dimension (span) and type of structure. Interdependence of the dimensions and types influences the spatial flexibility, while the interdependence of the materials and types can influence the capacity of structure to be transformed and therefore the spatial flexibility as well.

b. **vertical installations**
   b.1. positioning - central or peripheral positioning.
   b.2. accessibility - build in construction or independent of construction (T_{v2} value is obtained through consideration of b.1 and b.2).

Under flexible elements the following aspects were considered:

a. **inside partitioning**

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The materialization of the walls in the apartment and the possibility to remove them, or change their position depends greatly on the fact weather they are made of masonry or system walls ($T_v3$).

b. installation servicing – horizontal and vertical distribution net

In this context the accessibility and positioning were taken into consideration, such as for example, whether the installation servicing is built in construction or separated from it ($T_v4$).

Today we can talk of having inside partitioning and installation servicing as being separate from the main construction, while in the past this was not a case, which made buildings very difficult to adapt to new requirements. Whether the vertical installations on a building level and servicing distribution on a dwelling level are either built in construction or separated from construction, influences greatly the transformation value.

All the above-mentioned parameters together define the transformation potential, further in the text referred to as transformation value $\sum T_v$. They are basic components that were used for network training. This training is done by neuro-fuzzy system which will be briefly explained further in the text. More details regarding this training can be found in Ciftcioglu et.al. [1999].

Neuro-Fuzzy Approach

For this complex and ill defined problem a combination of neural network and fuzzy logic is invoked. By defining the design requirements (in this case transformation potential) as fuzzy sets, one can perform inexact reasoning with optimal information routing and decision making.

Fuzzy set theory was introduced by Zadeh [1965]. With fuzzy sets, a numerical value is classified into one or more linguistic labels. Before introducing information to a fuzzy system, the information at hand is fuzzyfied. This is done by an input classification, matching the input value against a chosen set of linguistic labels. These labels partly overlap, so that a numerical value can be classified into more than one label, each with an associated membership value.

The equivalence of fuzzy sets and radial basis functions (RBF) networks is already established [Jang and Sun 1993]. RBF networks are feed-forward neural networks which use radial basis functions in contrast with sigmoidal non-linearity of conventional feed-forward networks. Among several radial-basis functions, the Gaussian function is of particular interest and used in this research:

$$\varphi(r) = \exp\left(-\frac{r^2}{2\sigma^2}\right)$$

While radial basis functions have been used for many years for multivariable interpolation with firm mathematical base, it was only recently that they are introduced for use with neural networks (Broomhead and Lowe, 1988). Therefore, such a structure is coined as radial basis function network. Due to their connections to fuzzy logic, radial basis function networks are very suitable for artificial intelligence (AI) applications for linguistic information processing, as this is the concern of the present research as well. In the present application, for a set of provided building design information, the RBF network is "trained" which means, the information given is stored in a neural network where the functional relationships among the input data are structured in the form of input-out relationship. In this form, the neural RBF network serves as a user’s knowledge base. Having trained and tested the network [Ciftcioglu et. al. 1999] new unknown data (Pijnacker apartments) is introduced to obtain the output ($T_v_n$ assessments).

The method proposed in this paper has a high potential since it enables modeling of interdependencies of practically an infinite number of aspects. The quality of the outcome is dependent on the quality and the quantity of input data used for network training. At present, not all aspects related to transformation capacity are integrated in a model, but due to dynamic structure of this model addition
of any new aspect, or an improvement of the existing is possible. That is the main advantage of this neuro-fuzzy model compared to conventional expert systems. The rules are established in an intelligent way by machine learning techniques which make it possible to deal with any degree of complexity, rather than establishing the rules after careful deliberations on existing information [Durmisevic 2002]. User-friendliness of the developed tool can be improved since at this stage it is not developed with a user-friendly interface.

**Pijnacker Flats: Evaluation And Assessment Of Transformation Value**

A post-beam structure is most suitable structure type for transformation due to its spatial flexibility. In Pijnacker flats the main load-bearing construction is a tunnel-like structure which provides a certain degree of flexibility due to a larger span of 4.0 and 4.5 meters. This has an influence on \( T_v^1 \) value. The installations (\( T_v^2 \)) are placed on a periphery which has advantages in relation to the spatial flexibility. Depending on the apartment type, the tunnel can be to some degree opened as to spatially connect two areas and partitioning walls can be easily removed (\( T_v^3 \)). The vertical installations are easily accessible, but disadvantage is that all horizontal installations are built in construction which makes them less accessible (\( T_v^4 \)). All \( T_v \) values were evaluated on a scale from 0 to 1, with 0 being the worse score and 1 the best: These are the results of a typical floor plan assessment:

\[
\begin{align*}
T_v^1 &= 0.8273 \text{ (load-bearing structure);} \\
T_v^2 &= 0.8173 \text{ (vertical installations);} \\
T_v^3 &= 0.6454 \text{ (inside partitioning);} \\
T_v^4 &= 0.5136 \text{ (distribution installation net).}
\end{align*}
\]

As it can be seen from the assessment, the \( T_v^4 \) value is lowest, but considering the other \( T_v \) values it can be stated that transformation is meaningful, especially due to a fact that spatial transformation is rather high. This implies that a variety of apartment layouts can be accomplished. This is rather important for the users (possibility to choose), municipality (providing opportunity for a social mix) but also in the exploitation of these buildings in the future (a housing corporation Rondom Wonen who is at the same time the owner of the apartments). A typical apartment layout is given in ‘Fig. 2’.

![Figure 2. Apartment layout and assessment of transformation value of the same apartment](image)

‘Figure 3’ gives some impression of the redevelopment. This was a first proposal and in a meanwhile the project undergone some minor changes. For this project various apartment layouts were designed as to provide a social mix in a new redeveloped neighborhood. Taking into account the assessment of \( T_v \) values, together with separate cost estimation, it was systematically determined that 382 apartment had a future value and could be transformed while 60 apartments had such low \( T_v \) values that the demolishion was the best option.
Looking from an environmental point of view, the transformation is more preferred than demolition due to reduced amount of building waste.

**Conclusions**

The described knowledge model provides necessary support in order to assess the transformation potential of the apartments. It can be used for evaluation of the existing housing projects as well as for the evaluation of the design solutions. The fundamental decision-making by fuzzy logic is maintained. The knowledge modeling is accomplished by machine learning techniques which automates the modeling process. This technique is very often used in neural networks. This has many advantages, since based on project information, the knowledge model helps to pinpoint possible problematic issues but also to identify the positive aspects of the existing buildings. In that respect, specific support tools, as demonstrated in this paper, can improve efficiency in order to speed-up decision making process prior to design/redesign decisions.

**Acknowledgement**

At the time of the project start-up the researcher S. Durmisevic worked at EGM Research. She uses this opportunity to express her gratitude to EGM colleagues, with whom she closely cooperated during the project start-up, for sharing the relevant information for the purpose of this paper.

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*Determining future value of the existing houses by neuro-fuzzy system*
Methodology for dynamic briefing of adaptable buildings

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KEYWORDS
methodical design, interpretation, dynamic briefing

Abstract

Methodology for the dynamic briefing of the client by the design team during the development of the building design is of great importance as during the design process the initial design requirements change. The initial set of requirements is seen as a first step in a series of interpretations of the clients’ needs. The interpretation by the designers or interpretation of the client evolves during the design process. To support the design of large-scale, complex design processes, such as one has in the building industry, a domain-independent theory based on Methodical Design is presented. Based on the preliminary design proposals, the Methodical design methodology by iteration cycles to the refinement/adjustment of the program of requirements. This mutual enhancement is the main aim of methodology for dynamic briefing of adaptable buildings.

1. Introduction

Design processes are as old as civilisation itself. In the Stone Age the caves were developed and hand-held rock tools used to make adjustments to the natural surroundings. From generation to generation an evolutionary design approach was passed on. The design was learned through experience and from actually realising it. A big break through became possible in the nineteen-sixties, when the separation between product knowledge and process knowledge was made by scientific studies of design. Design theory became of importance. Theory has evolved rapidly but until now with only modest success. The impact on actual practice has remained limited. This lead to a focus on thorough empirical studies. Some believe that the best way forward for design theory is to use extensive empirical studies on real-life design processes in various disciplines in order to obtain more fundamental insight in such design processes. This often leads to more normative approaches. However, the design processes in practice are often far from ideal. Failure costs as a result of inadequate cooperation between the different evolved disciplines in the building design process are large. That was the main reason why in year 2000 the TVVL (Dutch Society for Building Services), the Royal Institute of Dutch Architects (BNA) and Delft University of Technology (TUD) started the research project Integral Design [Quanjel & Zeiler 2003].

2. Integral design approach

Observations in the construction industry show a fractionated process by different parties achieving their own aims, working on the same building. Different cultures and different traditions, many times
conflict with the common aim of completing the building. The intention of the Integral Design project is to break some of the barriers between the different disciplines during the design process as the first step to a better built environment. It wants to show ways to implement, investigate, teach and learn an integral approach [Quanjel, Zeiler 2003].

The Integral Approach in relationship to Integral Design has to deal with different scale-levels and different ‘kind’ of aspects. The Integral Approach can be described as the interweaving meachism between the several aspects and the different design disciplines. The ‘key-aspect’ is the *flexibility and bandwidth* in the design process to be reached by application of design methodology. The integral approach will guide, interdependent to the value-frameworks, will control and correct and will leave room to the specific method or solution for the several participants during the total process. The Integral Approach is conceptual and therefore inherits the several ‘specific methods’ such as for instance Strategic Design, Sustainable Design and LCA-Design. The Integral Approach is related to the longer term for different (time, site, process and program) settings; a sustainable approach [Brand et.al 2001].

The integrated building design process is one which considers all aspects of a building, its environment and life cycle, and is undertaken by a team which includes all relevant professionals and stakeholders working together throughout the process rather than sequentially and independently. At the early design stages, usually only conceptual sketches and schematics are available, often rough and incomplete. As the design proceeds, more information and detail will be developed. But the dichotomy of this system is that at the early stages of design there is little information, even though nearly all the important decisions have to be made at this time, as figure 1 shows.

![Influence/information contradiction](image)

*Figure 1. Influence / information contradiction at the early stages of design [den Hartog 2003]*

Integral design is meant to overcome, during design team cooperation, the difficulties raised with the early involvement of consultants. This is achieved by providing methods to communicate the consequences of design steps between the different disciplines on areas such as construction, costs, life cycle and indoor climate at early design stages. The aim is to support all disciplines with information about the tasks and decisions of the other disciplines. Supplying explanation of this information will improve understanding of the combined efforts [den Hartog 2003].
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2. Dynamic briefing

In the dynamic briefing framework, design is considered a problem solving activity where the need is transformed to a design problem, and its solutions co-evolve [Chakrabarti 1993]. In design the resources consist of knowledge, materials and building processes, while the constraints include laws of nature as well as time, organizational and financial limitations. Hence the following definition of design can be given. To design is to formulate a product model taking into account:

- the objectives to be achieved
- the available resources
- the prevailing boundaries.

The result of this activity, the product model is frequently called ‘a design’ i.e. a complete description of the object to be built.

Besides general factors on project and personal level, the design process is influenced by the context in which it takes place, such as company size, available production methods, nature and culture of industry sector and production quantity. Buildings are mostly designed through a slow process that develops parallel with the development of the design proposals and of the design assignment. The designer starts describing what the intended product should do, and through reasoning both the problem and its possible solutions co-evolve. This process eventually produces a solution. For the client it is of course the solution that is of primary importance. The design process should not only lead to a solution but also give insight in the reasoning about the design problems and the solutions itself. The argumentation on which the solution is based is important. Only when these are also provided it is possible for the client to make judgements or give feedback on the interpretation of the briefing by the designer. Often it is needed to change the initial design proposals according to the changes in time of the team knowledge about the design assignment. The clients’ perception of his own needs also often changes, leading to new or altered demands for changes in the developing design. All these possible misunderstandings as result of the evolving design (based on the rough design phases as conceptual sketch, preliminary design, final design) should be avoidable.

Although the great expectations for more rational and formalised approaches from the seventies are not met, the design theory still offers possibilities to more fundamental insight. Models in order to structure the design process are potentially very useful. As the large dispute about whether ‘Form follows function’ shows, there is a major part in architectural design which depends on emotional
creative process which cannot be reduced to rationality. Still, we prefer support of the (parts of) design processes by means of functional reasoning, reasoning through an design methodology, to current situation in practice. We believe that reasoning about the design brief in terms of the functionality required for solutions to the clients need is central to designing. This article deals with a domain-independent design theory to be used in the dynamic briefing of complex design processes as found in the building industry.

3 Methodology

Effective design and effective construction are both necessary to produce high quality buildings and are therefore closely related. This process is initiated by the design task based on the need that has to be fulfilled and results in a description of the product. The architectural design process is complex and has a vague structure. The designer starts from an ill-defined problem and through different steps and stages progress has to be made up to a blueprint for a solution. The conceptual design stage is especially vague. It often starts with rough initial ideas about the situation in which the building has to be placed and rough initial ideas about the function that the building should have [Aliakseyeu 2003]. As the design proceeds, more information and detail are developed. Though there is little information at the early stages of design nearly all the important decisions have to be made at this time. There is an influence/information contradiction [den Hartog 2003], or design process paradox [Ullman 1992].

The design process starts from making/reading the brief by the architect. The brief is a very important way of communicating between the architect, design team and client, see figure 3. Another way for communicating for the architect is through presentation, but that can only after the architect has a first conceptual idea of the design which can be presented to the client. Therefore, in the very early stage of conceptual design the brief is the most important communication tool. Still, the early interpretation of the brief by the architect has often to checked to clarify some aspects of the brief, or to discuss with the client some formulations in the brief.

Figure 3. The role of the design brief during the conceptual stage of the design process [Aliakseyeu 2003]

The transformation from clients’ need, which is the basis of the design brief, into a full product description involves several product states and design phases. The design brief is the first description...
of the desired product. In small stages over a longer period this state is transformed until finally a full description of the product exists. This description contains the information needed to realize the final materialized state; the product.

To design is to formulate solutions, taking into account the targets to be achieved, the available resources and the prevailing constrains. In order to survey solutions, designers classify them based on various features. This classification provides means for decomposing complex design tasks into manageable size problems. An important decomposition is based on building component functions. The functional decomposition is carried out hierarchically so that the structure is partitioned into sets of functional subsystems and the decomposition is carried out until arrived at simple building components whose design is a relatively easy task. Design is essentially a decision making endeavour, where a significant portion of the progress towards each solution state can be made by application and/or heuristically based operations [Mijers 1992].

In the project description the needs are described in terms which designers can use to choose from among alternative solutions as rationally as possible. This indicates that there is also an amount of subjective interpretation involved. Therefore, design can be also viewed as a big black box: ‘needs’ form the input and ‘blue print solutions’ make up the output. The use of a black box is appropriate for determining the functions of the product to be designed. However, as a model of the design process it is hardly useful. In other words: the black box has to be opened (see figure 4). Going back to the formulation of the design problem and the list of requirements is often an essential consequence of the gained insight into the true nature of the problem. The result of the gained insight is result adjustment and expansion or sharpening of initial formulation of the design task.

![Program of requirements](image)

**Figure 4. Use of the program of requirements as direct input for the design process**

Work done in later phases of the design process may change one’s understanding of the design problem and new information may become available. Therefore modification and refinement of the initial specification should be undertaken regularly. The design specification is best further developed in a strong interaction through successive iterative cycles, until design requirements and decision criteria fit one another, see figure 5. Archer has described this process quite strikingly: “The first thing to recognize is that ‘the problem’, like any other ill-defined problem, is not the statement of requirements. ‘The problem’ is obscurity about the requirements, the practicability of envisageable provisions and/or misfits between the requirements and the provisions. The design activity is
commutative, the designer’s attention oscillating between the emerging requirement ideas and developing provision ideas, as he illuminates obscurity on both sides and reduces misfits between them” [Archer 1979]

The insight gained in the cycle is fed back to the design brief and to the problem formulation and the list of requirements see figure 6.

4 Methodical design

To formalize the understanding of the design process an extended design model was constructed to put the identified activities, stages and strategies in the early architectural conceptual design process.
This is based on an existing design model which forms the basis of formulation of the extended model. As design paradigm is chosen the Methodical design model from van den Kroonenberg [1978], because the Methodical Design approach has typical and exceptional characteristics [Blessing 1994]:
- it is a problem-oriented approach
- it is the only model emphasizing the execution of the process on every level of complexity
- it is one of the few models explicitly distinguishing between stages and activities

Characteristic of methodical design is the systematic search for possible solutions to a design problem starting with analysing the problem and decomposing it into functions before generating solutions. Technical problems are solved in a structured way and methodical design assists in avoiding ‘jumping to conclusions’.

Incorporating decision methods and techniques into methodical design gives an overall methodical design matrix. The design matrix presented by Van den Kroonenberg [1978] and by DeBoer [1989], presents the design process in a condensed way at a specific level of complexity or abstraction. To extend the presentation of the design process a selecting step was introduced. The resulting decision based design matrix, see figure 7, gives a total decomposition of abstraction levels. The decision based design matrix provides an overall structure that makes the basic design cycle recognizable as such. In the decision based design matrix the cycle (define/analyse, generate/synthesize, evaluate/select, implement/shape) forms an integral part in the sequence of design activities that take place. Essential difference with the former approach is the shaping phase after the selection phase, in which the transformation to a lower level of abstraction takes place, the design gets more shape.

![Figure 7. Design matrix indicating the phases, abstraction levels, issues and steps](image)

Through evaluation during the different phases in the design process the aspects that are being evaluated, can be changed. Evaluating a design proposal demands execution of several steps at different abstraction levels. The first step is to generate solutions, in a next step the acceptable solutions are distinguished from unacceptable ones by checking whether they fit all requirements. Only after these first steps it makes sense to identify better (good) or best alternatives; depending on the extent to which they fulfil the needs, wishes and maybe even the unspoken dreams [Roosenburg & Eekels 1995]. Classification of goals and objectives and their role in evaluation is presented in figure 8.
Discussion and further refinement

Fully accepted research methods do not yet exist for design research [Reyman 2001], but new process design methods should at least be [Cross 1992]:

- inquisitive: seeking to acquire new knowledge;
- informed: conducted from an awareness of previous, related research;
- methodical: planned and carried out in a disciplined matter;
- communicable: generating and reporting results which are testable and accessible by others
- purposive: based on identification of an issue or problem worthy and capable of investigation;

No design method is the ‘one and only’: different persons have their own personal preference to methods, often also depending on the situation. It indicates that methodical design should not be considered as a recipe for all processes, but it is a good recipe to learn cooking. Gradually designers will modify the method they use and improve it. This requires that designers have sufficient knowledge of the roots of design methodology. In other words: methodical design should be a set of rules with which designers can start, as well as improve upon.

It is assumed, like in opportunistic design, that designers survey a problem, form a judgment about critical areas in the design matrix and make decisions about how the focus of attention may be optimized. Here a descriptive element in the prescriptive model is introduced. The matrix can be used, but need not be completely used. It is for the designer to make the decision about partly use of the design matrix. On this aspect it is good to remember French:

“Engineering designers do not on the whole use the systematic approaches to design advocated by academics. This is partly explained by their wealth of experience: very often the steps followed by the academic appear to the practical designer to be superfluous, since the outcome is obvious and the result can be gone to directly. In this conclusion they will generally be right, but occasionally they will be wrong, and will miss opportunities for better design as a consequence. However, academic methods, because they are cumbersome and preoccupied with process, rather than designing, may conceivably be inferior in many applications and lead to worse results because they divert the designer’s attention to matters of no real importance [French 93].”

Figure 8. Classification of goals and objectives and their role in evaluation
In our future refinement of integral design methodology we will focus more on the integration between rational problem solving, of which methodical design is a good example, and the theory of reflective practice of Schön [1983] see figure 9.

**Figure 9.** The relation between rational problem solving and reflective practice.

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Methodology for dynamic briefing of adaptable buildings
Dynamic briefing for adaptable building design

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KEYWORDS
methodical design, interpretation, multidisciplinary approach, decision making

Abstract

Because of the nature of design problems, with their open structure [Simon 1973], they can not be thoroughly thought out at the beginning of the design process. As such, the direction in which the solutions are to be explored is not self-evident, leading to resources consuming trial and error approaches that often don’t lead to satisfactory results for the client. In order to tackle this problem, a methodology for dynamic briefing of the client by design team during the development of building design has been proposed. It is based on the methodical design approach [vd Kroonenberg 1992] and assumes the initial set of requirements as a first in a series of interpretations of the clients’ needs.

1 Program of requirements

During the design process the initial design requirements change. They gradually develop from general to more specific, together and in interaction with the development of the design itself [SBR 1996]. Other various reasons for these modifications are the change of the stakeholders, adaptation of the budget, design assignment understanding progress etc. As such, the initial requirements can be seen as the first interpretation of the design task/problem. They are usually defined by the client, very often in cooperation with the client representatives, such as a building manager. Sometimes the designers themselves are also involved in the making of the initial program requirements. This is usually done by architect, who during this phase represents the whole building design team (seen as a ‘design unit’ in the context of this paper). As a central figure within later-to-be-formed design team it is therefore logical that the architect would be involved in this activity. However, the first interpretation of the design assignment in form of initial requirements has to be reinterpreted by the whole design team at the start of the design process, in order to develop common basis on which further activities can take place. The coordination of activities is based on the assumption that all parties have the same notion of the building (design) processes, the requirement already acknowledged and emphasized more than decade ago [SBR 1994].

Besides this requirement various design problems, which are encapsulated within larger design tasks, are also not unambiguous in their own and are therefore bound to change during the course of design process. The added difficulty is that not only the interpretation of these design problems changes accordingly, but that there are several steps to be taken before the actual interpretation by the design team (as a whole; one design unit) takes place.
Therefore, there are number of issues to overcome during design briefing:
Dynamic briefing for adaptable building design

- translation of the initial program of requirements to the initial design team interpretation of the design problems;
- openness of the design problems that causes the future changes, which require additional (re)interpretations;
- feedback to the client, which makes monitoring and attuning of the design process possible.

Through dynamic briefing these issues can be properly addressed. As the briefing is happening in the context of changing design requirements it has been labelled ‘a dynamic briefing for adaptable building design’.

2 Communication

Ideally, the design team as a whole should interact with the client at the very beginning of the design process, before initial program of requirements is set. The reason for this is to exclude as much as possible in-between links. Design team is the ‘place’ where the desired plan for the client’s ideas has to be ‘produced’. As pointed out in [SBR 1994] the quality of ‘supply’, the design, needs to meet the ‘demand’, needs, of the client. The first step in this process is to get the interpretation of the client’s needs right. A parallel with a description of communication, where everything between sent and received information is a noise source, can be made here. The communication, which is defined as transference and understanding of meaning between sender and receiver [Robbins 2001], has to be as straightforward as possible. This is needed in order to get the relevant feedback between the client and design team, an essential part of communication, because it determines whether or not the understanding has been achieved and if decisions can be made/approved.

This rationale could also mean that the role of the managers at the beginning of the process is just a surplus that could be left out of the communication chain. After all, managers are not intrinsically involved in the design process as such and can be regarded as ‘an avoidable link’ between the client and the design team. However, the alternative for involvement of the managers is that in practice their activity would form an integral part of the architect’s role. This could lead to even greater difficulties. As an active member of design team the initial interpretation of the architect can have a permanent and binding influence on the design process. And almost as a rule, it is much more difficult to get rid of this initial ‘picture’ if it during the design process proves to be less optimal than what would be possible through integral design team effort. This becomes usually apparent only in later design stages. To adapt these primary views of the architect costs time, time that in building practice seems never available and is always related to money.

Again, ideally the whole design team, rather than an individual designer, should be involved in initial contacts with the client. However, this is something that is difficult to realise in real life, because of the prevailing traditional approaches, but also because of the various (new) rules regarding the acquirement of projects (European tendering procedures etc.) that do not stimulate this described preferred setting. Given the current situation the manager, as a representative of the client, does not necessarily need to change his role, since we saw that the design team anyway has to reinterpret the design problem it has been presented with. The emphasis is rather on the fact that the team should get as much ‘free space’ as possible during the once started design process. To avoid unnecessary interpretation iterations caused by additional non-designer disciplines involved in building practice, a direct and effective feedback between design team and client is needed.

3 Shared understanding

Because design problems are open, or ill structured [Simon 1973], the development of design solutions leads at the same time to parallel development of the design assignment itself. The solution and the problem are evolving together [Schön 1983]. Because of this characteristic, the initial design proposals often change according to the in time increased team knowledge about the design assignment. Through this growing insight initial interpretation of the client’s needs is also bound for changes. Interpretation of the client himself changes as well, often based on the preliminary design proposals, and is the one that leads to adaptations of the program of requirements. Therefore, those
design proposals have to be spot-on from the very beginning of the design process. In addition, the situations based on the change of the clients’ perception of his own needs can also occur, leading to demands for changes in the developing design. These changes are, besides being time consuming, difficult to accommodate within traditional design process organisation types. This is especially important in case of use of the model of design process based on ‘decision documents’ [SBR 1994].

The nowadays buildings are designed by the multidisciplinary design teams; they are not the work of only one individual. In order to be able to work and learn within team configuration, creation of shared understanding is crucial [Mulder & Swaak 2002]. Besides mutual communication, the design team members need to develop shared understanding in order to be able to univocally communicate with the client. Shared understanding, not only of the problem the design team is faced with, but also of the possible solution directions that have to be explained to the client is needed. Through shared understanding the design team is able to more quickly generate adequate reactions to the clients’ new questions, doubts and/or uncertainties.

4 Methodical design

Methodical design [Van den Kroonenberg & Siers 1992], a problem oriented approach that distinguishes, based on functional hierarchy, various abstractions and/or complexity levels during different design stages and design phase activities can offer a suitable framework. This framework can accommodate the different subjective interpretations of the program of requirements, which are inherent to the design team setting. By structuring these subjective aspects the development of shared understanding is accelerated and generation of possible integral solutions is aided. Emphasis is put on working with functions because experienced designers prefer function-oriented strategy [Fricke 1993] instead to phase-oriented strategy that is often recommended by design methodology [Pahl & Beitz 1995] and models [SBR 1994]. Definition of functions during interpretation of design problems makes it possible to assess client’s needs on a higher, but better workable, abstraction levels than the program of requirements provides. Based on definition of functions, various design complexity levels can be separately discussed and, accordingly, possible solutions generated. This way interaction with the client is aided, and at the same time the decision-making process is structured, also regarding ever-changing program of requirements. Through iteration cycle of interpretation-generation steps the set of requirements is continuously refined, and with it also the design solution proposals. This process of continuous interpretation and solution feedback actively involves the client in the design process, transparently narrowing the field of possible solutions leading to well thought-out building concepts.

Figure 1. Continuous feedback between design team and client is the main aspect of dynamic briefing

The results of the design processes are directly used for dynamic briefing, meaning that the two are closely linked and are developed together, mirroring parallel development of the design problem and solution. The relation between the two most important parties during the design process is being enhanced; on the one hand the client whose needs have to be fulfilled, and on the other the designers
that are providing the solution for it. This approach also fits perfectly into existing descriptions of building process models [SBR 1994].

One of the main features of methodical design are morphological overviews [Zwicky 1969]. Using morphological overviews as a design tool all interpreted functions (step 1, figure 1) and all generated solutions (step 2, figure 1) for specific (design) problems can be structured. Besides their structuring, morphological overviews can visualise interpretations of the defined functions (in form of sub solutions), aiding self-reflection of design team members in process of creating shared understanding. The essence of this approach is the strict separation between generation of all possible solutions and selection between the suitable ones. Both interpretation and generation can be done on different abstraction levels. Distinction between abstraction levels is helpful in structuring the results and provides more insight during communication between client and design team. This communication pattern involving the client ideally takes place after both interpretation and generation steps (figure 1).

5 Workshops

The preliminary results from the ongoing research [Savanović et al 2005], that utilises workshops organised by the Royal Institute of Dutch Architects (BNA), the Dutch Association of Consulting Engineers (ONRI) and the Knowledge Centre Buildings and Systems, the cooperation between the University of Technology Eindhoven and the Netherlands Organisation for Applied Scientific Research (TNO), show that methodical approach is helpful within design teams, both regarding design and communication purposes.

During the two workshop series that were held in 2005 the design teams, which consisted out of an architect, a structural engineer, both building physics and building services advisers, had to design ‘a sustainable office building’. All participants were professionals with several years working experience. The workshop series lasted three ½-days, with each day divided in two separate design sessions. Between two days there was a one-week pause. The first day was used as ‘training session’, during which a simple design assignment was presented to the design teams. A different and bigger design task was given to the design teams on the second day, and they continued working on it during the third day. Design sessions were in turns used for interpretation of the presented design problem, generation of possibilities, and discussion of possible integral solutions with the client and selection of the final proposal. The representatives from BNA and ONRI played the role of the clients, who were consulted by the design teams during the last workshop day.

Figure 2. The situation where architect directly starts with the generation of possible solution was often witnessed during the workshops; initial interpretation and feedback were missing

The observed design processes showed some interesting results. All design teams were very enthusiastic, with some of them tending to proceed directly with designing even though not all information was initially presented. The traditional situation, where architect takes the lead and generates first proposals, without analysing the ‘field of possibilities’ [Krick 1967] often occurred (figure 2). The curious thing was that all (!) design teams during the (conceptual) design process apparently felt no need to consult ‘the client’, who was available and present all the time. The teams
would internally test their interpretation and mutual proposals, but no voluntary external feedback with the client was observed. This resulted in situations where certain design teams were busy with working their ideas out, only to discover during the last day that the client had completely different thoughts and ‘dreams’ about the result. These misunderstandings are comparable to situations in practice, where architects sometimes ‘blindly’ pursue their initial interpretations of the presented problem, leading to chain reaction resulting in failure costs. By defining the desired functions through team interpretation of the program of requirements, and communicating them to the client (figure 1), a first step in improving the design process can be made.

After each workshop day the participants were given questionnaires to evaluate how the proposed approach, working in design team configuration and using morphological overviews, benefited them. The majority of the participants were positive regarding the following: it increased the insight in contribution from other team members (this aspect was on average rated 7.4 out of 10), had positive influence on design process (7.2), and was helpful in communication (7.2).

The main focus during the workshop series was on the assessment of the used approach regarding the actual design processes. The aim was to provide better working conditions for the design teams. The only ones who could judge if that was indeed the case were design team members themselves. From the point of view of the design disciplines involved in this briefing-through-feedback communication process, the used approach proved to be a positive experience. In order to be able to say if this is also beneficial to the (professional) clients, a new experiment involving at least partially experienced clients would have to be conducted.

This research, regarding the use of methodical design aspects within design team configurations and within workshop setting, is going to be continued throughout the year 2006.

6 Acknowledgments

Knowledge Centre for Building and Systems (TNO-TU/e), Kropman bv and the foundation “Stichting Promotie Installatietechniek (PIT)” support this research.

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Digital media based documentation, visualisation and supervision of construction processes

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KEYWORDS
Building Information Model, visualisation of construction processes, digital construction documentation

Background
Experts who are involved into design, construction and operation of buildings are supported by various software systems to solve problems and to perform their tasks. A data exchange between different programs is mostly possible via fixed interfaces. This often leads to miscellaneous data loss. The documentation of the construction work is usually not planned explicitly before the start of work and is therefore strongly dependent on the individual skills of the employees on the construction site. In consequence, the integrated collection of information about the design phase, the construction process and the operation phase of buildings is of particular importance and should be improved by the implementation and maintenance of Building Information Models.

Planning of construction processes
Planning of construction processes is mainly realized via three different software systems:
- the design of the virtual building within the CAD-model,
- the supervision of bidding phase, contract as well as the billing-report in a TCB-system (tendering, contract, billing-report-system)
- the scheduling and schedule review in specific scheduling software tools.
To assure a digital supervision of construction processes a combined control of these planning systems has to be performed. Therefore, all building elements have to be defined distinctively consistent in all three systems. Modifications of the construction plan, the scheduling or the cost structure have to be passed on loss-free to any of the planning tools.
To each planning phase of a building different experts are assigned, who mostly use different planning tools. In such a surrounding field the introduction of a Building Information Model to control information and preserve the desired information independently of the assigned software is absolutely indispensable. The Building Information Model provides, that different planners can continue to use their preferred software, the one they're used to work with.

Digital survey of construction processes
For the digital survey of construction works on building sites common commercial digital cameras are being used. It is difficult to find a reasonable way of storing the gained data.
At most, the date, the designed quantities and qualities concerning a particular building element have to be derived from the particular photo documentation. The employment of new and raising digital caption methods allows many further applications. [Heim & Motzko 2002]

The modern geodetic methods illustrated in the following should be integrated in the Building Information Model as tools for documentation and in addition for the determination of the completion degree on building sites. Contactless measuring procedures can be divided into the photogrammetric and the laser-based measurement methods. Fig. 1 [Elsebach 2005] shows an overview of the digital geodetic methods and their applicable measurement systems at the today's state of the art.

**Digital Measurement**

<table>
<thead>
<tr>
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<th>Laser based Measurement</th>
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Fig. 1: Overview of the digital based measuring systems

Due to the constant improvement of digital photograph and evaluation systems, the work area of the contactless measuring procedures is in constant progress. Through enormous increases of computer and memory capacities in the last years it became possible to process digital photos of camera systems and laserscanning pointclouds with commercial personal computers. In the following some examples and application scenarios are shown how new photogrammetric procedures could improve the evaluation of building progress and the coverage of real estate.

**Selected use cases of photogrammetric measurements on building sites:**

Basic condition for the continuous statement of the building progress and the as-built documentation is continuous control and survey of the degree of completion. During pilot studies the different digital based measuring procedures were exemplary examined and evaluated. In addition different measurements with frames and multi photos were accomplished.

**Mono photo measurement**

In construction industry the rectification measurements is one of the most suitable sytems for measurements of objects with planar characteristics such as front, wall, ceiling and floor surfaces (see fig. 2). To take measurements in the frame it is first necessary to put a referenced area into a part of the frame. After the image has been processed with a photogrammetric software any distances within the frame can be measured.

![Figure 2: Frame of a wall as built a) with refence area and processed b) [Elsebach & Maffini 2004]](image-url)
The requirements of rectification measurements are quite simple. Beside a digital camera only the processing software is needed. This method can easily be applicated at least for the trades named above.

Multi photo measurement  
In contrast to the mono photo measurement, the multi photo measurement is not limited to planar objects, but permits the development of 3D-object models. In order to make this possible, the objects which should be modelled have to be framed from all-round. This leads to a substantial expenditure when the observed objects are complex building with slender structures. This method is particularly suitable for carcass and ground works (see fig. 3).

![Image](image.png)

Figure 3: 3D Model of a building modeled with multi photo measurements

Different proceedings may be chosen to develop a strategy for continuous data record during the construction. In the context of the planning of work a path with different camera shooting locations can be specified. In regular intervals the building is shot from these places. Alternatively to the path, computer-controlled cameras can be installed at pre-defined locations. The evaluation of the multi-photo measurements can be done either by rectification measurements as in the mono photo measurement, or by construction of a 3-D-Model.

While the superposition allows simple control of the degree of completion, the reconstruction of the building by 3-D-modelling produces the implemented quantities as well as growing model of the building.

Panoramic photography takes up a privileged position in the multi-photo Measurement sector. This method constitutes in the overlay of two full-spherical photographs accomplished in different heights. This system offers all possibilities of the rectification measurements without referencing of the frames (see fig. 6).

The presented methods offer the possibility to conceive a virtual building model beside the general building site documentation. The combination of different recording methods can result in an individual record depth and degree of detail. The necessity for a connection between the collected informations and the Building Information Model is common for all procedures. This is absolutely necessary to minimize the information loss.

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1 construction site “Ersatzbau Bauingenieurwesen in Darmstadt”, built with Photomodeler 4.0, 2003
Example of a Building Information Model

The Building Information Model functions according to the principle of the object-relational data bases - the individual software systems, which are already introduced in the companies, can be preserved in function. The single building elements such as supports, walls, carrier etc. can hereby work as information objects or entities.

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2 pilot project, recorded with SpheroCam HDR, 2005
In application of the model it is important that every single system (TCB system, scheduling, CAD system and image based information system) is addressed via the same information objects. Thereby the single information objects link to arbitrary attributes from the individual systems. These attributes can be for example the calculated costs, the remark date, the plan data, laserscan information etc..

**Implementation of Building Information Models**

The Building Information Model provides the entire life-cycle-documentation of the virtual and real phases of a building. It allows a continuous dialog between owner, designer and construction company in the different project phases. For the purposes of the construction company is the aspect of time-, cost- and quality-control a basic item. By using the presented methods of digital survey in connection with computer based estimating systems it is possible to create a target-performance comparison in various subjects (time, cost, quality etc.).

The Building Information Model can also be used to improve communication between owner and building company, with its ability to show direct connections between extra costs of a project and the changes of achievement.

More advantages could be expected in various areas:

- Extraction of basic data for controlling processes
- Development of a decision guidance by means of visualisation of critical aspects during preconstruction and construction phase.
- Prevention of information-loss within the life-cycle of buildings (e.g. the transition from execution to utilisation)
- Development of quality standards (for various projects) for the documentation of buildings

The Institute of Construction Technologies and Management of the TU Darmstadt carries out different Building Information Models in cooperation with industry partners, which are currently being examined regarding their functionality and ergonomics.

Heim, M.; Motzko, C. 2002: „Zeitnahe Leistungsfeststellung von Baustellen durch Bildinformationssysteme“, Bauingenieur, Band 77


The Management of Complex Design & Engineering Processes

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KEYWORDS
Free-form Architecture, Blob Design, Design & Build, Experimental Engineering, Complex Design Processing

ABSTRACT

The last few decades, structural designers have been confronted with spatial architectural schemes that greatly benefited from the aid of computer-operated design and modelling programs like Maya, Rhino and 3D-Studio Max. These architectural designs are referred to as ‘Fluid or Liquid Designs’ or ‘Blob Designs’. They contain sculptural building forms in an arbitrary geometrical form that cannot be generated or developed mathematically easily, even with computers. These building forms do not have a recognisable repetitive structure, either. At first, the gap between architects and structural engineers seems to open wide in each project. An even larger gap appears between architects, technical designers on the one hand and co-engineers, producers, co-makers, sub-contractors and builders. For the structural glass building parts, with its tight tolerances and high degree of prefabrication, an enormous effort is necessary in the engineering phase to accurately define all individually shaped building components. This will definitely transform ‘production’ into ‘co-engineering & production’. The introduction of this new view on architecture is more or less a revolution in the world of structural design.

1 Introduction

The second half of the 20th century has witnessed the development of a number of spatial and systemised lightweight structures: shell structures, space frames, tensile structures, cable net structures, pneumatic structures, folded plate structures and ‘tensegrity’ structures. Most of these structures were developed by dedicated pioneers in the 1950-ies who designed, analysed and built impressive amounts of new concepts: Felix Candela, Frei Otto, Max Mengersinghausen, Richard Buckminster Fuller, Zygmunt Makowski, Walter Bird, Peter Rice et all [Eekhout 1989]. The basic idea was to minimize the amount of material consumed. In order to attain this, extensive intellectual investments in man hours were necessary. Computer analysis software provided the accurate analysis of complex geometries of the components in these three-dimensional though – in our current view – highly regular 3D-structures. Thanks to the further development of accurate analysis programmes based on non-linear structural behaviour these 3D-structures can now be designed by structural engineers all over the world. They reached a status of accepted and mature technology. R.F.R introduced the intricate use of structural glass in buildings in the 1980-ies, based on regularity and systemization of the Serres of La Vilette, Paris in 1986 [Rice et al. 1995].
In the meantime the material/labour ratio shifted dramatically. For cost-effective structures the minimal amount of material is no longer a crucial factor, but the minimal amount of totally invested manpower. The post-war adage of ‘minimal material’ only became an intellectual goal for architects and structural engineers. It is not an issue for the building industry and clients. This greatly influenced the choice of building technologies over the last decades. Of course this differs from country to country. With increasing wealth, buildings were also realised in a fashion more elaborate than the very minimalist results of the early Modern Movement. Local colouring on an international scale could not be suppressed.

The development of architecture appeared to be more capricious. The Modern Movement with her world-wide innovation of concrete technology over local building technologies was caught up by other approaches of later generations of architects. The subsequent changes in architectural sub-styles from the 60-ies onwards, following ‘Modernism’, like ‘Structuralism’ and ‘Post-modernism’ could in a certain way be regarded as variations on the Modern Movement. Style is not only a way of building but also a total cultural embedment in all arts and in the whole of society. It is too early to predict that the current computer generation with its introduction of fast moving images derived from flashing videos, zapping of television programs and computer games will lead to an inherent different behaviour of the young generation of architects that grew up with this.

The growing complexity of the building process and buildings as achieved results showed a diminishing concern amongst architects for regular 3D-structures, putting an end to the pioneering era of lightweight structures. The traditional tensile structures, pneumatic structures, shell structures, space frames, dome structures, trusses and tensegrity structures will have to be mixed in their structural action in order to result in structural forms as desired by fluid design architects. All existing (sleeping or active) knowledge on 3D-structural systems has to be combined. There are several causes for this rupture in development:

- Higher building budgets in the last decades (compared with the post-war era);
- The conversion from a producer- to a consumer-dominated building industry;
- The generation of young digitised architects seeking their own identity.
- Development from industrialisation/standardisation via systematisation to individualisation/specialisation in design and engineering, accelerated by powerful 3D-computer programs.

In the 1980-ies computers initially were used to assist standardisation in design and production in collections of standardised components. Later a certain degree of systematisation with pre-design for the system and post-design for the application was introduced. The last step was a high degree of special and spatial designs without repetition of pre-designed components: leading to highly individualized building designs having its influence from the composing components to the entire artefact of the building.

Architects got bored with regular systemised structures and building components, being designed and developed not by themselves, and having too clear a mark of the developing structural designers. They now try to develop their own building technical design concepts, specific elements, components and details, fitting in the totality of the building design at hand. By lack of design experience in this field these technical designs are usually governed or overwhelmed by purely aesthetical considerations. In the newest trend the forms of digital baroque buildings are non-rectilinear, non-repetitive and in their conceptual stage only derived as clay-modelled sculptures. Computer rendering programs like Maya nowadays are able to juggle and generate all kinds of geometric forms, including the ones without any regularity in its geometric patterns. In the conceptual design stage, architects usually do not look for geometrical repetitive forms and systemised structural schemes or behaviour, but design like artists a totally new building.

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Structural engineers are initially paralysed when they have to develop a load bearing structure in the contours of these geometrical forms in order to materialise the structural concept of the building’s envelope. The same is valid for building technical engineers working these designs out more elaborately onto the level of shop drawings. The question is how to reconcile this ‘Computer Supported Sculpturalism’ with sound structural design and industrial prefabrication principles in a proper balance that revitalises the excellent and extensive experiences of 20th century 3D-lightweight structures. This should happen already in the conceptual stage, so that both existing know-how and experience are activated and the cost prices of these buildings are less of a surprise. The relation between pre-design principle and post-design application is at stake here. Principles were conquered and gained by pioneers and scientists later, while architects, acting as composers, but sometimes with the elitism of prima ballerinas, do as they like in both surprising and pleasing society at the same time. It raises the question of relationship between principles and applications.

2 Relationship architecture & building technology

Gaudi developed a suiting building technology to materialize his building designs, and stretched his influence from architecture up to the building technology and the material technology of free-formed load bearing stone and brick structures. But, primitive as his time allowed him, the Gaudi technology still puzzles scientists who analyse the unwritten regularities in order to complete the cathedral of the Sagrada Familia, like prof.dr. Mark Burry, working on the engineering of the completion of this masterpiece from his office in Australia [Gomez 1996].

Figure 1. Rise and Fall of Space Structures

Figure 2. La Sagrada Familia, architect : Antonio Gaudi
Likewise the change of any contemporary way of designing buildings requires the support of the technology of the composing parts in different levels, up to the lowest level of Material Technology, Physical Behaviour and Applied Mechanics. This ‘trinity’ forms the applied building sciences. A change in architectural mode of design will cause a marketing demand on the lower level of technology, up to the most basic level of fundamental science. Application directed architecture needs the support of the more basic sciences to renew itself to the ‘Liquid Design’ building technology. The basic sciences see architecture and building technology as applications. In the scheme (Fig. 3.) architects seem to tend more towards free-form designing sculptors, moving to the right hand side of the scheme. In the recent design experiences of the author, frameless glazing using tensile structures and sophisticated double glass panels were greatly stimulated by the development of UV-resistant glue. With this glue it was possible to connect the inside of the glass panels to the outside surfaces of the (Quattro) spider connectors on top of the cable structures. Laboratory compression tests and lamination technology for glass borosilicate tubes brought this development one step further into the direction of the ‘Zappi’ ideal. ‘Zappi’ is the marketing name of a new type of trustworthy transparent structural material, launched on the TU Delft in 1992 [Eekhout 1992].

![Figure 3. Relation between research and design](derived from a scheme of prof.dr. Berkhout [Berkhout 2000])

Other intermediate fields of technology like Building Applications could contain only another composition of materials, elements and components in space in order to form the building designed, without introducing a new approach in these fields a matter of composition rather than invention. Many Blob designs can be built with contemporary materials in a contemporary production and building method. Others need adaptations of the current production technologies. There are several combinations possible of conventional and new materials, components, structural schemes, productions, geometries and integrations. Some of the clearest combinations in this 6x6 matrix are:

- Conventional materials in conventional components & productions for conventional structural schemes & geometries in conventional integrations;
- Conventional materials in conventional productions for new geometries
- Conventional materials in new geometries & integrations
- Conventional materials in new components & productions because of new geometries and integrations.
- New materials in new components & productions acting in new structural schemes caused by new geometries and integrations.

In building technical respect Fluid Designs are first of all material compositions with a new and unconventional geometry, whereby architects hope that the spatial composition will be the first and only derivation in the building cycle. A complicated geometry, however, requires complicated geometrical surveying, both in the design and engineering phase as well as in the phase of the individual productions of building parts and in the composition and integration of these on the building site.
The nature of many of the curved forms of building elements means that they have to be produced in an alternative manner. It could be by casting of free material into a complex element form. It could also be by deformation of economical commercial plate materials into a 2,5D or 3D form. The 2,5 D element form can be developed from a flat plane, but for the formation of a 3D panel more rigorous formation techniques in temperature and pressure are necessary, like explosion deformation of aluminium panels and hot mould deformation of glass panels. The geometrical definition and fixation of these 3D elements will complicate the engineering of these elements greatly, but also the production and the fitting together of the collection of panels belonging to one building part. On top of this there is the joining of the different building parts, engineered and produced by different parties in the building: the building ‘seam’ and the building ‘knot’. So the decomposition of a geometrically complex building into elements and components to be made by different engineering co-makers requires an optimal description in the form of a computerized 3D-CAD mother model. In this respect it is of great importance to keep the hierarchy of building products in mind (Fig. 5.), like published in [Eekhout 1997], so that materials and commercial materials are not confused with elements and components.

3 ‘Liquid design’ architecture after Gehry’s Guggenheim

And out of the blue came the Guggenheim museum in Bilbao, opened in 1997. Perfectionist American design blended with a Spanish way of building. But after the opening of this Museum designed by Frank Gehry the world was amazed. It really boosted the ‘Liquid Design’ era. Gehry designs his buildings in clay as sculptures. The model that satisfies him most is measured electronically and fed...
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Eindhoven The Netherlands 03-05 July 2006

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into a geometrical computer program. Gehry’s office in Santa Monica uses the French Dassault-based program Catia for this purpose, developed for engineering aeroplanes. By then the enlarged clay geometry is fixed and the building is tendered as a total package. Then the subscribing main-contractors have to find sub-contractors who are willing to engineer, produce and built the building parts exactly as designed by Gehry. Subcontractors have to buy the Catia program as well in order to detail the global geometry as given in the main design. From this 3D-Catia model the construction and composition of all elements and components of each different building part, taken care of by each subcontractor, is derived and fixed, especially when these elements and components have to be prefabricated. Other young architects may be more flexible with the overall geometry. Fact is that these non-rectangular geometries have to be fixed by the project-architect and that only the usual tolerances from engineering, production of elements and their positioning have to be compensated. There is no room for deviating geometries of one building part, as this part will never be fitted in between the other building parts.

This type of building designs dictates a very close co-operation between the participating engineering & producing & building parties. Much more than the architecture of the 1980-ies we could speak about ‘High technology engineering & production’. And the aspect of mutual trust between collaborating parties plays a role versus the intrinsic suspicion inherent to the ad hoc selection of the tendering system on the open market.

4 Higher degree of co-operation: collaboration

A free-form geometry involving all building parts of the building design leads automatically to a very accurate co-operation, rather collaboration between the building team partners, much higher and more intense than ever experienced before. It takes for most of the concerned architects a number of projects to agree with this and to change their usual distance to the production & building phase and work towards an integrated approach of all building team parties concerned. The building team is to be defined as the sum of all participating architects, designers, advisors, main contractor, building managers, component designers, sub-contractors and producers involved in the project.

One could define four major stages:

- Design of the building and its components
- Engineering of the building parts (elements, components and site parts)
- Productions of elements and assembly to components
- Building on site and installation of prefab components

Each of the 4 stages has its own characteristics of design considerations and assuring quality of the building as the end product being a composition of the different building parts, installed on the building site by different building team partners. The phase of design of the building and its components will be the global domain of the architect and his advisors. In ‘Liquid Designs’ the tendency is for standard products to become systemized and for building systems to become special project systems. The need for special components will increase because of the special geometry of the building, influencing the form and position of each composing element/component. The tendency towards individualisation can be described as: Industrialisation in lots of one.

The design phase has to result in a 3D-CAD mother model of the building, drawn by the architect. He has to integrate in his model the principal element and component sizes and their principal connections, as from this model the different building team members will start their own co-engineering. The architect has to incorporate in his 3D CAD mother model all relevant data of all different components of the different building parts, each building part to be worked out later by the different co-engineering members of the building team. The information contained in this virtual model has to go very far. The 3D-mother model will not be used for tendering purposes, as it is not readable for other people than engineers, like quantity surveyors. Drawings still will remain the information carriers at the tendering process.
5 Co-engineering, production and installation

Different building team parties are involved to engineer their own production. These engineering activities all have to be based on the central 3D-mother CAD model. This model is the basis for the engineering of the total building. The keeper of this model is indispensable in the office and will become a crucial factor in each co-engineering company. Despite computers, in-house logistics will be depending on one master-engineer only! For the co-ordination and integration of the different co-engineering parties in the building team two clearly distinct modus operandi can be followed:

Separate Model: Every party works on his own program, taking the basic data from the mother model. Subsequently the problem will be how to check the quality of these separate computer drawings and outputs and how to relate them to the common details. Where two or more building parts are joined, each to be worked out by a separate building party. In the Netherlands the steel construction engineers work with Strucad or X-steel, while façade engineers work with Autocad 2000 based software. These two software packages are not compatible. Installation engineers make use of yet another software package. Checking the different results is extremely difficult and mistakes only come out on the building site. The architect does not check any drawing for its dimensions. This traditional pattern is not satisfactory at all.

Collaborative Model: Each party works on the 3D-CAD mother model successively as it is allowed ‘slot-time’ (like aeroplane traffic coordination). During the start the situation is fixed and detailing and modifications of elements and components can be fed in. The whole is to be worked through. The end situation will be fixed and communicated to all building parties. After the proper closing off of the slot-time of one party, check and certification by the model keeper, the next is allowed his slot time. Simultaneous work on the 3D model by more than one engineering sub-contractor is not allowed, as it will lead to confusion and possible legal problems. Gehry enforces the use of Catia in his projects. But now different teams in the engineering department of one producing company could be working with different programs. This will lead to mistakes and confusion. So a plea is made towards the development of an universal 3D-computer program to be used by all corresponding building team members, capable of handling the conceptual design, the presentations, the overall building design drawings, the statical analysis, the engineering co-ordination drawings, the shop drawings up to the quantity lists.

After each of the building-directed engineering contributions of all participants, regular geometrical checking has to be done. Neglect of this will lead to large problems in the integration and co-ordination of the engineering, in production and installation and hence, much effort has to be spent here. Liability is also at stake here. Four building parties are able to execute this: the architect, the building technical engineer, the building contractor and the geodetic surveyor. Each option has its advantages and disadvantages. Each proposed party has to realise assort of forward or backward integration. The data from the overall 3D-mother model or from the individual overall CAD model or drawings will have to result in the drawing of individual element drawings, in the form of shop- or production drawings. They are made to feed the production. This will be done either direct in CAD/CAM for cutting, drilling, punching and machining operations, depending upon the development of each trade. It could be done direct or indirect via manual machine activities like welding and bending operations, casting of steel nodal pieces and assembly of elements to components, hot dip galvanisation and painting or coating afterwards and protection for transport to the building site.

The engineering part of site activities are the installation or assembly/erection drawings which indicate the identification of the transported components and their location by XYZ co-ordinates of the prominent click points. These click points will have to be established on basis of the characteristic geometric points of the 3D-CAD mother model. The fixation of these click points during the progress
on site is a service provided by the main contractor. Because of the complexity of the geometry and the absence of straight and orthogonal lines that can easily be fixed by craftsmen (water level, plummet and the mechanical refinements thereof) in Liquid Design Architecture this new service of geodetic surveyor is an absolute necessity to build these buildings. The surveyor makes pre- and post checks of the positioning of the components on the site.

After completion of the work of an earlier contractor the surveyor will examine the click points on site with the theoretical ones and their tolerances. This is done in order to prepare and inform the next contractor who has to build starting from these data. This subcontractor is only able to compensate certain tolerances as his production is already completed when he will start on the building site. The discipline of prefabrication and industrialisation and the installation of subsequent trades on the site will have to go over in the near future into a discipline of industrialised complex building geometries. Many times the building process of ‘Liquid Designs’ is approached with the same attitude as traditional building. In those cases most of the building parts are produced on the building site and the mistakes of earlier labour are expected to be corrected by later labour. But dealing with fluent architecture in the traditional way leads to longer juridical struggles than the building time itself, disappointments and bankruptcy of the weaker parties. Tendering documents should contain the most effective modus operandi and respective procedures and relationships followed, but they seldom do.

13 Conclusion

The last decade ‘Liquid Design’ buildings have become possible because of the increased accuracy and complex 3D geometries of computer hardware and software. The design & engineering is the core of the operation and within this process the design decisions are most important. Complex issues can be dealt with by an analytical engineering approach. There is not a problem that cannot be solved. The most advanced technology has to be developed further in order to meet the new geometrical demands, which places buildings at the same level of complexity as yachts, but at a lower economical level. Cold bending and twisting of glass panels, even laminated and insulated panels mix low cost prices with complex form results. The new generation of ‘Liquid Design’ buildings with their computer designed arbitrary and non-rectilinear form, are mainly generated out of sculptural considerations by architects. All lessons from the past decades where systemized spatial structures and economical building industrialisation with the most sophisticated products were developed and their salutary regularities, do’s and don’ts were developed, seem to have to go in a higher gear. The structural glass components of these buildings require an enormous effort in collaborative design and engineering. One would recommend that at least in the design phase the concept of the building technical composition would be developed simultaneously with the architectural concept. Both in the design & engineering phase as well as in the productions & realisation phase an extremely high degree of collaboration between all able building parties concerned, is an absolute necessity to reach the goal of successful ‘Fluent Design’ Architecture, that is successful for all parties. Frameless glass structures contribute to that higher level of technology in Modern Architecture.

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The Management of Complex Design & Engineering Processes
Individual Workplaces and Group Spaces: new flexible learning environments in secondary education.

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KEYWORDS
Analysis, activity patterns, precedents.

1 Changes in the educational system

In the last 10 years secondary education in The Netherlands has focused on new teaching models which resulted into significant changes in teaching and learning, new curricula and different, new facilities. One of the fundamental elements of the educational renewal is that instead of acquiring factual knowledge the emphasis is now on obtaining skills and developing the learning process (Dudek, 2000). The traditional school with mainly passive, listening students was transformed into a school with actively learning students (Schiel and Gier, 1996, MesoConsult, 1997). Traditionally a group of students of the same age would learn the same subject in a fixed period of time. At the moment there is a shift to the individual learning process: which subjects students are interested in, what they need to know in order to answer their own questions, how much time a particular student needs to tackle this specific problem. Consequently students may choose the appropriate way of studying a topic (within frameworks defined by their teachers). This can vary from working in a group of students that share the same interest or level to working individually on an assignment. Traditional lessons and instructions with a large group of students still remain but mostly as an introductory activity. The recent emphasis on individual learning coupled to the already established tendency to work variably in smaller groups and the ongoing computerization of learning aids present new challenges to the programming and designing of new school buildings and especially to the adaptation of the existing stock.

2 Accommodating different activities

A choice in the way you want to work asks for a variability of workplaces in the building. However variability is uncommon in existing school buildings, as these often follow traditional and conventional teaching models (Dudek, 2000; Horne, 1999). This means that the existing types of school buildings need to adapt to the new ways of working and often integrate individual workplaces and group spaces. In many cases the problem is solved only locally and opportunistically, without much concern for efficiency in activity scheduling or the overall flexibility of the building.
The three types that now dominate the existing building stock are the corridor type, the hall type and the pavilion type (Boersma et al., 1996). The basic school type was the corridor school. The introduction of different subjects transformed the one room school building into several separate rooms connected by a corridor; the corridor type emerged. The development of the hall type was a natural consequence in the 1950s, when a central hall for group activities was introduced. Further transformation of both the corridor and the hall types has lead to the pavilion type, a school which consists of a number of pavilions or wings of different size and character.

1. **Corridor type.** The main characteristic of the corridor type is its sequential spatial structure. Spaces are positioned on either one or on both sides of the circulation space (the corridor). Exceptions like the entrance or the gym are visible as separate wings shoved into the building.

![Figure 1. Corridor school; Prismacollege Graaf Engelbrecht](image)

2. **Hall type.** The different wings of this type are actually obvious variations of the corridor type (Steijns and Koutamanis, 2004). These wings are all connected by a central hall which usually houses different functions. The hall school is recognizable by the internal circulation ring which connects the wings.

![Figure 2. Hall school; Dockinga College](image)

3. **Pavilion type.** The different pavilions in the pavilion type school building are easy to recognise and can all have their own structure. These individual pavilions are variations of the hall type (with a circulation ring) or the corridor type (Steijns and Koutamanis, 2004).

![Figure 3. Pavilion school; Trevianum Scholengroep Sittard](image)

A common characteristic of all three types is the presence of a large number of traditional classrooms (either connected by a corridor or a hall). This makes all the types predominantly appropriate for class teaching. The possibilities of integrating the new activities in the corridor type building are limited. Individual and small group spaces are usually positioned on one or on both sides of the circulation.
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space. Most common is to use the corridor not only as circulation space but also to create individual workplaces. The central hall of the halltype school building originally was designed to anticipate on the need for space for group activities like watching a film or performing a play. With the changing need for different activities the role of the central hall changed as well. It is now often equipped as a space for individual working (Steijns and Koutamanis, 2004). The new requirements are accommodated mostly separately in two ways:

1. Spaces adjacent to the classroom
2. Central facilities

By accommodating the new spaces adjacent to the classroom an uneven distribution arises. One group of students that uses the specific classrooms may have access to more space than groups that are allocated in other classrooms. Also an uncertain relationship between different scales (group sizes) and the corresponding spaces. There is a clear preference for centralizing facilities in most schools. The main reason lies in the organisation and economy. It is easier to have more control of these centralized spaces, students and facilities. Hence the transformation of the school library in a multi-media space. On paper this is a useful combination but in practice it may attract more users and activities than planned.

### 3 Temporary changes

An alternative approach is to depend on the flexibility of equipment and furnishings to transform the scale and arrangement of workplaces in the same space. At a school for secondary education in Utrecht, the multifunctional tables can be used for students to work in groups as well as for working individually behind a computer. The computers can be folded in and disappear underneath the table to make it appropriate for working with small groups of students (Rietveld et al., 2004).

![Figure 4. Arrangement A of a classroom (Vaxa).](image)

![Figure 5. Arrangement B of a classroom (Vaxa).](image)

An other possibility is not to have the flexibility in the furniture itself, but in the arrangement of the furniture in the space. Arrangements A and B (Figs 2 and 3) are examples of how to organise the
standard furniture of a classroom to make it appropriate for either working individually and working in small groups. The approach of accommodating different activities in the same space actually is a rather old-fashioned solution because the class still has the same rhythm but only parallel activities.

4 Strategy

We propose that treating individual workplaces and group spaces as yet another feature of a school building fails to take into account fundamental changes in the learning environments of secondary education. We propose a strategy that consists of three steps. The first step is to analyse the activity patterns with respect to the accommodation of different activities, the corresponding use requirements and the performance of existing school buildings in accommodating them. A list of all activities of all user groups forms the basis of the brief and the clustering (Fig. 7).

The second step consists of analysing the dynamic patterns resulting from the co-existence of individual, group and communal activities in the same or adjacent spaces especially in relation to the adaptation of the learning environment to suit these activities (including ergonomics, time and motion, acoustics and lighting). Students are increasingly organising their own schedule and schools are changing from an hourly schedule to e.g. a timetable with half day periods. Schools are becoming more dynamic and confused as to which activities are taking place at what times of the day over which period of time. By projecting these on a topological representation (Steadman, 1983; Steijns and Koutamanis, 2005) it is possible to trace small or large groups dynamically, as well as produce cumulative overviews for a given period of time (Fig. 8). It gives an abstract but unambiguous representation of local and global patterns which express qualitative and quantitative requirements of each group of users and each use type.

Figure 6. One cluster of activities

Figure 7. Cumulative representation of the activities of one user group in an hourly schedule.

The third and final step is knowledge transfer from other building types characterized by similar transformations, such as offices, libraries and Internet café’s. By selecting appropriate precedents on the basis of the results of the second step we can identify similarities and differences from the environments studied in 1 and subsequently specify promising directions and strategies for the integration of new learning environments in existing school buildings and types. Considering the new activities in a school building, the evaluation of the open-plan office in office buildings for example can show us how we can deal with housing a combination of activities like working individually,
having meetings and relax at the same time in the same area. A well-known example is the 50 m x 50 m square floor plan of the Villa VPRO, an office for a radio and tv station. There are no corridors but large folding floorplates on which services, circulation, desks and other objects are gathered.

5. Evaluation

The distinction between different aspects in the accommodation of new learning activities requires a clear correlation with new or adapted spatial and functional types. The resulting configurations of individual workplaces and spaces for small and large groups are spatially and structurally not fixed. On the contrary, transformations in time (even in the same day) are commonplace. Most school designs produced under these circumstances show a preference for centralized facilities, arguably mainly because they offer extensive control possibilities. However, this fails to resolve wider problems concerning space use and utility. In most cases the new facilities attract most attention and users, while other parts of the building are poorly occupied. Another fundamental problem is the uncertain relationship between different group sizes and corresponding space scales. By considering each major aspect cluster in a different step we propose a closer correlation between decision-taking and spatial or functional types. This facilitates the transformation of existing (conventional) types into modern adaptations, as well as transfer from other use types, where similar requirements and use patterns have stabilized in recognizable configurations. We assume that the emergence of such patterns in Dutch school buildings is not simply a matter of time but also a question of specificity in the brief and focused analysis in designing.

6. References

Shaping the program to the architect’s needs: A pilot study

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KEYWORDS
Briefing, Programming, Architect-client communication, Facilitating design

Introduction

Programs of requirements, or briefs, need to be presented in a form that is meaningful, accessible and useful to architects. The current form of program documentation is not often perceived by architects as ideal. Architects may not even read large programming documents (Brand, 1994). Recent publications on programming has focused on the client’s point of view (Salisbury, 1997), workplace performance (Horgan et al, 1999), value management (Yu et al, 2005) and information management. Text books concentrate on collection of data, and strategic decision making (Blyth & Worthington, 2001; Cherry, 1999). Attention is rarely focused on how architects use briefing documents. Yet the brief or program is first and foremost a means of communication between client and architect. If architects experience programs as inadequate bases for design, then the briefing process may have failed in its primary purpose. It is therefore essential that more attention is paid to the way architects use programs.

Architects begin their work by analysing the program (either as a document or as an idea implicit in the client’s request for services). This analysis has been described as “the exploration of relationships, looking for patterns in the information available … the ordering and structuring of the problem.” (Lawson, 1980) This process often involves duplicating much of the work that has gone into the preparation of the brief. This suggests that there is a misfit between what we currently include in an architectural program and what architects need. This suggestion is supported by surveys done in the UK showing that both clients and designers are often ill informed about each other’s contributions to the programming process and the status of the information produced. (Brown, 2001) Why do architects re-do much of the program? Is the program incomplete? Do architects require additional information? Do architects need to gather the information themselves, regardless of its presence in the program document, for institutional or cognitive reasons? Do architects need specific representations? Only when we can answer these questions can we begin to shape programming documents in a way to more effectively support designers.

The proximity of England and the Netherlands creates an exciting opportunity to examine different approaches to architectural programming. The two countries have diametrically opposed traditions of programming. In the UK, architects traditionally do the programming as an inherent part of their
initial design work [RIBA 2000]. In the Netherlands architects rarely prepare programs. Indeed, a completed program forms the basis of the contract between client and architect, and the architect’s work is judged on the degree to which the design satisfies the program.

A pilot study was carried out based in interviews of two architects – one Dutch, one English. They were asked: who reads the brief? how they process the information it contains? what is excess or is missing from the program? and what must be translated into other representations before beginning to design? In addition, the architects were asked what other practices they engage in at the initiation of design and throughout the design process to collect additional information regarding the project and to elicit opinions from their clients. Throughout the interviews and the analysis of the data attention was paid to secondary as well as primary benefits of the practices examined. For example, was the interviewing of clients regarding their needs (duplicating interviews made by the preparers of the brief) in fact of greater value in the formation of a good social and professional bond with the client? (All quotations not otherwise indicated are from the interviews with the architects.)

2 Dutch experience

The Dutch architect is the ‘management’ partner in a medium sized firm with a good reputation for both design excellence and professionalism – that is for both aesthetics and function. He is primarily responsible for ensuring that projects are well run and meet the client’s functional, financial, and schedule requirements. He usually receives a program or brief prepared by a project manager or business consultant working with the client at the initiation of a project. Depending on the nature of the commissioning procedure they may or may not meet the client at this stage.

Their first step is to hand the program over to a junior designer for analysis. This person summarizes the program and makes a series of diagrams, including relationship diagrams and volumetric analyses (areas, sections and volumes representing the different spaces listed in the program). Some programs contain these diagrams, but the architects feel that it is essential that they, their staff, make the diagrams themselves. These are given back to the principals, and it is on the basis of these that the principals begin the sketch design.

The program itself usually has far too much material in far too much detail for the initial design steps. Summarizing the program serves to filter out the excess detail. Sketch design begins by tracing over the programming diagrams. It is necessary, says the Dutch architect, to get the feel of the assignment, to experience the diagrams. This can only be done by making or tracing the diagrams themselves. It seems to be part of a process whereby the architect internalizes the problem.

Where possible, the Dutch architect has a strong preference to get to know the client first. This meeting is on two levels, learning about the organization and learning about the people in the organization who will be running the project. The architect primarily is interested in learning about the history of the organization, what their mission is, why they wish to have new accommodation, what they like and dislike about their current accommodation, how they go about doing their things – their operations. These things, the Dutch architect finds, are nearly always absent from a written program. The client’s reasons for moving, their satisfactions and dissatisfactions with their current accommodation and the nature of their operations have already been reduced to specifications of rooms – relations, areas, materials, dimensions, etc. While these specifications are important inputs to the design process the Dutch architect finds them inadequate to making a design. He needs to know about the qualitative, the soft, the emotional aspects of the assignment. The architect also values the opportunity to understand the political structure of the client organization: who will he be dealing with? and who will finally make the decisions?

Ideally this meeting of client and architect will take the form of an excursion with the client representatives, the architects, the project managers and even the consulting engineers, to either a number of buildings of similar programmatic type identified by the architects as interesting or

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inspiring examples, or buildings designed by the architect. These excursions are excellent opportunities to get to know each other, to establish the client’s level of ambition (how willing are they to undergo the intense and difficult process of reaching an exceptional building) to learn from the client’s reactions to the various projects, to exchange opinions with the engineers, to discover hidden agendas (both those of the client and those of the architect), and to establish a common set of reference images to which they can refer in the future. Where such an excursion is not possible, photographs, illustrations and drawings of buildings from archives, books and magazines are used to create the references. In either case, the architect feels that it is extremely useful to get a feel of the nature of the assignment. He repeatedly stressed terms like ‘feel’ over the acquisition of specific data or constraints regarding the building.

3 English experience

The English architect is a self described architectural stylist, and is the principal architect in a medium sized firm specializing in cultural facilities. In line with British practice, this architect normally develops the brief as part of his services, but while many UK architects will subsume briefing into stages C (Outline Proposals) and D (Scheme Design) in the RIBA Plan of Work, the stages at which an architect’s design contract typically begins, this architect prefers to begin briefing with stages A (Inception) and B (Feasibility) [RIBA 2000].

The architect is very reserved in his relationship with the client, rarely meeting with them, and relying on minutes and verbal reports of meetings from his project architect. He finds that by being remote he protects his authority. He rarely spends social time with the client, and depends entirely on how the client representative presents the client organization rather than investigating the organization himself or delegating such investigation to his staff. However, he does investigate sites personally. He also relies on what he refers to as an extensive repertoire of social and spatial conventions.

Typically he receives a very short ‘client’s brief’ [Tunstall 2000], often merely a verbal statement of what the general goals of the project are: “Well we have a theatre and a gallery space, and a café. And we want exactly the same thing but in a better order with larger size.” Regardless of the extent of the client’s brief, the acquisition of information regarding the client’s needs is delegated to his management partner and project architects. They will produce a digest and present this verbally to the architect. The design then progresses through a series of informal but structured meetings between the architect and the project architect in which the architect puts questions to his assistant, and sketches ideas for the further development of the design. Internal documentation of the program and design consist mostly of scheme designs, models, and the architect’s hand sketches.

The English architect uses “the design of buildings as a way of discovering what the brief is about, both in terms of spatial configurations and their meaning to the client …” That is, he begins to design and uses this design as a means for exploring both the requirements of the client. This is done by making a series of studies interrogating both the site constraints and the different options available for organizing the client’s activities in space. “… the only way you can ever really discover what a building should be is by designing it.” This stage concludes with a report outlining two or three ways in which the client’s brief can be realized within the limitations of their budget. The report includes a description of the site, “observations which would affect the massing and style of the building”, identities numbers and areas of rooms, and “any key observations that [are] particular to the client’s type of business.” Relationships between rooms are expressed in the designs rather than in diagrams. He has occasionally use spreadsheets to manage the room requirements list, but only for very complex projects. For the English architect it is the drawings and models that are the most important representations of programmatic information. His approach to programming is very concrete, preferring to present possible architectural solutions rather than abstract statements of requirements or diagrams. In his experience clients understand concrete proposals better.
At the end of the Inception and Feasibility stages the client is asked to study the report, to make a choice from among the schemes (the architect always makes his recommendation clear) and to sign off on it. This ensures that the client puts sufficient effort into the briefing process and protects the architect from changes in the brief generated by the client later in the design process. The chosen scheme then becomes the brief. Although he recognizes the desirability of establishing the brief early in the process, the English architect does not believe that it is possible to completely determine the client’s needs in advance of the design process. Inevitably, in his experience, additional criteria emerge during the design process.

4 Comparison

These two architects clearly have radically different approaches to relating to the client. The Dutch architect prizes a good social, team-like, relationship with his clients, while the English architect prefers to maintain his distance. These differences certainly reflect personal as well as national differences. What is therefore more interesting is the commonalities between the two. Both architects prefer to begin the sketch design with a limited amount of information. They both prefer programmatic information to be delivered at an appropriate stage in the design process, with more detailed information about materials, dimensions, door swings, etc, delivered at the detail design stage. In each case, the principal architects delegate the process of compiling and analyzing the data that makes up the brief, whether that data are presented in a written program or are obtained through meetings with the client. Both firms have established patterns of information flow, from the client, to the firm’s files and the memories of individual staff designers, and finally to the architect himself.

Further, both architects place a certain emphasis on getting a feel for what the brief will be, but whereas the Dutch architect is still thinking of an implicit and abstract feel for the brief, the English architect is much more concrete – thinking of the design as the only possible expression of what the brief will be. Each architect has a process by which he internalizes the program: by tracing the diagrams or by visiting the site, and by thinking “about things a long time, very, very thoroughly”. It seems that it is not only a question of explicit information about numbers and sizes of rooms, but about some sort of intuitive grasp of the program.

Finally, while the Dutch architect desires that the client not move forward to architectural solutions, but describe the history, mission, and operations of the client organization, the English architect is satisfied with an expression of needs in terms of the properties of the building, both architects expect the client to have and communicate a thorough understanding of their own history, mission and operations. Where this does not exist, the design process takes much longer.

5 Conclusions

It is clear from the experience reported by these two architects that their involvement in the programming process (officially or not) is an essential part of their design approach. Reading a brief is insufficient preparation for design, architects must perform certain aspects of the programming process themselves. Still, a few concrete recommendations for the preparation of program documents can still be made.

1. Architect’s should be able to express their information and briefing needs to their clients who, in turn, should be prepared to supplement programming documents prepared in advance to meet their architect’s requirements. The two architects interviewed differ in their approach to programming and clearly require different things in order to serve their clients.

2. The program should contain a description of the mission, history and operations of the client.

3. It should contain a brief summary of requirements upon which the sketch design can be based. This should indicate both areas and heights of rooms. Further specific requirements should be
presented in separate sections of appendicies. (This recommendation correlates with Cherry’s (1999)advice from the US, where it is architects who prepare programs for other architects.)

4. Programming processes should include design studies, both to force strategic choices from the client, and to convey these choices to the architect. (This recommendation is in accord with UK recommendations for the use of exemplars in the specificaiton of requirements for design-build contracts).

These recommendations should lead to the development of programs that will be more accessible and useful to architects. They cannot guarantee that architects will be spared their redundant programming activities – both architects seemed as individual and as firms to be engaged in a process of analysis … a cognitive process, in which the personal participation in the acquisition, organization and representation of programming information plays a part in the preparation for the initial acts of design. The extent to which this cognitive process can be made more efficient is not clear. Only by allowing the design architect to participate in the programming phase can additional efficiencies be achieved. The integrating programming and design has been advocated by others (Spekkink, 1992), but barriers in practice and contracting have prevented clients and architects from adopting this approach. The English architect’s application of the RIBA stages A and B, pre-design stages seems to be a successful way to keep design and programming contractually distinct while allowing the desired integration. It is only when the architect is allowed to participate in and use design to stimulate the strategic choices of the design that the client can be best served with respect to their future needs.

6 References

Managing the design process during the design meetings – the need for flexibility

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KEYWORDS
Architectural design, Design meetings, Design management.

1. Introduction

The main objective of a building, apart from the esthetical grounds, is usually to serve a need for housing. Consequently being an architect is, next to a creative and artistic profession, a servant profession. In terms of problem solving a design is one of the acceptable solutions for a problem [Hamel, 1990; Simon, 1987]. The domain of acceptable solutions, the solution space, is described by the design constraints, imposed and have different degrees of flexibility [Lawson, 1997]. Due to the increasing complexity of design problems and thus design constraints, there is a growing focus on the management part of the design process [Prins, M e.a. 2001], which more and more results in the client hiring an external project manager. The traditional focus of the project manager used to be on time and budget, but interventions concerning the content of the design increasingly become common practice. Architects and project managers often have different ways of working and thinking, which is not always recognized.

The design process lacks a plan for the activities that need to be conducted to reach the desired outcome. During the process, insight, both from the architect and client gradually increases, which involves re-discussing earlier decisions. Ultimately, this leads to a cyclic design process. These characteristic features make the design process very dynamic, which asks for a flexible approach to managing this process. This paper deals with the need for flexibility when managing designing. The purpose of this research is to obtain more empirical insight in and knowledge of the relation between managing and designing, which then can be deployed in practice. The research is exploratory, as it is a first time application of protocol analysis to the relationship between issues and interventions during the design process. The findings are of preliminary nature.

2. Theoretical framework

First a framework has been developed, which describes the relationship between the design process and the managing process in a theoretical way. Firstly, we have to describe the design and managing process separately. These descriptions need to be generic enough to be valid and recognizable for everyone, despite the personal and unique characteristics of these processes. Therefore the design process and the managing process have been described by their elementary activities, which are activities that are
reoccurring in every stage of the process and recognised as such by a wide variety of authors [see for an overview Boekholt, 2000]. To describe the process of designing the model developed by Zeisel is used. In Zeisel’s opinion design is a complex activity including several analytically distinct elementary activities, which are imaging, presenting and testing. Imaging means forming a mental picture of a part of the world. It is the conception of an idea, a spatial representation of the imagination of the designer, which he converts into a drawing. This converting onto paper, to externalize and communicate his images is called presenting. After presenting a design idea, the designer takes a step back and evaluates his ideas. To evaluate he needs design constraints and criteria to test out his ideas. As Zeisel puts it: “Design testing means comparing tentative presentations against an array of information like the designer’s and the clients’ implicit images, explicit information about constraints or objectives […]. Testing is a feed-back and feed-forward process.”

The steering of the design process is described as a succession of the activities registering, interpreting and intervening. This cycle shows similarities with the traditional management control cycle [Wijnen et. al., 1996]. An important difference is that the traditional cycle is aimed at controlling previous defined and planned activities, while the design process lacks this kind of planning, as is mentioned before. Registering means to observe the actual situation. The project manager or the client registers the activities or results of the design process. Subsequently he interprets these activities or results in order to intervene in the design process. To be able to interpret a design it is indispensable to compare it with design constraints and judge it by design criteria. These design constraints and criteria are partly similar to those used by the designer to test his own design. Next to those more broadly based constraints and criteria, personal and implicit criteria (both from the designer as the client/project manager) always play a role in evaluating the design. The theoretical framework combines the design and steering cycle in one scheme, as is shown in fig. 2.

![Design cycle diagram](image)

**Figure 2.** The theoretical framework which formed the base of the empirical research. This framework shows the cycle of design activities and the way the successive steering activities are related to it.

### 3. Methodology

The relationship between intervening and imaging, presenting and testing, has been examined in practice, for example, what kind of intervention is used to deal with what kind of issue? To examine this relationship, design meetings of several cases have been attended and the conversations between architect and manager/client have been analysed through protocol analysis. Therefore a classification of the issues and the interventions has been developed. The first step in classification is to define to which elementary design activity e.g. imaging, presenting and testing, the issue is related. Issues related to imaging, the
actual idea of the architect, are chiefly issues concerning the content. Issues related to *presenting*, are chiefly communication problems. Finally, issues related to *testing* are usually connected to the design constraints and criteria. The same three main categories, that is imaging, presenting, testing, are used to classify the interventions. When a problem has to do with one category of issues, the intervention is usually directed towards the same category. For example an issue related to imaging is followed by an intervention directed towards imaging.

**Interventions**

The next step is to classify the interventions more precisely, in order to analyse practical situations more accurately. All the interventions were classified as either result-oriented or activity-oriented, proactive or reactive and direct or indirect. This produces eight subcategories for each elementary activity, as is shown in fig 3.

Result or activity-oriented characterises whether the intervention tries to influences the result directly or to influence the activity which is conducted to reach the result. For example when a manager wants to reach optimal integration between the technical and spatial design, he might point out the way he thinks this should be done. This means he specifies the solution; this makes his intervention is result-oriented. Another option available to the manager is to provide the opportunity for the designer and the technician to consult each other. This means he defines the activity that in his vision needs to take place at this point, which is an activity-oriented approach.

Proactive or reactive signifies the extent to which an intervention intents to anticipate the subsequent steps in the design process. In the previous example, both the interventions are proactive because they try to influence these subsequent steps.

Direct or indirect intervening is characterized by the extent to which a solution is suggested in the intervention. When the manager tries to reach integration between the technical and the spatial design by pointing out his ideas on how this should be done, this is a direct intervention. While getting the designer and the technician around the table is an indirect intervention.

![Intervention Tree](image)

Figure 3. This intervention tree shows the eight different types of intervention.

4. **Results**

From two cases (design projects), observations were made during meetings of the design team to determine relationships between the above defined categories of steering behaviour and categories of design activities. From each case 4 meetings were observed. Per meeting we observed for approximately 2 hours.

A frequency matrix of categories of issues and types of interventions used by the project manager was compiled (Table 1) based on the observations from the 8 meetings. This matrix shows the frequency of a
type of intervention by the project manager in response to a category of issues. Patterns occur in the relationship between issue and intervention (Table 1 and fig. 4), as is shown by the the higher bars in figure 4).

<table>
<thead>
<tr>
<th>Issue</th>
<th>To image</th>
<th>To present</th>
<th>To test</th>
</tr>
</thead>
<tbody>
<tr>
<td>I1</td>
<td>10</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>I2</td>
<td>15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>I4</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I6</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>I7</td>
<td>2</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>I8</td>
<td>1</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1. Matrix showing the relationships between the type of issue that occurs and the type of intervention that is used by the project manager to deal with it.

Figure 4. Graphical representation of table 1

Interventions aimed at imaging and testing are mainly result oriented, while the steering behaviour concerning presenting has a tendency to be action oriented. The personal, creative and cyclic character of the design process implies that there is no predefined set of activities to perform, so therefore action oriented intervening asks for a lot of insight in the ongoing process. Furthermore architects are professionals, who are not likely to be managed on their throughput, but rather on their output. The interventions that are a response to presenting issues are an exception, because these are more often action oriented. This can be explained by the fact that presenting is the main design activity in design meetings. Imaging and testing by the architect ususally takes place at the architectural office, not during a meeting. Figure 5 shows for each of the three intervention types the proportion of result/activity, proactive/reactive and direct/indirect interventions. The steering behaviour which is directed towards imaging is mainly reactive and direct, besides result oriented. This is understandable, when you realize that the architect has the natural initiative when it comes to the design itself.

The interventions aimed at presenting is mostly action oriented. These interventions have a strong tendency to be proactive and indirect. This tells us that when the project manager/client tries to influence the throughput of the architect, the issues are mainly related to communication and moreover that the managers steering behaviour in these cases has an indirect nature. The inevitability of this becomes clear when you realize what an activity-oriented, proactive, direct intervention would be. It would imply telling the architect ‘what to do next’.

Managing the design process during the design meetings
Interventions oriented at the design activity of testing are usually result oriented. The preferred way of intervening seems to be slightly result-oriented, yet the proportions of proactive and reactive interventions are rather in balance (57% to 43%). But there is a difference between criteria that are common for all stakeholders and personal, subjective criteria. When the interventions towards testing are separated into two categories (common versus personal constraints and criteria), it appears that the steering behaviour related to testing based on common constraints is mainly proactive (66%) and direct.

Figure 5: Main research findings, in terms of tendencies in correlations between steering behavior and design activities.

5. Conclusions

This research has shown us tendencies between steering behavior and design activities. Although the amount of data is too small to generalize, the tendencies our data show, as summarised in figure 5, are remarkably strong. It is necessary to extend the research sample to improve the robustness of the findings. The categories defined for both types of behaviour proved to be adequate for protocol analysis research. Further research is needed to underpin our findings both in terms of adaptiveness of designers to steering behavior as in terms of the actual efficiency and effectiveness of the observed steering behaviour.

The findings indicate that the situations in which the project manager has a proactive and direct role are usually related to common design constraints and criteria. Thus a next step that asks for further research is how this proactive and direct role should or can be utilized favourably during the design process. During the design process flexibility is needed considering the design constraints and criteria.
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Managing the design process during the design meetings
The architect’s role in the dynamic design process  
- Possibilities and obstacles

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KEYWORDS
The architects’ role, design process, users’ involvement, design dynamic

Introduction
The building process involves both dynamic processes and professional teamwork, a combination that confers on all the actors great economic and technical responsibilities. There are arguments for involving the user in the design process, so as to achieve appropriate outcomes. It is important to maintain a creative and generous working climate early on in a building-project, especially if users are involved: users may not be used to the aim of the process or the language used in the dialogue between the actors involved. It can be difficult to keep a dynamic process “alive” when a host of regulations and laws is directing and controlling both the actors’ roles and their responsibilities to society and the project. There are also cultural factors and traditional working methods that can restrict the innovative design process. The architect can be the actor who guides the users through this dynamic process, keeping it alive. To achieve good results the architect needs certain skills and experience and need to draw on various models and methods to support the process. Which are the possibilities for and obstacles to steer the dynamic process? And what are the qualifications and working models needed to ensure success in this task?

Background
Several companies have expressed a desire to better understand and work with the user requirements. The positive outcomes of such efforts will probably be better products, more satisfied customers, and better company images. When a new building project is planned, many resources are brought together. The building process is a large-scale example of a creative and dynamic process supported by a dynamic organisational structure. However, there are several obstacles to maintaining the dynamic and creative atmosphere of the process. Laws, regulations and economic factors can impose restrictions, as can negative attitudes and poorly exercised leadership. A creative process requires a certain amount of trust and courage regarding both the process itself and the actors involved. Other industries use a range of methods and models to support new product design and these could be used in the building trade as well. In these processes experience gained from mistakes made is used to adjust the working methods, in the interests of improving both the product and the production process itself. Unfortunately we can see the same mistakes made over and over when producing buildings: it seems as if we keep building full-scale prototypes without ever learning from our mistakes. The responsibility to build sound, healthy buildings that are economically viable over the long term requires both good planning and good organisation.

The architect can be the actor who initiates the dialogue and maintains good communication between the users and the professional team involved. Different working models and methods can be used to obtain a better communication. Both full-scale models and 3D modelling at the computer can be used to describe to users how project plans are proceeding. A dynamic and creative process needs the right attitude towards the task from all the actors involved and the architect can be both interpreter and guide through this complex process. If all actors share a
The architect’s role in the dynamic design process

Theory
Customer-focused planning and design is needed if we are to take the next strategic step in a changing world. The best strategy is to be able to discern customer expectations and needs even before customers themselves can. Customer-driven processes are often used in the development and design of new products other than buildings. It is useful to engage in dialogue during the creative process, in order to set as many guidelines as possible before production. Involving users takes time, and the need for resources is obvious, because time represents money - especially in the building process. The professional team of architects and engineers will have to meet the users and discuss their requirements and then translate these into drawings and plans. Professional architects must also be willing to involve users when they expect the professionals to respect their point of view due to their increased understanding, which may present problems for the architect. Involving the user in the building process raises questions about relationships involving roles, power, knowledge, competence and who is responsible for decisions. Case studies conducted by Elisabeth Hornýnsky Dalholm [2000] indicated that the architect must reflect on how to communicate with users and that both the architect and the user must have trust in the process. Several product design and development models are described by Eva-Stina Björk [2003] in her doctoral thesis, Insider Action Research. Integrated Product Development (IPD) entails the concurrent development of products, production processes and marketing procedures. These three types of processes are difficult to plan, study and generalise because they are complex and partly non-linear and chaotic. To understand what is going on in such processes, a researcher must be substantially involved and participate continuously in them in real time. The philosophical basis of such research is quantum mechanics and complexity theory three different positions are possible: observer, team member and project leader. Björk’s studies show that the project leader role was an optimal role for acquiring an overall view of the development process. There are difficulties, however, in sampling the flow of information, so the project leader will be unable to have a holistic view of the situation. It is essential that product developers have social competence and empathy in order to assimilate input from the users, purchasers, and other actors involved. Björk’s thesis specifically examined the development of assistive products for disabled people, a process in which these competencies crucial in order to gain a true understanding of user needs. To increase the speed of product development various models of parallel product development are used models such as Simultaneous Engineering (SE), Concurrent Engineering (CE), Integrated Product Development (IPD), and Collaborative Product Development (CPD). However, these models are rarely used in practise, so improvement is necessary. Professor Stig Ottson at Halmstad University started to improve the IPD model of Fredy Olsson making it to a dynamic IPD model called Dynamic Product Development (DPD). The difference between this and its precursor lies in its holistic/quantum mindset and philosophy. DPD includes tools to be used by the practitioners. Active participation and engaging in dialogue in order to keep the users’ needs and requirements in focus are recommended in this method. In this way of working knowledge accumulation allows the overall and tested business/product plan to be realised early in the process. The three parties required for this process are Business, Users and Society (BUS), and their involvement means that the end product will be profitable, user friendly, and environmentally friendly - in other words, sustainable. In short the user and the usage are the central points around which everything revolves. Design for Usability (Dfu) is also described. Designing for usability in products is a complex task in which hard functional values and soft values both need to be taken into account. According to Ottson [1999] product developers require data input both before and during the development process in order to identify and satisfy user demands. However, data reliability differs depending on the data collection method used, as the figure below shows (fig 1).
When dealing with Product Development it is important to devise an efficient plan for the project at an early stage. Traditionally, efforts made to describe the common goal are cited as having a positive effect on the complex process of product development.

Kerstin Sahlin-Andersson [1989] describes the opportunities for architects to assume the task role of monitoring the unclearness, chaos, and complexity, so as have the possibility of changing the plans as needed during the development process. She refers to Marsch [1976], who describes how in unclear situations development can be supported by a “sensible technology of foolishness”. This means that goals should be shaped by action and experience and that goals made early on in a process may impose unnecessary limitations. He describes the possibilities of working more experimentally and how it can be easier to add new ideas to an ongoing development process in the absence of traditional goals and programs. Treating goals as hypotheses allows us to change how we work and help us develop unusual combinations of attitudes and behaviours. Sahlin-Andersson describes the possibilities for architects to work with the present situation, but to consider the unclearness and avoid stereotyped imitation; possibly they will have the courage to play with new ideas that are more or less connected to reality during early investigatory work.

Birgitta Ericson and Britt-Marie Johansson [1994], describe various kinds of obstacles that prevent the architect from really being part of the innovation process, obstacles arising from “silent knowledge” and traditional ways of thinking. They refer to an article by Eskil Ekstedt [1991] that describes the “know-how” inherent in the architect’s role that contains often-mute experience, valuation, and imagination, regarding how certain work is being done. If better “know-why” knowledge is manifested, the innovation process could be more successful and the architect could be more supportive.

The building Industry is known for being conservative and traditional in its working methods and attitudes. “Why try something new, when things are going just fine with the way of working that we are used to?” is a common remark heard when someone is trying to make changes. However, there is no reason why the structure underlying the building process could not be regarded as a learning organisation and theorising in this area could well be useful. This could also be useful for discerning the possibilities for learning in a collaborative and cooperative way. Johnson, Johnson, and Smith [1991] refer to various books that describe the positive effects and power of cooperative interaction.
There seems to be a synergy that produces the most effective method for generating creative thinking when several people focus cooperatively on the same problem which Hill [1966] refers to as a “mastermind method”. If the reward system is based on favours awarded for individual performance, there will be obstacles in a culture of reliance on team efforts. Johnson, Johnson, and Smith clearly demonstrate the importance of developing cooperative learning skills in our students. This can be difficult, because such behaviour often runs counter to well-established values. One major outcome of cooperative learning is that people who work together develop positive relationships that are essential for motivating long-term achievement efforts and for healthy social, cognitive, and physical development. A cooperative learning structure includes various assigned roles, such as those of summariser, accuracy coach, elaborator, and observer. Checking for understanding and elaboration, are vital to high-quality learning. Caring about each other in the group comes from a sense of mutual accomplishment, from mutual pride in joint work, and from the bonding that results from joint efforts. All this contributes to a group’s productivity, because of the sense of personal responsibility and of sharing the work. It also increases the willingness to take on difficult tasks and supplies motivation and persistence in working towards the goal. As traditional colleges are very oriented towards competitive and individualistic learning and organisational structures faculty must truly understand the role of the instructor in implementing cooperative learning. In Ten steps to a learning organization Kline and Saunders [1995] describe several examples of how to work with learning and development in an organisation. Peter Senge’s The fifth discipline [1990] examined the learning organisation, doing so before similar theories were expounded by W.E Deming. Kline and Saunders noticed that a clear description of the process of how to do the work was missing. They described how to build up and maintain an environment that supports learning on all levels and stimulates the power and joy of the learning process for the individuals involved. They also refer to John Naisbitt [1982], who in the book Megatrends talks about the need to treat individuals in a company more carefully as the technological level becomes increasingly complex. He describes the phenomenon as “High tech-High Touch” and says that all individuals in an organisation must be more prepared to make a greater range of decisions of a more complex nature, decisions it is impossible to leave to a small group in the company. Organisations working on improved quality and customer focus produce positive results if the manager shows dedication to these issues. The whole organisation also needs to embody understanding of the issue and if the organisational culture supports this way of working, good outcomes will result. A good innovation climate is fostered by a feeling of general security and trust in a company. Employees need to know that it is acceptable sometimes to make wrong decisions, that testing and experimentation with new ideas is allowed. It is also good to foster in individuals better self-esteem and to support cooperative learning. The greatest threats to good learning results are fear, and hidden agendas, old structures, and traditional culture. By means of group learning such phenomena can more easily be uncovered and processed. It is good to know that you are not alone with this feeling of fear and experience of hidden agendas etc, and through fostering such openness, innovation can be more easily be accepted. Innovative work by definition entails a certain amount of risk taking, and a company must support this way of work, and prove that it does by awarding those who innovate.

In Architectural Management in Practice, Stephen Emmitt [1999] describes the problems that often arise when an individual attempts to combine the chaotic ethos of design and the restraint of management. Architects also struggle with cultural differences between the worlds of design and production. Issues of conceptual design have been studied, but issues related to detailed design have been largely ignored. Emmitt describes the core skill, the architect as designer must posses, in order to participate in a process constrained by time budget and having the purpose of producing a product. The design process needs to be monitored and co-ordination is a fundamental element of design management. If communication is to flow freely, team members must have a certain degree of empathy and respect for one another. This role calls for particular skills.

Kristina Grange [2005] describes how the building trade is characterised by the jealous guarding of one’s special preserves and old structures. Such defensiveness prevents fruitful co-operation between the actors involved in a design and building project. It is necessary to change such negative attitudes towards each other, she says, and if possible allow architects to contribute more to the building
process. Some explanations of this fact look at the historical trend of large-scale projects, focusing on production, and ignoring the architects. Today architects must taking part in the entire design process, making more contributions than simply those concerning aesthetics and superficial design concerns. The poor overall quality and the lack of an actor responsible for the wholeness of the project, argues strongly for a better process.

**The Aim Of My Paper**
The building process is complex and involves several actors with different roles and skills. In handling user involvement, there seems to be a need for several competencies in addition to those fostered by traditional architecture education in Sweden. The building process is, creative and dynamic, and throughout it the architect has the important role of maintaining communication and dialogue. Knowledge of how to handle people and their reactions and interactions in such a changing process can be useful. The pedagogical role of guiding the users and actors involved, can also provide a good opportunity to reclaim a more central and important role [Svetoft 2005]. To be able to handle such a management and design role, architecture education needs to be combined with economics, law, and construction and production studies. Based on my own experiences working as an architect on scholarly reflections during the case studies, I feel that we need to be more knowledgeable about:

- How to open up a discussion in order to formulate user’s needs and requirements and how to match one’s “expert knowledge” to conditions encountered in a given “real-world” situation.
- How to acquire robust tools during one’s education to better address these situations.
- How to foster new understanding and attitudes towards issues of work and responsibility in being a part of creating the environment surrounding people’s everyday lives.

**Method**
After reading descriptions on the websites of three Swedish universities of architectural education programmes and of the role of the architect, several questions remained. What are the content of such education and what tools are students being given that are applicable to handling user involvement and being part of the creative process? Is there any discussion in the universities of the future role of the architect?

To try and get some answers to these questions I surveyed third year students in Lund University in March 2006. This paper contains the results held at a workshop and answers to questions posed to third year architecture students in Lund University. Twenty-three students attended the workshop and everyone was participating and answered the questions. Nine groups were formed and after twenty minutes there was a presentation and discussion held with the whole class. The answers from the groups and the individual questionnaire are reproduced. I will conduct more research in the future to see the point of view of other actors involved in the building process by doing interviews.

**The Architects’ Role In The Dynamic Process**
What is the role of the architect in the dynamic and creative building process? Which are the possibilities and the obstacles for the architect to steer the dynamic process? The education lays the foundation for the attitudes and knowledge about the different skills that are needed. In order to know more about the attitude towards the role as an architect in the dynamic process I had the opportunity to meat the students in the third year at Lund University. If the right product is going to be developed the users’ involvement are necessary. Co-ordinating and communicating is essential for a positive creative process.

My first question to nine different groups of students was how they see the future role of the architect, how to co-operate with other actors involved and what they want to achieve:

- establish a trustful situation to the other actors and the possibility to be a part of the whole process. They want to be good architects but not on idealistic terms.
- be the one responsible for the “ideas”, with participation, and be able to work with clear areas of responsibility. Be a part of sustainable solutions in the built environment.
- be the driving force through the process from the start to the finished product. Create conditions for a good environment.
The architect’s role in the dynamic design process

- be the co-ordinator with responsibilities in order to keep out conflicts. Create built environment that give possibilities to different kind of living. Obtain a standing for long-term consciousness.
- have the courage to question the traditional construction form. Keep up the debate about the role and maybe work in team – change the picture of “the lonely architect”. Create participation and discussions about other values than the building itself.
- be both the co-ordinator and the leading designer with a good social climate and understanding as guidance instead of position and power. Create a better society/world with a better social climate, a good environment for people to meet. Nice, bold and fresh environment. Have we as humans influence on the architecture or do the architecture have an influence on us? (the hen or the egg)
- have the opportunity to work in all countries in Europe with responsibility for the whole process.

The next question to the student-groups was which changes in the architectural education they think can be necessary:
- broaden the education with possibilities to develop higher level of attainments.
- get a better holistic view and understanding of the other actors involved. More time to go deeper in certain topics.
- lengthening the education in order to create a better holistic view and a better understanding -not only theory.
- get more of special topics and have a discussion of real conditions/practice. Ecology, sustainability and more extreme conditions and with a global perspective without losing focus on local conditions.
- economics, law, construction, management and communication
- get more time for social/society topics and a better understanding of the building process.

The next question to the individual student was if the user should be involved in the building process and if these topics have been included in the courses:
- Yes, because the user is the one living with the design. It can be done by using physical and creative models. The topic should be in a course in the early part of the education.
- Yes, because they possess a knowledge that the architect never can achieve on their own. Maybe the architect should be responsible of taking the decisions due to a holistic view. In the education the students have been acting against “purchasers” and been presented to an implemented project.
- Yes and No, the architect should participate in the situation of the user and try to get the user a feeling of involvement. But in the end it’s the architect that decides.
- Yes, architecture has no value if it is not aimed for somebody and everybody can experience architecture. We don’t have the expert-knowledge that is incommunicable. No nothing about this topic has been brought up, but these issues should always be there as well as the environmental issue.
- Yes and No, it can bring forward better solutions and understanding of the users but it can end in too much subjective opinions. One lecture about Bo 100(A project in Malmö by Ivo Waldhör, with user involvement)
- Yes considering that what we are building must be useful for a long time it is unnecessary to create bad environments that is not appreciated.
- Yes, by explaining the conditions and try to get the user to understand the value of the architecture. By the dialogue and in exchange I could get a lot of important input from the user that can increase the character of the project.
- Yes, the users should of course have influence on the design. It is possible to have several meetings during the project for the users to express there requirements. One should also follow the way it is used in order to see what’s good and bad from the user perspective. No we haven’t had any courses on this topic but it but should have the opportunity to practise in a project with user involvement.
- Yes, because we create the building for the user and it is the responsibility of the architect to find the point when both are satisfied with the project. We had a two hour lecture about Bo 100 in Malmö. It is too little time during the education period for four and a half year.
- No The architect should have the ability to live the part and satisfy the users’ requirements and also have a long-term perspective. I am interested in getting more knowledge about how to really involve the users – more than to tell the colour of the wallpapers. How can they really add something to the process?
- Yes, to involve the people in the process and share the knowledge – and maybe reconsider. No you only get a glimpse of the process/method but there should be more of a discussion about how the interpretation should be done, by someone who is not an architect.
- Yes to democratisation the process and to do the work more interesting and connected to reality. No we have nothing about this topic in the education.
- Yes democratization through meetings, and maybe financed from foundations. Maybe by laws that gives the Real estate owner the responsibility. Yes we had some lectures with examples of projects. These were initiated by the students themselves.
- Yes, to gain a better understanding of the usage. One could use discussions or 3D-models as a tool. Only brief parts about the subject have been given in lectures about user involvement.
- Yes, user involvement generates more satisfied customers and increases the awareness of the built environment. This can lead to a better insight and understanding about the importance of the built environment. Lectures in these issues were given in the late eighties by the Department of Building Functions Analysis.
- Yes, because it’s a co-operating process were the user is directly connected to the result in this case the building. There has been a lecture about a democratic perspective of the building project.
- Yes, New ideas- better result. The society goes through changes which creates new requirements of use. Only a short lecture in this subject was given in first year.
- Yes but only for general requirements. But I’m more sceptical about users’ special needs designs an environment that is supposed to fit others. Only short parts of this subject were presented in a project, could have been more of this.
- Yes, to be able to analyze and respect the users’ requirements and be able to communicate and explain basic facts and technology and to steer the designing process. Short parts of this issue have been given in lectures, but more time is necessary combined with social - psychology and management.
- Yes, the users’ experiences of the built environment should be the base for the designing process. Possible to get a picture of what they like/don’t like and what can be improved. No but be a part of a project that you have chosen.

Conclusions

There are possibilities for architects to play a role in the dynamic and creative design process. This chaotic and complex process is impossible to control and if you attempt to do so, it will no longer be “alive”. The design process allows the linking of two worlds or cultures - the chaotic and creative culture of design and the restrained culture of management. This cultural clash can offer new possibilities if better dialogue is achieved. The building process combines the design process with considerable recourses such as money, working time, and building materials. This gives the actors involved the responsibility to work effectively. Because “time is money” any improvements that make the process shorter and easier to handle are desirable. Influence is of great importance if taking the role of having the possibility of changing the plans as needed during the development process. Some of the design models mentioned above can be used as can good leadership and organisations that support the creative process. Knowledge of the process can give important tools for facilitating the production of new, better, and more usable products.

But there are several obstacles to playing such a role in handling the design process. The building Industry is full of traditions and is not known as innovative. There must be good arguments if one wishes to change methods and strategies. Maybe the collaborative learning process can offer some new directions in the way of working. The role of the architect is based on their education and the team member must have respect for one another. The attitudes towards the role and the other actors involved is an obstacle because the architects’ struggles between the worlds of design and production. It seems that the Swedish architectural education focuses too narrowly on aesthetics and on giving students the tools with which to express themselves. There seems to be a lack of knowledge of the methods and models to use when communicating and maintaining a holistic view. The communicating and co-operating architect must have more knowledge of economics, law, management and social psychology.
Discussion

The architect’s role is an example of a life-long learning process in which experience shows you how to work and improve one’s skill. Answers from the third year students at the architectural education in Lund reveal the gap between theoretical and practical skills. Preparation for their working life and the role of handling the creative and dynamic process is of great importance. Some of this knowledge can be regarded as “silent” knowledge and must be experienced. To practise the role in working life is maybe the best way to learn these skills. There are also difficulties and obstacles inherent in the traditional role of the lone architect, the arbiter of good taste and design. In this tradition making a compromise is like surrender and dialogue with the user is of no use. If there is to be a change of this tradition, the surrounding structures and actors must allow and support it and new expectations must be fostered.

One’s attitude towards the role of the architect and awareness of the attendant responsibilities is often based during one’s time of education. The students in Lund University are eager to help create a better society and built environment. They also long to be part of the whole building process. Co-operating with the other actors involved and trying to better understand the users’ needs and requirements are also part of their outlook. Several students can also perceive the positive effects of exchanging knowledge with the users involved, and they can even grasp the democratic issue of involving citizens in the design of the built environment. This way of working, however, demands communication and co-operation skills and entails playing a pedagogical role when handling the process.

Lecturers and fellow students should take advantage of the opportunity they have to discuss the role of the architect and what they want to achieve as one. There also seems to be a possibility of adding a broader range of theoretical knowledge to the architectural program. The students interviewed gave examples of needed courses as well as better tools and models for communicating with users. The expectations of architects’ commitment and skill can only be fulfilled by the architects themselves. In today’s building industry the level of functionality, responsibility and ability of architects is comparable to that of other actors, and there are signs of new actors that assume the role of managing the process. The students’ eager and positive views on their future role in creating a better world are comforting and one hopes not groundless.

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Optimum Architectural Group Design as Reflection in Action

A tool for dynamic design negotiations

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KEYWORDS
Architectural Group Design, Dynamic Briefing, Geometric Modelling, Linear Programming.

1 Introduction

In nearly all architectural (and also urban) design problems, not only the quantities of and the preferences for the architectural resources (rooms, corridors, offices, entrance hall, etc.) to be allocated play a role, but also the location of the resources in the architectural space. A lot has been studied and written in the domain of design methods about this spatial dimension of these resources. It is common in architecture to optimise on architectural criteria. The style, the concept, the fashion, and the architectural beliefs are dominant issues. However, the user, the owner, the investor, and the politician increasingly wish to have more influence on the design. And they use their own criteria like price, functional capacity, personal taste, maintenance cost, etc., to select alternative building designs.

In this paper we will explain a design tool with which it is possible to optimise and steer from both the designer’s point of view and the user’s point of view. This tool is based on mathematical techniques for dynamic negotiations on the spatial dimension of the resources. Since the tool is an extension of the basic tool for multi-actor optimisation with negiotiable constraints based on Linear Programming modelling from Operations Research ('Open Design' methodology, developed by Van Loon [1998], Van Gunsteren and Van Loon [2000]), we will start with the general LP model and will extend this model step by step with a geometrical (spatial) component. This results in a tool with a numerical part and a geometrical part (See Fig. 1).

Figure 1. The combined numerical and geometrical model

The LP model incorporates the constraints with regards to the design brief and those with regards to the allowed combinations of functions and spaces. The output of an LP run represents an allowed allocation of functions to spaces within the brief constraints. The geometrical model is then used to
visualise the output of the LP model. The designer can use the geometrical information obtained to re(de)fine the allowed combinations of functions and spaces: reflection in action. This information is fed back into the LP model as altered constraints. New LP runs can be performed in this fashion until the allocation of functions to spaces meets a desired layout. In the event that the layout remains unsatisfactory, relevant stakeholders might dynamically alter their constraints in the design brief.

2 Mathematical description of the tool

In architectural design, a dominant spatial dimension of resources is the position of resources in two- and three-dimensional space. This position is commonly expressed in a floor plan, and/or a 3D model of the building(s) and its urban environment. In terms of allocation of resources, a floor plan is a proposal for allocation of architectural spaces (resources) to accommodate (human) activities such as living, shopping, eating, office work. In terms of Open Design, it is said that the design problem is: Which spatial layout of the resources fits best to the activities to be accommodated in accordance with stakeholders’ wishes, goals, and constraints, and with the architectural style chosen?

Starting from the standard LP model:

$$\text{Maximise } Z = \sum_{j=1}^{n} c_{j}x_{j}$$

subject to:

$$\sum_{j=1}^{n} a_{ij}x_{j} \leq b_{i} \text{ for } i = 1,2,\ldots,m, j = 1,2,\ldots,n$$

and:

$$x_{j} \geq 0 \text{ for } j = 1,2,\ldots,n$$

and defining the activities as demand ($d$) and the resources as supply ($s$) the problem of the best spatial layout (which is called in OR literature the transportation problem, or the distribution problem) can be represented in an LP model as follows:

$$\text{Minimise } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij} \text{ for } i = 1,2,\ldots,m, j = 1,2,\ldots,n$$

subject to:

$$\sum_{j=1}^{n} x_{ij} \geq d_{i}, \sum_{i=1}^{m} x_{ij} \leq s_{j} \text{ for } i = 1,2,\ldots,m, j = 1,2,\ldots,n$$

and:

$$x_{ij} \geq 0 \text{ for } i = 1,2,\ldots,m, j = 1,2,\ldots,n$$

In this model $x_{ij}$ is the representation of an activity $i$ in space $j$. And in this model $c_{ij}$ is the representation of the cost (expressed in money, energy, appreciation, and the like) of the realisation of activity $i$ in space $j$. This representation can be explained with two aspects of the relationship between activities and spaces as follows: Since in buildings (human) activities are not fixed to one unique space – or in other words activities are spread out over more (different) spaces, like rooms, auditoria, corridors, zones, areas – a design expresses (among a lot of other things), at least a spatial pattern of different architectural and urban spaces to fit an amount of different activities allocated to the designed spaces. The second aspect concerns the fact that most of the architectural spaces are suited for more than one activity, but of course not all. This means that the designer can propose alternative arrangements of the activities demanded, for a given spatial arrangement of spaces. Also the other way around, i.e. for a given spatial arrangement of activities, alternative layouts of architectural spaces may be proposed. By changing the input values of $c_{ij}$ (in Open Design called the negotiable elements of the constraints), a representation of the design process on both aspects becomes available.
With this mechanism, a designer is able to represent his pattern of possible activities in such a way that he can calculate how well this supply fits the demanded activities. A step further in the spatial dimension of the resources brings us to the following observation: while architectural spaces may be suited for more than one activity, they are not necessarily suited for all activities. This is based on technical constraints such as daylight, noise hindrance, permitted location in the building, or conceptual constraints like structure of spaces, patterns of connections.

Now we can extend the model for this design problem (the limited distribution problem). Whether space \( j \) is suited for activity \( i \) or not can be represented as follows:

\[
\text{Minimise } Z = \sum_{j=1}^{m} \sum_{i=1}^{n} c_{ij} x_{ij} \text{ for } i = 1,2,\ldots,m , \ j = 1,2,\ldots,n
\]

subject to:

\[
\sum_{j=1}^{n} a_{ij} x_{ij} \geq d_{j} , \sum_{i=1}^{m} a_{ij} x_{ij} \leq s_{i} \text{ for } i = 1,2,\ldots,m , \ j = 1,2,\ldots,n
\]

and:

\[
x_{ij} \geq 0 , a_{ij} = \{0,1\} \text{ for } i = 1,2,\ldots,m , \ j = 1,2,\ldots,n
\]

Due to the LP problem solving algorithm, \( x_{ij} \) will be zero (non-Basic) if \( a_{ij} = 0 \), and \( x_{ij} \) will get a value if \( a_{ij} = 1 \). This means that if the designer decides that space \( s_{ij} \) is not suited or otherwise not appropriate for activity \( i \), he makes \( a_{ij} = 0 \) and automatically \( x_{ij} \) becomes 0. In other words, using the zero and one value of \( a_{ij} \), the designer uses the model to calculate the best allocation of activities to the designed pattern of spaces.

With the following example, the function of the variable \( a_{ij} \) can be explained. A floor plan \( F \) for building \( B \) consists of four spaces \( s_{1}, s_{2}, s_{3}, s_{4} \). The floor plan should accommodate three different activities \( d_{1}, d_{2}, d_{3} \). The designer of the floor plan decided that \( s_{1} \) is suited for \( d_{1} \) and \( d_{2} \), \( s_{2} \) is suited for \( d_{2} \) and \( d_{3} \), \( s_{3} \) is suited for \( d_{1} \), \( d_{2} \), and \( d_{3} \), and \( s_{4} \) is suited for \( d_{1} \) and \( d_{3} \). See Table 1.

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Table 1. Example LP matrix illustrating the function of \( a_{ij} \)

In the representation of the space allocation described above, it is assumed that the total demanded space for activities equals the total supplied space for the activities. In the beginning of a design process this is often not the case. In architectural design, demand and supply are independent of each other. They are not fixed by the start of a design process. Designers propose spatial arrangements of spaces based on their ideas, style, and concepts. Of course, these proposals are not that far from the demanded spaces, but they are not equal. So, a design can give ideas for activities one was not thinking of. Similarly, a designer can discover that he does not yet have space for an activity which certainly should be in the building. The designers have to find the best fit. Demand and supply are, therefore, not fixed at the start. With two extensions to the above model it is possible to cope with this design question:

\[
\text{Minimise } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \text{ for } i = 1,2,\ldots,m , \ j = 1,2,\ldots,n
\]
subject to:

$$\sum_{j=1}^{n} a_{ij} x_{ij} - D_i = 0, \sum_{j=1}^{m} a_{ij} x_{ij} - S_i = 0 \text{ for } i = 1,2,\ldots,m, \ j = 1,2,\ldots,n$$

$$\forall_{i=1}^{m} D_i \leq d_{\max}, \forall_{i=1}^{m} S_i \leq d_{\max}, \forall_{i=1}^{m} S_i \leq d_{\min} \text{ for } i = 1,2,\ldots,m$$

and:

$$x_{ij} \geq 0, \ D_i \geq 0, \ S_j \geq 0, \ a_{ij} = \{0,1\} \text{ for } i = 1,2,\ldots,m, \ j = 1,2,\ldots,n$$

3 Application of the tool in practice: The Stedelijk Museum, Amsterdam

The Stedelijk Museum Amsterdam (SMA), the museum of the city of Amsterdam presenting contemporary art, began the renovation of its main building on the Museumplein in 2004. The building, designed in 1895 by the architect A.W. Weissman, no longer met today's requirements for a museum. Over the last decades a chronic shortage of space had arisen. In the 1950s and '60s annexes and intermediate floors were already added to the main building. The Portuguese architect Alvaro Siza Vieira made the initial plans for both renovation of the old building and an extension. Based on these plans a preliminary bill of requirements was made. This bill of requirements was approved by the municipality along with a budget. The project management consultancy PKB was then asked to refine the bill of requirements to reduce the probability of overruns in time and money. With the aid of both a numerical and a geometrical computer model closely linked to each other, PKB was able to formulate a final bill of requirements that satisfies the budgetary restrictions as imposed by the municipality and the geometrical restrictions as imposed by the existing buildings. The process in which these two models were used to support decision making and the models themselves are described in this section.

The Stedelijk Museum Amsterdam was asked by PKB to give detailed information about its requirements. Starting point was the proposal of the municipality’s Sanders committee. This proposal comprised of a set of spatial restrictions and a budgetary restriction. The spatial restrictions were given in the form of bandwidths per function. In other words, both minimal and maximal floor space requirements. PKB also made some calculations on the cost of renovating the old building and on the cost per square meter of the extension.

The need arose to have a model that could allocate functions per room and per floor in the existing building, because numerical output alone would not provide sufficient information to the Stedelijk Museum. Therefore, a detailed LP model was linked to a geometrical model. The numerical model represented all rooms on each floor of the Stedelijk Museum. In this model, the Stedelijk Museum
could express for each room its fitness-for-use for each function, using Boolean values. For instance, not all rooms where fit to be used for exhibitions. The geometrical model was a drawing in AutoCAD that also represented all rooms on each floor of the Stedelijk Museum. (The extension was represented as a rectangle per floor, because its shape did not matter in this stage.) With these budgetary and spatial restrictions, the numerical model could be optimized. The results where handed back to the geometrical model, which colour-coded the different rooms according to their function (Fig. 3). In other words: the numerical results became graphical. The resulting drawings were presented to the Stedelijk Museum to see whether a proposed layout of functions was acceptable. This iterative process ended when the Stedelijk Museum was satisfied with a proposed layout.

Figure 3. Visualisation of allocated functions to spaces

The use of both numerical and geometrical models greatly reduced the time it normally takes to develop a bill of requirements for such complex projects. The open process made the staff of the Stedelijk Museum feel their wishes were taken seriously and not swept under the carpet. In contrast to traditional approaches, PKB could now provide confidence that the bill of requirements would satisfy both budgetary and geometrical restrictions. In the traditional approach some rules of thumb would be used to establish if the bill of requirements would meet both sets of restrictions, which often gives rise to unpleasant surprises in terms of overruns in time and money.

4 Reflection in action

The above way of modelling assumes that the designer has an overview of the spatial arrangements of possible activities. To add detail to this overview, he can use expert knowledge, from specialists in acoustics, daylight, construction, and so forth, as well as from the prospective users, who have expert knowledge on the exploitation, maintenance, and such.

The design tool explained in this paper enables optimisation from both the architect’s point of view and the user’s point of view. The procedure supports what Schön [1982] calls reflection in action.

5 References

PARAP/Rgd - tool for budgeting, cost estimating and floor area analysis of office building designs.

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KEYWORDS
Mathematical cost modelling, quality-cost analysis, office design, cost estimation of office buildings, budgeting

1. Introduction

Hardly ever a new office building is built without a budget for the building costs. To establish and control a budget, in order to stay within limits, one needs costs estimates right from the first initiative. However, generally at this stage information, on which a cost estimate can be based, is scarce. One uses assumptions instead. To get a cost figure in the initial stage of the design process it is still common practice to take all these assumptions together in just a single calculation rule: costs per functional unit. The unit depends on the type of building to be designed e.g. prison cell in case of prisons, hospital beds in case of hospitals, pupil for a school, employees with office buildings. The unit rate is based on a generally used average, sometimes adjusted by experience of the cost expert, but doesn’t take into account the design, simply because there is not a design yet. This way of estimating costs is common practice among policy makers, investors and also designers, to quickly establish a budget. But it is a very unreliable way of budgeting and more often then not in the procurement phase budgets have to be adjusted (unfortunately always upwards), making it more difficult to maintain the desired building quality.

2. Problem definition

Our research builds on cost modelling methods as explained and applied in [Dekker et al. 1993; Meijer 1981; de Jonge et al. 1982] and is aimed at developing computer aided tools for estimating building costs in the initial stage of the design process of office buildings. Research has shown [de Jonge et al. 1982; Meijer 1982; Gerritse 2005] that designs based on the same brief can differ significantly in costs when only a few basic conditions for the design differ e.g. type and structure of building, number of floors, building shape and service installations. Decisions made in the initial stage have a considerable impact on building costs. The more one progresses with the design the more difficult it is to influence costs in a significant way. The main problem then is: how to get a consistent and reliable estimate of building costs in the initial stage of the design of an office building in order to establish a realistic budget that doesn’t have to be adjusted several times during the process. To solve this problem it would be very useful to have
an instrument with which one can establish in the initial stage not only a consistent and reliable cost estimate, but also gain insight in cost consequences of changes in design conditions at this stage.

3. Modelling approach

In order to develop our tool we used a model of an administrative organisation, a model of an office building that deals solely with quantities and a collection of models of building elements aimed at determining the size of these elements and their unit rates. The collection of models of building elements is divided in a set that deals with service installations, a set dealing with construction elements and a set dealing with construction time and preliminaries. The input for and the output from the models is listed by the user interface. This interface has a part for input (and change) of values related to the requirements for the office design and a part that outputs building costs in accordance with NEN 2634 standards. We have mutually connected all relevant data by mathematical cost modelling and this means we are able to dynamically connect building performance to building costs. Figure 1 shows a schematic representation of the system and mutual relations between the components. In the following paragraphs we focus on the model components and describe these in more detail.

3.1 Model of an administrative organisation

The purpose of the model of an administrative organisation is to calculate the net functional floor area (NFA) needed to accommodate the organisation. All calculations are based on Rgd standards [Rgd, 1995]. These standards define the size of a workstation, what kind of rooms a standard office building should have and define the size of these rooms as a function of the size of the organisation. Applying these standards the model arrives at the NFA based on a given number for the full time equivalent (FTE) of persons at work and a part time factor (PTF) which determines the number of workstations that are shared. Next this number is multiplied by a percentage that expresses the extra floor area needed to fit-in the NFA. NFA plus the extra floor area leads to the total required usable floor area (UFA), which is an important input variable for the model of the office building.

Figure 1. A schematic representation of the system and the mutual relation between the components.

The purpose of the model of an administrative organisation is to calculate the net functional floor area (NFA) needed to accommodate the organisation. All calculations are based on Rgd standards [Rgd, 1995]. These standards define the size of a workstation, what kind of rooms a standard office building should have and define the size of these rooms as a function of the size of the organisation. Applying these standards the model arrives at the NFA based on a given number for the full time equivalent (FTE) of persons at work and a part time factor (PTF) which determines the number of workstations that are shared. Next this number is multiplied by a percentage that expresses the extra floor area needed to fit-in the NFA. NFA plus the extra floor area leads to the total required usable floor area (UFA), which is an important input variable for the model of the office building.
3.2 Model of an office building

The basic modelling principle is a representation of a real object into a model by applying abstraction and simplification [Bertels, K & Nauta, D. 1969; Bijleveld 2005]. To describe our model we use concepts that refer to a design like representation of our model (fig. 2), but the implementation in a spreadsheet is made up only of constants and variables and of formulae connecting these. The modelled office building has a central zone for circulation and allocating mains and circuits and is bordered on both sides by a zone designated to the various kinds of rooms. The entrance is located in the middle of the longitudinal outer wall. A central hall is located along the entrance. In case of a multi storey building and depending on the building type, a double free space above the entrance and central hall is allocated. Space required for service installations machinery is located on top of the building. Depending on the size of the building and in accordance with fire regulations one or more staircases and elevators (with their designated area) are added to the building. Many aspects of the building model are made variable, e.g. width of the building, thickness of inner and outer walls, the amount of daylight in outer walls, number of stair cases, kind of interior finishing etc. We have also predefined four different building types. They differ in default values for spatial dimensions and air-conditioning system and represent the kind of office buildings the Dutch Government Building Agency (Rgd) uses to accommodate their employees. The computer model of this office building represents not a building with a constrained geometry. The geometry changes when the size of the organisation and the number of floors are changed. Furthermore it changes when a user changes one or more of the parameters of the building model. If the geometry changes, quantities of building elements change and thus building costs.

![Figure 2. Schematic representation of modeled office building.](image)

![Figure 3. Transformation of slab shape into different shapes while keeping the same geometric characteristics.](image)
The shape representing the geometry is best described as a slab shape, but one isn’t constrained to this shape. With the same geometry different building shapes are possible, e.g. a T-shape, L-shape or X-shape. These shapes have the same gross floor, façade, roof, ground floor, upper floor area etc as the corresponding slab shape., and therefore there is no difference in building costs. However in real life a difference in costs can arise because of more or less efficient use of space and allocation of staircases and elevators.

3.3 Modelling building elements

The collection of building elements addressed by our tool complies with the NL/SfB classification system [de Jong 2000] and with NEN 2634. The set we use constitutes a complete, be it a fairly standard, office building. Each element of this set has been modelled in order to calculate a unit rate for an element. Each unit rate is founded by construction input calculations, which take into account the costs of labour, materials, equipment, organisation and working capital. All formulae used in the various models are derived from regression analysis and standards, customized by cost expert assessment. When calculating a unit rate of an element the value of the units length, width, item and m² are important determinants of the unit rate. These values vary per building and with soil conditions of the building site. Soil conditions are extracted from a database covering the soil conditions of The Netherlands by postal code and these conditions determine the costs of earthwork and foundation. By modelling building elements in this way, unit rates dynamically change when the geometry of the building changes and site conditions change.

3.4 Modelling service installations

The set of models of service installations also comply with the NL/SfB classification system and with NEN 2634 standards. The models deal with calculating unit rates for air-conditioning, water, gas, power, lighting, communication, security, transport and elevators. The choice for a particular air-conditioning system is determined by a data set with predetermined values. The values of these data differ for each of the four building types (as mentioned in paragraph 3.2) and therefore the kind of air-conditioning system for these types. Once the air-conditioning system is known, the model calculates numbers, capacities and matching unit rates of devices and facilities, diameter of pipes and ducts, which are tuned to the size and shape of the chosen type of office building.

4. Establishing the geometry of an office building

To be able to calculate building costs we need the basic geometry of the building. To define this we need the length of the building. The length of the building is initially determined by fitting the UFA into the building while keeping building width and number of floors fixed. The length of the building determines the number of staircases and elevator shafts. The size of the entrance area is step by step connected with the UFA. Once the entrance area, the number of staircases and elevator shafts are known, the total floor area for circulation (CFA) (horizontal and vertical) is known. The area needed for service installations (SIFA) is also step by step connected with the UFA and expressed as a percentage of the UFA. The area for a machinery room (which belongs to the SIFA) on top of the building is connected with the type of office building and expressed as a percentage of the UFA of the chosen building type. Finally the ‘tare floor area’ (TFA) is calculated, which is the part of the gross floor area occupied by solid materials and therefore mainly determined by the footprint of inner and outer walls and of columns. The sum of UFA, CFA, SIFA and TFA leads to the total gross floor area (GFA). Next step is to add the m² area of the double height space to the GFA and deduct the area of the machinery room from the GFA. The resulting floor area together with the number of floors and a default building width define the basic geometry of the office building.
5. The PARAP/Rgd-tool in use

Initially the geometry of the office building is calculated on basis of just two input values supplied by the user: the number of FTE and number of floors. This input determines to a great extent building costs. The tool outputs the required number of workstations, a detailed list of rooms with their default number and size, the required m² for the various areas as defined in [Rgd, 1995] and a detailed cost estimate. As the output is based on default values and represents a quality we consider as standard, it is very useful as a reference for upcoming design alternatives. In [de Jong 2006] the principle of references and design alternatives is elaborated. Design alternatives arise when parameters are changed. It is possible to change almost every parameter which has a default value assigned. Each time a value changes, immediately a complete new set of values is calculated, reflecting the impact of the changed value on all connected data or, to put it in other words, each time a complete new design for an office building is calculated. A user can change input values on three levels of detail, each level requiring more expertise, knowledge and information about the design requirements. On each level of detail the output for building costs can be used as a budget, but at a lower level of detail one must be prepared to allow for a certain bandwidth in budget to accommodate future changes in design. An important reason to change parameters is to meet the requirements for the design. If we define quality as “meeting the requirements”, our tool is most useful when studying the connection between quality, as implicitly expressed in the brief, design and costs, because each change in requirements causes a change in the design. This change in design then is always reflected in the building costs.

6. Conclusions and discussion

Our cost modelling approach makes it possible to very precisely calculate building costs, based on the scarce information available in the initial stage of the design process. Our approach also lends itself for establishing a budget that is both realistic and reliable and can be maintained throughout the design process without much alteration. An important use of the PARAP/Rgd-tool is analysis of the connection between quality (here: design requirements), design and building costs. It remains to be seen if this tool is general enough to be applicable to other types of organisations and buildings. Though the instrument clearly is of use for anyone interested in cost estimating, it is questionable if in particular architects/designers find our approach practical.

7. Acknowledgements

We like to thank the Dutch Government Building Agency (Rgd) for funding this research, thereby providing the PARAP research group with the means to develop the PARAP/Rgd-tool. Also we like to thank Karel Dekker, Wietze van Houten, Willem Meijer and Ruud Melis for their contribution to the development of the PARAP/Rgd-tool.

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Briefing: Static or dynamic?

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KEYWORDS
Dynamic & Static Briefing, Project Specific Briefing, Design Management, Juridical Aspects.

Abstract
In the literature on building project management little attention is paid to the briefing process and the brief. This might be due to the fact that within today’s practice the briefing process often is done by the client himself, his real estate department, by housing- or more in general by organization-management consultants. Although in the Dutch standard regulations briefing can be contracted as an additional task to the architects work, only seldom an architect is directly involved in the briefing process. Within a context of modern procurement approaches, examining the Dutch situation in particular, this paper tries to set directions for future research on briefing, discussing the multifaceted character of briefing. It is stated that briefing has to include, on a well-balanced level dynamic as well as static aspects, according to project specific characteristics.

1 Introduction
Nowadays there is a tendency for more integrated procurement routes. It is expected that in these cases the innovation potential of commercial parties is challenged far more than in cases of traditional procurement routes. It has to be remarked that in practice as well as in research the definitions of the different procurement routes are weakly set, and sometimes used more as a ‘selling argument’ than as an actual way of organizing and contracting (Holstein, Prins et. al. 2004; Ang & Prins, 2002). This complicates a systematic evaluation of meeting expected requirements. However, integrated procurement methods have one thing in common: the wishes and demands of the client are contracted to commercial parties rather early in the process. In doing this, the influence of the client during the design and construction process decreases in comparison to traditional procurement methods. At the same time long term risks are transferred from the client to the contracting parties This will only result in a win-win situation for both client and commercial parties if needs and wishes are clear and adequate throughout the process. Early experiences with integrated contracts like DBFMO are often discussed on their effectiveness in the Netherlands, but up till this effectiveness hasn’t been systematically researched. Most cases concerning integrated procurement seem to show a struggle between a fully specified brief with a static nature, and a more dynamic type of briefing. This dynamic type of briefing can accommodate growing insight during the process of all parties involved. In the next paragraphs several viewpoints on the characteristics of the brief and the briefing process will be discussed. Some evidence will be given that the real question of briefing goes far beyond its static or dynamic nature. The brief and the briefing process in integrated procurement routes should be in line with the specifics of each procurement route.
2 The brief as evaluation tool within design

Traditionally design is often summarized as the classical triad of analysis, synthesis and evaluation. Within more recent literature (for instance Allinson, 1997; Gray and Hughes, 2001; Boyle, 2003) often next to this, the ‘problem finding character of design’ is articulated. Within the beginning the problem to be solved is vague and undefined and client and designer while evaluating design variants, throughout the process are learning and are altering and sharpening the design task and the brief. Most literature in accordance is focusing on this dynamic nature of the brief as well as the interconnected process of generating design variants.

3 The brief as communication tool between client and designer

As opinions about the structure and the content of the brief might vary (see for instance Duerk, 1993), most authors see the brief as a written expression of the clients’ requirements and the internal and external constraints of the project. This brief could vary from rather simple tables of functions including for instance square meters to more advanced briefs in which more intangible aspects of the project are defined. The clients’ strive for a more systematic and objective approach might differ from the more chaotic, intuitive and artistic approach designers have. The designers core business is problem solving by trying to translate expectations and dreams of the client into design solutions. Buciarelli, (2003), addresses this language problem between the verbal thinking client and the visual thinking designer more in general for the engineering sciences. Brown (2001) also addresses the role of the brief as communication tool and the problems that arise while applying the brief in several types of integrated procurement routes. Latham and Egan stated that the problems in the UK construction industry will remain unresolved, unless more attention is given to the communication procedures, protocols and the role of briefing.

4 The brief as a tool for quality assurance and process planning

In the Dutch SBR 258 report on ‘Briefing as a tool for quality assurance’ briefing is explicitly addressed as an aspect of ‘growing insight’ (Spekkink, 1992). This is translated to a concept with a phase bound development of the brief, giving the brief explicitly a dynamic nature. In this report the brief is seen as strictly connected to the –formalized- phases of the design process, which means that the brief can be seen as an output of the current phase as well as input for the next phase of design. In this sense the brief also gets meaning as a planning tool for the design process. The recent update of this report by Wijk (2004) still has the aim to get the requirements of the client and end-users ‘as objective as possible’. The brief is decomposed into so called blocks (project definition, use functions, values, image, budget, norms) on four scale levels (location/site, building, space, place). The Dutch NEN norm more or less follows this line of thinking. As several blocks can occur explicitly more than once on the same level during the design process, this attempt to briefing might be seen as an attempt for dynamic briefing although the strive for objectivity and the strict formalizing also has a tendency to a more static type of thinking. The publication by Blyth & Worthingthon (2001) is equal to this approach, but adds levels of decision-making, and principles of lean thinking. They even connect briefing to systematic post occupancy evaluation and facility management, giving it a cyclic and dynamic life long nature within the continuous design of a clients’ housing needs.

5 The brief as a contract

The brief as a contract document between client and designer, defines the architect’s assignment. This asks for a more static nature of the brief. From a stricter juridical viewpoint as soon as the brief changes; client and architect working according to the original brief in fact need to re-contract. In the Dutch practice almost all architects work is based on a to the initial investment related kind of lump
sum fee based system. This implies that if the brief changes, the extra work caused by this change will cause a financial loss for the architect’s organization unless additional agreements are made.

The Dutch Standard Regulations (the so called SR ‘97, see BNA, 2005) consider the brief primarily to be static in terms of a functional program and a budget for the project. There is some openness to negotiate within the SR ‘97 on adaptations during the design process, but the brief is explicitly seen as a contract between client and architect. The new standard regulations (DNR, 2005/6, See BNA 2005 (2)) don’t really alter on this concept. Thus from a managerial or/and juridical perspective a static brief seems to be preferred above a dynamic one.

6 The brief as a tool for building specification

The idea behind the concept of performance specifications is that the client, in the brief, expresses his required performances instead of describing the exact definitions, the required properties and design solutions (for an overview on this topic, see Ang & Prins, 2002). The idea of the performance concept in building is expected to enhance the innovation potential of the contracted designing and construction parties. Although not published, the implementation of the performance concept, introduced early in the 1990’s within the Dutch practice, appeared difficult, especially when the relation between architect, contractor and client is concerned. In essence the performance specifications, once established by the client, have a static nature. In more recent approaches go/no go type interventions by clients came up, which can be classified as a combination between dynamic and a phase bound development, but in essence this concept of the brief remains static while trying to give contracting parties room for developing innovative solutions. Designers find it difficult to accept that performance specifications are a way to stimulate innovation. Nevertheless performance specifications can be considered as a first serious attempt to make a break through in classical thinking about briefing and the briefing process, while trying to give space to more integrated procurement routes.

7 Static and dynamic briefing

It might be assumed that the apparent ‘conflict’ between the dynamic and static nature of the brief will lead to conflicts between client and architects. An extensive case study by Barrett and Stanley (1999) and a study by Brown (1998) underpin this same assumption as they conclude that often briefs show little evidence of rationale; it’s a ‘messy’ and a ‘jumble of conflicting and confused aims’. Prins et. al. 2001 distinguishes three types of briefing and proposes a solution to the possible conflict. Proposed are different types of contract payment terms in relation to the type of briefing applied: Fee or lump sum fee base payments, in case of a real static brief, phase based contractual arrangements and payments, in case of a phase bound development of the brief, and payment based on worked hours in case of real dynamic briefing. Underlying assumption of this proposal is that every other type of coupling between briefing and payment will lead to conflict. Duerk (1993) distinguishes three similar kinds of briefing but perceives this as different believes: one in which it is believed that, to maintain integrity of each process, the program should be absolutely separate from the design, another belief in which design and briefing are fully intertwined and cannot be disconnected and an approach which advocates “activities of programming are clearly articulated yet distinct from those of design while still maintaining frequent, regular interaction between the programming and design processes including evaluation processes.”

8 Jurisprudence

It might be assumed that the ‘conflict’ addressed in this paper between the dynamic and static nature of the brief, or even more its intrinsic multifaceted character, will lead to conflicts between client and designers. A literature survey on arbitration and juridical procedures between client and architect on
this topic over the last nine years show surprising results. For the literature survey the Dutch textbooks of Wijngaarden and Chao-Duivis (version 2004, volumes 7, 8, 9, 10, 11) have been used. As the DNR (published first in 2003; De Nieuwe Regeling; ‘The new Arrangements’) is too recent to find cases on, this survey is limited to conflicts, arbitration and mediation about the SR 97 up till its final published version in 2005. Strictly seen in these books only ten cases are reported about conflicts between client and designer on the briefing process, from which none directly refer to the SR ‘97 arrangements. With a broader look more cases can be found, as within the Dutch contracting practice between client and designers, contracting is also possible without a formal brief. Strictly seen, given the SR 97 text, only the budget and the functional program are the only constraints that the architect and designers are bound to. So the fact that only twelve cases were reported on the esthetical value and performances of the designers in this sense, can be explained by the fact that these responsibilities cannot be taken into account. Probably the client has to protect himself to unwished design esthetics. However if really explicit wishes are made clear by the client, the designers and his advisors has to provide conforming to the assignment. Two cases are published about not fully defined or incorrect budgets. Lots of cases are reported on fees and financial settlements. Only one case concerned the actual payment because of radical changes in the brief. Another eight cases are published about a dispute whether it concerns a full or a partial assignment, or no assignment at all. Although conflicts are foreseen for example by Brown (2001) and Barrett and Stanley (1999), less evidence for this can be found surveying almost 10 years of Dutch arbitration, mediation and juridical procedures in construction. This might be due to several reasons which could be further researched:

1. Clients as well as designers are ‘suffering’ from growing insight, in other words both parties are equally ‘guilty’ to the delays and failures and disappointments.
2. As according to Mintzberg and Greiner (cited in Prins et. al. 2001, see also Weggeman, 1997) architectural offices might be seen as so called operational adhocracies, designers are more quality driven as money and efficiency driven.
3. According to the bi annual surveys of the BNA (Royal Dutch Association of Architects), still approximately 70% of the design tasks are traditionally contracted. In these cases the architect explicitly is the trustee of the client (See BNA’s code of Ethics). As a trustee and given points 1 and 2, legal procedures aren’t the first option to resolve conflicts.
4. Too less non traditional procured cases are executed in the Netherlands to give evidence, that in these instances formal conflict more often occurs. Beyond that much of these cases explicitly are governmental led, and had a more or less experimental status.
5. Architects fees, compared to costs of further time overrungs and total costs (clients hours) of juridical procedures might prevent clients from escalating conflicts.
6. Dutch architects are in general responsible to a maximum of the fee they committed for (but limited to app. 750,000 euro in all cases), so legal procedures in terms of a client’s perspective often not will be worth the money.

9 Conclusions

In this paper based on the demands of modern procurement, several viewpoints of briefing are examined. In most literature the dynamic brief is strongly advocated. Some authors belief that design and briefing are completely intertwined and ought not to be disconnected. However in terms of striving for objective requirements, clear communication, and the brief as a contract, a static nature of the brief seems to be more appropriate. This is even more the case as when looking to modern integrated forms of procurement, the role of architects as the clients trustee substantially is reduced, and firm and objective long-term appointments are the basis of contractual thinking.

Our main hypothesis is that the multifaceted character of the brief as described in this paper deserves significant more attention in research as well as practice because modern procurement asks for modern briefs and briefing processes. Phase bound development in these terms might mean that first a static brief is defined which forms the basis for the integrated contract. Secondly dynamic forms of briefing are introduced during the design process where growing insight of all parties involved can be
integrated (client, contractor, designers) within the borders and constraints set in the static starting documents. This might imply significant changes in the way integrated construction processes take place and are organized nowadays. Given the considerations in this paper a brief can be characterized within a three dimensional space in which:

- on the one axis the degree of dynamic versus the static nature is specified,
- on the other axis the degree of object specification is set,
- on the third axis the process demands are specified in terms of a rather open and flexible sequence (as in most forms of traditional contracting) to closed turn key like long term contracts as DBFMO.

This way of thinking concerning the brief and briefing process might open up integrated procurement routes for client designer communication, much more as as accepted nowadays, trying to match expectations and dreams to be translated into reality, while also giving space for the advantages of integrated procurement. Part of the problem is to distinguish fixed and tangible aspects from the still variable and sometimes intangible ones, while defining the first as constraints for the latter.

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Briefing: Static or dynamic?
Continuous Briefing and User Participation in Building Projects

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KEYWORDS

Briefing, strategic briefing, user participation, case study.

Introduction

In recent years the interest in briefing has increased. One reason is that the view of buildings has changed from seeing buildings as mainly architectural expressions or passive physical constructions to regard buildings as facilities that must support the needs of an organisation. An increased awareness of buildings as physical frames for work processes, that can either obstruct or be designed to support the dynamic needs of organisations, has emerged. This has been reinforced by the increasing amount of knowledge work and the need for modern organisations to support the creativity of the knowledge workers by a diversity of settings and the need to create suitable working environments to attract the most desirable part of the workforce. Another reason for an increased interest in briefing is the trend for companies to put more emphasis on branding and the possibility of using building as part of their face to the public. This has altogether created a new perspective on briefing as a mean to create supportive surroundings for businesses in new buildings that are used as symbolic expressions of companies’ image.

This paper examines the literature to identify how the briefing process can be organized to fulfill these new requirements. This requires a change in the briefing process from an expert based information collection to a guided learning process with involvement of top management as well as end users. It also implies a change from mainly being a process of developing a design or construction brief to a more continuous process during the whole building project from feasibility study to commissioning.

An example of this new briefing process is provided as a case study of a huge ongoing building project. It concerns a new headquarters for DR (Danish Broadcasting Corporation in Copenhagen. The complex called DR Byen (DR town) is altogether 130,000 sqm, and it is divided in four segments designed by different design teams following an architectural master plan competition and three ordinary architectural competitions. The author of this paper was deputy project director in the client organisation for the building project from the start in 1999 until 1 April 2005 with responsibility for briefing and design coordination. He is now a researcher and lecturer at the Department of Civil Engineering at the Technical University of Denmark. Hence, the research can be seen as a kind of action research. The author has presented his experiences from the early stages of DR Byen in a book published in Danish [Jensen, 2002].

Theory

The briefing processes
The new way to regard briefing was outlined by Nutt [1993]. He described the traditional briefing as design briefing defined as a definite phase leading to a set of requirements specified in a design brief. The nature and pace of change has, according to Nutt, challenged the simple basis of the traditional brief and exposed the limitations in the logic of its process. The future needs cannot be forecasted with confidence. Instead, Nutt suggests firstly to incorporate truly strategic characteristics in the design briefing procedure and secondly to foster strategic attitudes within a post-occupancy briefing process. This resulted in a proposal of a briefing process starting with an organisational/development brief, a design/construction brief and a use/facilities management brief, which together constitutes the strategic brief.

Barrett & Stanley [1999] has undertaken a major empirical investigation of briefing in the UK, and they observe that briefing is done in a lot of different ways dependent on the experience of the individual professional. There is no formal education of professionals in briefing, and there are no general accepted methods and procedures. They stress that briefing must be seen as a process and not an event and conclude, that better briefing requires that the building client becomes empowered.

The idea of strategic briefing has been further developed by Blyth & Worthington [2001], but unlike Nutt they do not see the strategic briefing as an overall framework for briefing but as a specific briefing activity at an initial pre-project stage. In their interpretation the strategic brief is more or less similar to the organisation/development brief described by Nutt. Furthermore Blyth & Worthington operates with a lot of different briefing activities, for instance related to concept brief, project brief, detailed brief, fit-out brief, furniture brief, operational brief, environmental brief and facilities management brief. The brief activities vary according to the organisation of the building project.

In Sweden comprehensive research on briefing has taken place, and Ryd [2001] and Fristedt & Ryd [2004] also stress the importance of seeing briefing as a continuing process. They adopt the idea of strategic briefing as an activity in the pre-project phase, but they compliment the strategic brief by a tactical brief in the design phase and an operative brief for the construction phase. Furthermore, they emphasize the continuous follow-up of and feedback between the different levels of briefing activities.

However, the traditional ways of regarding briefing as a definite stage to define requirements for buildings still prevails for instance in recent international text books, for instance Cherry (1999).

**User participation**

An important question in relation to user participation is, whether genuine participation requires real influence on decisions about the building project. This has been investigated in relation to a Norwegian hospital project in Trondheim [Jensø, 1999]. The conclusion was that genuine participation requires some degree of involvement in decision making. However, even without involvement in the decision making users can obtain real influence on a project by being part of the information process.

User participation is not a new phenomenon. It started in the 1960’s as part of the increased focus on democracy in the workplace. The development in user participation during the last 30 years has been described by the Swedish researcher Granath [2001] as a change from a power based to a knowledge-based process. Granath identified three steps in the development of user participation. The first step had a focus on democratic representation as a parallel to the political system, which in the briefing process meant that staff representatives became members of building committees. The second step had a focus on product quality, and in the briefing process this meant that interviews with staff were carried out by building specialist. The third step is based on staff in the knowledge society being the most important resource for companies, and an active involvement of staff is a necessity to create improvements in the work processes.
User participation is of particular importance when a building project is part of an organisational change process. Another Norwegian research project on the hospital project in Trondheim investigated the relation between the development of processes in an organisation and the building process. Klagegg et al [1999] define a so-called “clutch effect” (koblingseffekt) between these processes. One of the most important elements in creating such a clutch effect is to define an overall vision for the building project based on the development needs of the organisation. The strategic briefing is very much aiming at this. Among other elements in creating the clutch effect is involvement of the users in the building project and creation of a shared understanding of the project among all participants.

User is a broad term, and it can be useful to distinguish between different groups of users. Both Barrett & Stanley [1999] and Blyth & Worthington [2001] describe a so-called user gap referring to users often not being involved in the dialogue with neither top management nor experts in building planning, because the main dialogue takes place between experts and top managers. However, top managers can also be regarded as a group of users. In the “democratic” step in the development of user participation the main users were top managers and elected staff/union representatives. Another main category of users is the end users, which covers the ordinary employees but can also include middle managers. A special group of users are internal specialists, who get involved in the building project because of there special competencies within a specific part of building planning.

Case Study

DR Byen is a complicated development which besides a construction project with a budget of € 400 million (1999 price level) includes an € 100 million investment in electronic media technology. The technology project has been planned parallel with the construction project and integrated in the building client organisation. The technology implementation is carried out at the end of the construction work in each segment before staff is moved in. Although most of the technology is new, there is also a considerable amount of technical equipment reused from existing facilities.

Altogether 10 briefing activities have been undertaken as part of the DR Byen project as shown in Table 1 together with information on the users mainly involved in each activity and the project stage, where the briefing activities has taken place. Briefing started at the pre-project stage to create a basis for the project decision. It was followed by an initial strategic briefing process to define the overall vision and objectives. A competition brief and a construction brief was developed for each segment with extensive involvement of users in workings groups during the development of the briefs and as well as in the follow-up activities during design development. A parallel briefing process concerned the broadcasting technology and a particular briefing process concerned facilities management with involvement of number of internal specialists. The interior design briefing was divided in an interior room layout stage followed by an interior furniture design stage; both involving a large number of user groups. The removal briefing was divided in two parallel processes – one for furniture and archives and one for technology to be reused.

Evaluation And Discussion

The case study is an example of a briefing process with a client organisation as a mediator between the users on the demand side and the design companies on the supply side. The client organisation has facilitated the briefing process and formulated the final brief documents based on input from the users and formulated the requirements and intentions in a form which is in accordance with the professional language and standard that are common to the design companies. However, the client organisation has been careful to make sure that the users take responsibility for and ownership of the requirements. This was accentuated by the working groups involved in the briefing process having a manager appointed by DR’s directors as chairman.

The briefing process has, in general, taken place as a more or less continued process following the principles outlined by Blyth & Worthington [2001]. One difference was that the strategic briefing
Continuous Briefing and User Participation in Building Projects

took place at the initial project stage after the formal decision by DR’s board had been made and not in the pre-project stage as suggested by Blyth & Worthington. The reason for this is that DR is a political controlled institution, where formal decision is necessary at an early stage. The case is also a clear example of a building project which is used as part of a fundamental change process in a company. Such a case puts particular emphasis on the timing and coordination of the change processes in the company and the briefing process.

<table>
<thead>
<tr>
<th>Briefing activity</th>
<th>Users involved</th>
<th>Project stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Briefing for decision Proposal</td>
<td>Top managers</td>
<td>Pre-project feasibility study</td>
</tr>
<tr>
<td>2. Strategic briefing</td>
<td>Top managers and Union representatives</td>
<td>Project definition after board decision (part of Five Finger Plan)</td>
</tr>
<tr>
<td>3. Competition briefing for the master plan</td>
<td>Top managers and selected middle managers</td>
<td>Preparation of competition with follow-up after competition</td>
</tr>
<tr>
<td>4. Construction briefing</td>
<td>Middle managers and staff (end users)</td>
<td>Preparation of competitions with follow-up afterwards and during design development</td>
</tr>
<tr>
<td>5. Technology briefing</td>
<td>Middle managers, technology specialists and staff</td>
<td>Design development and detailed design</td>
</tr>
<tr>
<td>6. Facilities management Briefing</td>
<td>FM managers, specialists and staff</td>
<td>Design development, detailed design and construction</td>
</tr>
<tr>
<td>7. Interior room layout Briefing</td>
<td>Middle managers and staff (end users)</td>
<td>Design development and detailed design</td>
</tr>
<tr>
<td>8. Interior furniture layout briefing</td>
<td>Middle managers and staff (end users)</td>
<td>Construction and technology Implementation</td>
</tr>
<tr>
<td>9. Technology removal</td>
<td>Middle managers and staff (end users)</td>
<td>Construction and technology Implementation</td>
</tr>
<tr>
<td>10. Furniture and archives Removal</td>
<td>Middle managers and staff (end users)</td>
<td>Construction and technology Implementation</td>
</tr>
</tbody>
</table>

Table 1. Briefing activities and users involved in relation to project stages in DR Byen

This can be compared with the linkage between business planning and facilities planning, which Barrett & Baldry [2003] describes as four alternatives: Administrative, one-way, two-way and integrative linkage. In relation to DR Byen the strategic briefing as part of the Five Finger Plan was an ideal example of an integrative linkage with a fully synchronized coordination between strategic business planning and the strategic briefing for the building project.

Later on, during interior design, the situation was less ideal as the implementation of the change processes in major parts of the user organisation had not progressed sufficiently for the users to be ready for the briefing process, when this was needed to accommodate the building process. The interior design process, so to say, got caught in the middle between the synchronization of the business processes and the building project. The linkage was no longer integrative but an example of a two-way linkage without sufficient synchronization. This is probably a common situation in huge building project with many years duration. The business organisation is changing dynamically and the users want to postpone the decisions on requirements for the interior design to the last possible moment, while the design team wants to know these requirements as early as possible. Therefore, the opinion on the right time for the last responsible moment will vary between the parties – particularly on complex building projects.
In relation to user participation the chairmen of the work groups for construction briefing turned out to have a very important role. This was the case during the initial steps of the briefing process, where the quality of the decisions was dependent on how the chairman managed the working groups. However, it was just as important in the follow-up, which based on the experiences in segment one was intensified in the following segments. The client representatives had meetings with the chairmen every second week in between the fortnightly meetings with the design team during the design development stages. The chairmen were important both as decision makers, ambassadors and gatekeepers in relation to DR’s organisation. As a consequence is caused severe problems when a chairman left there position and was replaced by a new manager. The participation of the users in the briefing process had a clear positive effect. The users involved in working groups expressed much higher appreciation of the relocation project in satisfaction surveys compared with other users.

Conclusions

With the increased focus on buildings being an important asset for the development of companies and creation of attractive working environment for knowledge workers the briefing process has got more focus and the need to involve the users in the briefing process has increased. Briefing has changed from being a single process in a specific initial stage resulting in a final document with definite requirements to being a continuous and interactive process during the whole building project, where the users’ requirements and intentions for the different parts of the building process are presented and discussed with the design and construction team, and where the design, construction and commissioning proposals are evaluated and optimized. The client organisation has a crucial role in mediating between users on one side and design and construction team on the other side and in creating synchronized coordination and integration of the business processes and the building process.

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ADAPTABILITY WITHIN THE PROCESS AND THE PRODUCT: THE WINDOW AS A CASE

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KEYWORDS
Adaptability, design process, design language, design principles

ABSTRACT

Induction

Instead of dealing with ADAPTABILITY in a general sense, we can deal with a specific, in this case the window, and then generalize in order to develop a common approach to ADAPTABILITY in building / architecture.

Design Process

In design and execution we have the operations such as reasoning, weighing, choosing, thereby incorporating the existing knowledge at that moment in time. That as such is a huge challenge, especially if we also have to reach consensus as a society. In this paper a step by step development process is proposed, allowing knowledge to be positioned where it belongs and making relationships explicit. In this string of steps all building agents can follow and communicate their ideas, thereby influencing the outcome of the whole process. This is possible because the applied knowledge is at the level of solution principles, a level that all building agents should be able to understand.

Process, Product and Adaptability

So we have the ADAPTABILITY within the design process, but also the solutions themselves as products allowing for ADAPTABILITY during use. This paper will illustrate this process of design and prototyping for ADAPTABILITY using the Morphological Method specifically developed for representing knowledge and thereby enabling communication. An actual window development will be shown, that will clearly stress the importance of joints in the light of ADAPTABILITY.

INTRODUCTION

Dealing with the development of a window-frame is for the sake of the topic of this conference aimed at adaptability, but all aspects of design and execution are part of the whole process of development of a building component. We have distinguished the aspects Mediator, Creator and Informator, being useful in order to improve communication between
agents. Then there is the point of knowledge management. Experience shows the discrepancy between knowledge represented as static lists and design and development as a process. In addition there is the issue of collaborative design that should lead to integrated design solutions.

This is just to mention a few things that keep us busy, especially their co-ordination. What the following case tries to achieve is the following:

Acknowledge that everything is a developing / evolutionary process. In the development process of the window-frame we distinguish 9 + 1 steps (Emmitt, Olie, Schmid, 2004). Position knowledge where it should be relevant in the process. In the development of the window-frame knowledge chunks are assigned to the relevant steps.

Knowledge as such is represented as much as possible as a morphological image, resulting in what we call the Morphological Method. The morphologies reflect basic principles, that could be understood by most agents in building. We take advantage of people’s ability of “visual thinking” by using a visual language (Kiroff, 2004).

The resulting understanding helped by a common language enabling better communication opens the door to creativity leading to innovation. One of the most important innovations is dealing with change, that requires adaptation in building.

THE WINDOW AS A CASE

To make the point of the adaptation potential in the design process as well as in the resulting product we will deal with the specific case of the window-frame. This means that by dealing with a specific case we intend to generalise for all cases, being the induction method.

It must be understood that we are dealing with the substance of a building and not the spatial aspect (which is addressed indirectly). Then we have in the window the most complex of situations in a building. All possible factors in all three aspects of Mediator, Creator and Informator (Emmitt, Olie, Schmid, 2004, Principles of Architectural Detailing) play a role in the “window” of a building.

THE MORPHOLOGICAL METHOD

The language of building, of architecture is the image, the drawing, the sketch.

In the following case representations are manipulated step by step (for the actual representations see Emmitt, Olie, Schmid, 2004: Principles of Architectural Detailing). The representations are knowledge wise at the level of principles. So with these representations (form) of principles (content) we hope that communication between agents can be improved because of a common language. A common language helps to achieve understanding, and understanding takes away fear of the unknown resulting in the flexibility of minds needed to think in terms of change and therefore adaptation in building. Of course this is as yet an assumption.

STEP 1
Determining discontinuity of main components (mediator/creator)

The question here is whether all these factors should be controlled by one hole in the cavity-wall or by more holes, maybe even a hole for each factor (if it were possible to isolate the factors!).

Which choice would be the best for a high degree of adaptability?

STEP 2
Determining the additional component(s) (creator) and functional continuity (mediator)

The question here is whether we can control passage with one pane or better with more panes.
More layers offer more combinations of filters/screens/baffles, therefore enabling a higher degree of adaptability?
Functional continuity is a complex issue.
The question here is whether we want to control each factor separately and all factors simultaneously.
If the window adapts because of change of one factor, does this affect control of the other factors?

STEP 3
Determining jointing parts and assembly direction (creator).

The window-panes must be joined to the cavity-wall.
The question here is whether we join each window-pane separately or we join the panes together in one joint with the cavity—wall. In addition the question whether we assemble from the inside or from the outside.
What would be the best for adaptability and for which factors?

STEP 4
Determining size and position of (possible) additional component(s) and jointing parts (creator / mediator).

We first must determine the position of the window-panes.
The outer window-pane can be positioned at the backside of the outer leaf or even past the outer leaf and all positions in between.
The inner window-pane can be positioned at the outer side of the inner leaf or even past the inner leaf on the inside and all positions in between.
The jointing parts literally connect the window-panes to the inner and outer leaves and in addition to each other, thereby closing the cavity.
Here again the question of what would be the best for adaptability?

STEP 5
Determining preliminary shape joint faces (mediator).

We have the joint faces between window-pane and jointing part, and jointing part and inner leaf. Factor-principle Air shows the range of sealing principles that can be chosen.

We have the joint faces between the window-pane and the jointing part and the jointing part and the outer leaf. Factor-principle Moisture shows the range of sealing principles that can be chosen.

Adaptability usually implies change of position of parts in order to change degree of control of passage of various factors: the question here then is how does the shape of the joint faces relate to this change of position?

STEP 6
Determining specific shape joint faces (mediator).

Factor-principle Moisture shows the range of sealing principles that can be chosen. Do the specific joint faces comply with possible specific required performance when considering adaptability?

STEP 7
Determining prevention shapes (mediator).
What we try here e.g. is to keep excessive water from the joints. There are various ways to achieve this. The basic principles would be using a jutting barrier (addition) or a gully (subtraction). These measures of prevention shapes must not conflict with the adaptability of the joint as a whole (?).

STEP 8
Determining correction shapes (creator).
In this step we investigate whether there are reasons due to the factors Execution, Durability and Maintenance for adjusting shapes. We see that we must adjust the shape of the sill in the joint faces of the two window-frames in order to be able to assemble the outer window-frame: How do we do this? We must have an idea of various scenarios in order to have an idea of necessary correction shapes when dealing with adaptability.

STEP 9
Determining primary and secondary sections of parts (informator).
Primary sections/shapes are those parts of joint faces that are essential for the sealing function. The secondary sections/shapes are those parts of joint faces that allow a certain freedom of shape without resulting in inadequate sealing performance of the whole. This does mean that we must choose which shapes we will apply to these secondary sections. In the light of adaptability considering specific required performances it could be quite possible that primary and secondary sections of joint faces could differ!

SOLUTION VARIANT (STEP 9 + 1)
These 9 steps, as they have been dealt with here, lead to a comprehensive solution principle. All the configurations comply to a grid, measuring in both the x- and y-axis in alternating zones of 6 mm and 18 mm. This grid was determined on a trial and error basis. The grid gives a consistency of information, enabling development on the basis of layering. The grid is intended to ensure modularity and to express proportions between parts and whole. Therefore the grid does not express actual dimensions, but rather an order of size. Dimensions are determined for solution variants when we choose actual materials for the parts in the solution principle. Then we can determine the necessary tolerances needed for assembly and performance. Step 9+1 shows the chosen materials to determine this specific solution variant of a window-frame system.
Figure 1. A solution variant with actual materials and tolerances

PROTOTYPE

Of this solution variant we go on to make a prototype. In the prototype we include a horizontal and vertical mullion. The morphological principles are derived from the principles applied in the jamb and the sill.

Some of the expected performance of the morphological principles can be justified by substantial scientific proof, usually supported by research and experiments in the past. But what we want to know is the performance of the whole, which is unique. By monitoring the various performances we can make adjustments, where and when necessary, with contributions by all agents applying their specific expertise.

Figure 2. The inner and outer window-frame assembled together

DISCUSSION

The questions we could deal with now are:
What is adaptability or adaptable?
How do we achieve adaptability?
Does the example of the window-frame represent a way of achieving adaptability?
What is adaptability?

Adaptability is the ability to respond in an acceptable / resolving way to change. What are the changes we know from experience and what are the expected changes? Can these changes be categorized so that we could relate these categories of changes to categories of responses?

When thinking along this line we can imagine that we would ultimately envision the building (and maybe the whole living environment) as an organism sensing change and reacting appropriately; actually to be more precise we should say that building and people together are an organism with the people as sensory nerve centres controlling the building as an extension of their own bodies. Why shouldn’t the building be able to get “goose pimples” just as we do when we get too cold?

How do we achieve adaptability?

We could make the distinction between people, building and external factors. Each of these three are adaptable to a certain extent. We have the three phenomena Energy (including material and mind), Space and Time. This is what we have to work with. If a change occurs in one of these phenomena, then a reaction / adaptation can be expected in the other phenomena. If it gets too cold in winter we could migrate to the south or we stay here and then the way we clothe ourselves must change and the buildings we live and work in. Considering buildings in that sense it is quite unusual that buildings look quite the same in summer and winter! (yet understandable because of the inner climate control equipment we put into buildings nowadays).

If we focus on adaptability of buildings we must realize that to begin with there must be a demand for adaptability. There is always a demand for interior spaces of certain sizes and relationships, and indoor climate conditions, but these will always be changing or external factors (outdoor climate conditions) will change, but indoor climate conditions not. Maybe the most important point to think about is that we might need a different idea about what a building is: not so much an economical piece of static hardware, but an integral part of our environment, even seen as an extension of ourselves as an organism, programmed as such, being able to function as an extension and being highly adaptable / responsive to ever changing conditions. Buildings performing in this manner can be expected to also have their value in the economic market.

So it’s a question of attitude, demand, vision, expectation that will change the way we look at buildings and especially their adaptability.

The Window-frame as example

In the development of a window-frame as shown here we have used a grid to give all drawings modularity enabling comparison. The morphologies are based on knowledge at the level of solution principles. These principles can be understood by all agents in building because of experience and/or because of education (?!), meaning that there is a level of common knowledge considering at least the “factor-principles” (Olie, 1996). So the representation is a common language based on the Morphological Method (Olie, 1996).

The development is a step by step procedure in which at every step choices must be made. These choices are made within the “solution space” represented by the italic text. This solution space is continuously expanding (we hope) due to progress in shear makeability. An
important aspect is the set-up that specific knowledge is positioned in specific steps and their graphic representations. In other words you have the knowledge where and when you need it (knowledge application in the design process is very poor). Finally it all results in the actual prototyping and the accompanying tests: “the proof of the pudding is in the eating”. An idea becomes alive with a prototype, minds and tongues stir, opinions clash, unexpected links trigger creative thinking: evaluations, adjustments, adaptations, adaptations to make the product adaptable. Adaptable considering the factors Light, Air, Warmth, Moisture, Sound, Field, View, Minerals, Plants, Animals and People (all belonging to the aspect MEDIATOR), Execution, Durability and Maintenance (all belonging to the aspect CREATOR), Material, Image and Control (all belonging to the aspect INFORMATOR). The *italics and underlined* text in the window-frame case deals with adaptability specifically. The development of the window-frame shown here (in abbreviated fashion) could be generalized for all product development to encourage innovation in building, especially adaptability. The joint in building is a key factor, especially when dealing with adaptability.

CONCLUSION

Adaptability must be a major item in the brief for a product, being component or a whole building. This requires an appropriate kind of design process which allows and supports a way of thinking in this sense, especially as a development team of agents, all having their rightful contributions. The design attitude along with the design process is conditional to achieve a high degree of adaptability in our building products. Using a common language as the Morphological Method enables understanding and communication. Translating specific detailed knowledge to the level of solution principles represented by the Morphological Method ensures the availability of operational knowledge in the design process. The development of a window-frame is just an example, being foremost an example to show the importance of joints in building in general (the window-frame itself is only a jointing part between glass and wall!). But it should be obvious that the phenomenon of joints plays an essential role in adaptability in buildings. Adaptability is not new in building, it has always been present. Since the 1950’s many good ideas and directions have been initiated, but few have followed through. Habraken’s “Supports” (Habraken, N.J. 1972) and the conference “The Responsive House” (ed. Allen, E. 1975) are a few worth mentioning. It seems we will need a comparable “Zeitgeist” to get back on the track. Of course adaptability is only one of many criteria for design of buildings. Integral design is our main goal resulting in true sustainability in architecture. Sustainable architecture cannot be achieved without adaptability.

References


Steering creativity in design teams: 
An explorative study about the relationship between leadership and autonomy of professional designers

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KEYWORDS
creativity, leadership, designing professionals, autonomy

Abstract

In this paper we explore the area of creativity that is particular to the complex setting of project organizations as faced by professional designers. These specialist designers can be characterized as being creative, visionary, spatially aware and abstract thinking practitioners with a high level of technical knowledge and experience (Schön, 1987). These professionals are usually designers who also hold management functions in their own mother organization. Since knowledge about the design exists on a cognitive level of the design team members, it is particularly important to have a better view on the ways cognitive processes can be steered. Any negative occurrences during a project can surely be transferred back to the mother organizations of the designers, which could cause a snowball-effect.

Research in the area of creativity encompasses a substantial body of empirical evidence concerning the processes that people use to think and to solve problems, which allows us to examine and apply this information to different kinds of social settings. This empirical research has expanded the Componential Model of Creativity defined by Amabile (1983) and has therefore considerably contributed to our academic and practical knowledge concerning this widely used concept. Various leadership styles and the influences thereof on the autonomy of designing professionals were investigated. The importance of this relationship is conveyed in its consequence. Perceived autonomy of designers consequently influences their intrinsic motivation, which in turn influences the creativity of professionals. This phenomenon was studied in two conditions, namely low and high time pressure. Results have shown that autocratic leadership negatively influences the level of autonomy in both conditions, but this relationship is moderated by the setting of clear goals and responsibilities. Democratic leaders are susceptible to change to autocratic leadership during high time pressure. Negative influences thereof on the perceived autonomy are moderated by early creation of a positive environment. Further knowledge on this matter could offer project leaders interesting insights for enhancing creativity within a project organization, and could consequently enhance the performance of designing teams within mother organizations.

Introduction

Developments like intensified competition, globalization and technological developments imply an increasing degree of blurring of organizational boundaries. Design teams are confronted with new
organizational forms, new associations of organizations and new trade-offs between make, buy and co-operation not only at the level of an individual organization, but also with respect to inter-firm relationships, industry structure and regional clustering of organizations. These organizational breakthroughs that blur traditional organizational boundaries tend to evolve into network and project based forms of organizing.

Professionals engaged in some sort of designing activity, such as product design, building design, R&D specialists etc. often work in a project based organization. A project organization is a temporary organization created for the realization of a common purpose (Boddeke et al., 2002). Different actors usually have to work together on a specific design. The design stage is therefore a crucial stage that must be elaborated carefully in order to increase the level of creativity in the design team. Research indicated that poor design has amongst others a very strong impact on the level of efficiency during the production stage (Ferguson, 1986). Since architectural designing, and especially nowadays, is actually a people’s business, it is of great importance for academics to further investigate the different kinds of socio-psychological mechanisms occurring in this particularly creative phase. This might greatly enhance the quality of the design and consequently also the end product.

The field of creativity has made progress in understanding what types of climates support creative productivity. Evidence is found that leadership influences the employees’ feeling of autonomy, which in turn influences the employees’ intrinsic motivation, and consequently employees’ creativity (Amabile, 1983). Research also showed that sufficient time is needed in order to produce creative outcomes (Amabile, 1983; Csikszentmihalyi, 1994). However, most groups or teams are formed with specific goals in mind; often involve imposing a deadline for their completion (Boddeke et al., 2002). Time pressure is thus a common and necessary condition under which groups operate. The concept of time pressure seems to be contradicting the notion of “sufficient time” needed to enhance ones’ creative capabilities, as often portrayed in creativity studies. Since the project leader is the one coordinating the project, he must make sure the goals and quality of the design are being attained within a certain time-frame and budget. The project leader is thus embroiled in some sort of dilemma, since he should give the employees a minimum of disturbance, while making sure the deadline will be attained. So how does this concept of time pressure relate to the concepts of leadership and autonomy and how can we link this to the concept of creativity in project organizations?

Creativity

Creativity can generally be defined as the ability of people to combine ideas in a unique way or to make unusual associations between ideas (Amabile, 1996; Reiter-Palmon & Illies, 2004). Domain relevant skills are the basis for performance in a certain field. According to Amabile (1996) there is a high correlation between creativity and proficiency in domain relevant skills. However, a great deal of domain skill knowledge does not insure creativity. Creativity relevant skills are the skills that make creativity possible. Some of these skills are personality traits and some can be learned. Examples such as flexibility, risk-taking, originality and playful exploration may respond favorably to training and can therefore be improved or enhanced. The motivational variables determine an individual’s approach to a given task. Previous research has shown that intrinsic motivation is crucial for creativity, while extrinsic motivation being detrimental for creativity (Amabile, 1983; Torrance, 1987; Oldham and Cummings, 1996). In other words, people will be more creative when they are primarily motivated by interest, enjoyment, satisfaction and challenge of the work itself, and not by external pressures such as the expectation of evaluation, or even by reward or the lack of choice regarding their own engagement. These psychological needs, providing some sort of desire or sense of worth for people’s actions and thoughts, can thus influence the concept of creativity.

Five stages of creative performance can be determined: 1) external or internal stimulus 2) building up and/or reactivating store of relevant information and response algorithms 3) search memory and immediate environment to generate response possibility 4) test response possibility against factual knowledge and other criteria 5) complete attainment of goals or progress towards goals or failure.
Figure 1 relates the three components of creative performances with these five stages. The model focuses on the judgment of success and failure aspects. If some progress is made towards the goal there will be a reengagement to the problem or task, and so to speak a return to stage one will be most probable.

Conceptual Model

Contextual variables like time pressure, autonomy and leadership have all been found (Torrance, 1987; Amabile et al., 2002) to somehow influence the intrinsic motivation of people and also the cognitive processes involved in producing creative outcomes. For example Amabile’s study (1996) concerning the influence of time pressure on employees’ intrinsic motivation and creative cognitive processes showed that although time pressure led people to work harder, it brought about less creative cognitive processing. This finding is consistent with other creativity researchers’ findings, like for example Wallace (1926), Campbell (1960) and Simonton (1999), whom had had stressed the importance of “incubation time” in the creative process.

A finer-grained analysis of the impact of environmental mechanisms in the componential theory might lead to a systematic distinction between the aspects of the work environment that are likely to work through motivational mechanisms and others, such as time and resources, that are likely to operate through more direct means” (Amabile, 2002, pp. 17-18).

Figure 2 Modified view of Componential Theory of Creativity
As described above, leadership is of great influence on employees’ autonomy in organizations. In trying to link time pressure to these two variables, you must think of two conditions, namely that time pressure could directly influence leadership by asking for different types of leadership in different levels of time pressure; and that time pressure could influence employees’ autonomy by making them feel less autonomous when involved in tasks under high time pressure. The latter condition might cause people to feel as if they are controlled by the environment. It is therefore plausible to assume a moderating effect of time pressure on the relation between leadership and autonomy. The exploring nature of this research has led to formulations of various hypotheses, which should then be subjected to further examination. The following figure depicts the conceptual model of this research:

![Figure 5 The conceptual model](image)

**Research Approach**

A series of semi-structured interviews had been conducted. Interviews have been recorded and written down into transcripts to preserve their quality. These transcripts have consequently undergone further investigation. Data obtained by semi-structured interviews had been investigated for patterns that seem to serve changes in the variables across several observations. This analysis aims to understand a particular case or several cases by looking closely at the details of each (Miles and Huberman, 1994). In this research, we employ a variable-oriented analysis, because our focus lies on the interrelations amongst variables, and the people observed are primarily the carriers of these variables, namely leadership and feelings of autonomy. Time pressure is a variable dependant upon the requirements of the environment.

The manner at which one encompasses a certain coding-system in the research can differ amongst researchers and as stated earlier, depends on the theoretical and epistemological orientations of the research in question. In this research, there has been an incorporation of systematic coding. The coding was oriented around the topic in question in order to represent the interplay of subjects’ perceptions of the nature and dimensions of the phenomenon in question. This research therefore made use of content analysis. Content analysis is a research method used to quantify and analyze the words, concepts, and relationships within certain passages. This technique is beneficial for understanding social communication and interaction, and allows for an unobtrusive means of analyzing these interactions and relationships. The indicators of the independent variables have therefore been bestowed with codes. These codes have then again been placed to certain pieces of text, acquired from the written transcripts. In order to arrange the analysis of the interview data in an efficient manner, Miles and Huberman’s “Monster matrix” was used. Each participant had its own matrix with the various leadership styles on the vertical axis, and the two conditions, namely low and high time pressure, on the horizontal axis. By examining the transcripts, narrative extracts from the interviews that best fit the identified indicators are selected and consequently listed on the matrix.

**Findings**

The findings of the project show that different leadership styles do bring about variations in the levels of autonomy as perceived by architects. Although the conceptual model of this research presumed a moderating effect of the concept of time pressure on this relationship, this was not found. Time pressure seems to directly influence the leadership style employed by the project leader.
This change in leadership style could then again influence the architects’ feelings of autonomy. No indications of time pressure were found to directly influence professionals’ feelings of autonomy, and therefore the assumption in the conceptual model of its moderating position is refuted. We did find other moderating variables, namely clear responsibilities and goals and the setting of a positive environment. These variables could both moderate the influence that leadership styles have on the levels of autonomy as perceived by architects. More specific, autocratic leadership will negatively influence the feelings of autonomy as experienced by designing professionals during low time pressure, and consequently also during high time pressure, but this relationship is moderated by the distribution of clear responsibilities and goals. Democratic leadership will positively influence the feelings of autonomy as experienced by designing professionals during both low and high time pressure, but this form of leadership is very susceptible to change to autocratic leadership during high time pressure, which does not alter its effect on autonomy unless managed untactful. Transformational leadership positively influences the feelings of autonomy as experienced by designing professionals during both low and high time pressure. Certain characteristics of transactional leaders (management-by-exception active) negatively influence the feelings of autonomy as experienced by designing professionals, while others (management-by-exception passive) positively influence the perceived level of autonomy during low time pressure, however transactional leaders in general mainly display autocratic characteristics during high time pressure, which does not negatively influence the level of autonomy if clear goals and responsibilities have been distributed.

**Conclusion**

The results of the investigation have practical implications for the communication in design teams of construction projects. It shows that different leaders can positively or negatively influence the much needed autonomy of design professionals during face to face contact. For example dialogues, informal- and team meetings, but also through on distance communication by telephone, instant messaging, tele- and video conferencing and email. This accentuates the importance of well developed communicating techniques by the group leader, which could be enhanced by means of training. It has also been mentioned that perceived low levels of autonomy have detrimental consequences for designing professionals. It might cause low intrinsic motivation and thus diminishes the creativity of designers. Another consequence of perceived low autonomy could be less willingness of designers to communicate key knowledge to other team members; or inefficient documenting of the progress of the design team in projects that are characterized by continuous change processes. These issues can be translated also to other projects in the mother organization of the designers. That is to say that many designers holding a management position in their mother organization transcend these negative ‘experiences’ acquired during a project to other design teams they lead. Time pressure has been observed to change the leadership style of most leaders, except the style of the transformational leader. The latter has the capacity or charisma to transfer the situation to the professionals themselves making them feel as if they lead the project. This can be very fruitful to improve the team’s level of creativity. Other leaders can make use of different techniques, such as providing clear responsibilities and goals or by setting a positive design environment, in order to minimize the negative effects of their leadership style.

So it can be said that designing professionals are very much in need of appropriate leadership behavior throughout an entire project. The fact that they are experts in their field does not take away their need for inspirational coordination by a team leader. Especially during high time pressure this leader should be able to adapt himself to a situation and strategically lead the creative process by not only focusing on the constraints, but also ensuring the vision is not lost by the team members.

**Discussion**

Our findings question the existence of a causal relationship between intrinsic motivation and the creative cognitive processes as depicted by Amabile’s Componential Model of Creativity. If time pressure has an influence on the leadership style employed, which could then influence the perceived autonomy, and the latter could be moderated by clear goals and responsibilities (first stage of the creative cognitive processes), it would be possible for the creative cognitive processes
to directly and indirectly influence the intrinsic motivation of architects or any other professional designer. It seemed that if a deadline is in any way endogenous to the task itself, this should lessen the controlling aspect of the time pressure and, as a result, may serve to get participants more deeply involved with their work and heighten their sense of positive challenge in it as Amabile research showed (2002). This reasoning is very interesting compared to the findings of this research. The findings show that leadership styles serve as an intervening variable between the influence of time pressure and the perceived level of autonomy. So it could be said that time pressure influences the leadership style employed. This leadership style then again influences the perceived autonomy, which is actually affected by the controlling aspect of time pressure as endorsed by such type of leaders.

Future research should focus on expanding our knowledge on the various relations between autonomy, leadership and time pressure on the one hand and intrinsic motivation on the other hand. It is also very necessary to study the various manners at which different leaders behave when communicating through different channels. This would enhance our knowledge on the effectiveness of different communication skills of the different leaders.

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An Investigation of the Briefing Process in Hong Kong’s Construction Industry

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KEYWORDS
Briefing, Limitations, Hong Kong, Construction industry

ABSTRACT

A briefing is the process through which a client clarifies and informs others of his or her needs, aspirations and desires, formally or informally. This paper introduces an investigation into current briefing practices in the construction industry in Hong Kong. The research finding shows that the briefing generally starts from the functional brief and is followed by the concept design and scheme design in the private sector. This study revealed that current practices, which have been in operation for a long time, sound practical in the industry. However, these practices are subject to the constraints of a lack of a comprehensive framework; lack of identification of client requirements; lack of contributions from clients; lack of involvement of stakeholders; and lack of time spent on the briefing. The paper improves our comprehension of the nature of client requirements and provides valuable insights into the details of briefings in the public and private sectors of the local industry.

1. INTRODUCTION

A briefing is the process through which a client clarifies and informs others of his or her needs, aspirations and desires, formally or informally (CIB, 1997). It provides a channel to convey decisions and information between clients and consultants. Thus, a better understanding of their requirements and preferences at the project inception stage can be achieved (O’Reilly, 1987; Fisher, 1998). Nowadays a considerable amount of research has been conducted into how to improve briefings since the Banwell Report was published in 1964 (e.g., Newman et al., 1981; O’Reilly, 1987; Salisbury, 1990; MacPherson et al., 1992; Latham, 1994; Green, 1996; CIB, 1997; Fisher, 1998; Barrett and Stanley, 1999; Kamara et al., 2001 and Blyth and Worthington, 2001). Consequently, the client’s requirements may end up not being clearly defined. After thirty years, the Latham report (1994) also concluded that effort is required to understand the needs of clients. In Hong Kong, a recent report by the Construction Industry Review Committee (2001) also recommended that clients should set out the
requirements of their projects clearly, systematically and comprehensively in construction projects. For these reasons, a study has been conducted to investigate the practices and problems of the briefing in the industry in Hong Kong. The study was limited to focus on briefing on residential projects in the private and public construction sectors only, which played a significant role in the industry. This paper begins with an introduction to the research methods employed and detailed illustration of research findings on current practices in briefing.

2. METHODS OF STUDY

The residential market is highly competitive in Hong Kong. Briefings in the industry are usually confidential and only a small group of senior managerial staff from client organizations are involved in the preparation of the initial brief. As a result, the size of the target population may be too small to satisfy the requirements of quantitative analysis. To overcome this, the quota sampling method has been adopted and details of the research framework are as follows:

Research data was collected from the client organizations selected from the government and the Real Estate Developers Association of Hong Kong in accordance with their business nature and share in the local residential market. A total of eight client organizations participated in the research. They are well-known client organizations in the public and private sectors of the industry, and four of them are companies listed in the local stock market. With their support, three focus group interviews were successfully conducted. Over 30 construction professionals (7 for pilot study, and 27 for interviews) attended them between March and May 2002. Most of these attendees were senior members of staff with more than two years of experience in conducting briefings. They included 7 executive directors, 6 project managers, 4 architects, 8 quantity surveyors and 9 engineers. As requested, their identities and details of their background will remain anonymous in this paper.

3. CLIENT CHARACTERISTICS

Clients are usually categorized in accordance with the following factors: sector (public or private); size of organization (small or large); project interest (developer or owner-occupier); project continuity (continuing or one-off), and level of experience (high or low) (Naphapiet and Naphapiet, 1985; Rougïve, 1987 and MacPherson et al., 1992). Referring to these factors, the characteristics of clients in Hong Kong’s construction industry are illustrated in Table 1.
4. PROCEDURES OF BRIEFING

A briefing, which is comprised of the initial brief and the detailed project brief, has eight stages: strategic analysis, client analysis, facilities analysis, statement of needs, confirmation of needs, functional brief, concept design, and scheme design (Latham, 1994; Atkin and Flanagan, 1995; Kamara et al., 2001). As shown in Table 2, these stages are not fully implemented in the industry. The procedures for briefing in the public and private sectors are quite similar, and they are normally comprised of three stages only.

Table 1. Characteristics of clients in Hong Kong’s construction industry

<table>
<thead>
<tr>
<th></th>
<th>Clients in the public sector</th>
<th>Clients in the private sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of organization</td>
<td>Large</td>
<td>Large</td>
</tr>
<tr>
<td>Project interest</td>
<td>Owner-occupier</td>
<td>Developer</td>
</tr>
<tr>
<td>Project continuity</td>
<td>Continuing client</td>
<td>Continuing client</td>
</tr>
<tr>
<td>Level of experience</td>
<td>Very High</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Table 2. Procedures of briefing in Hong Kong’s construction industry

<table>
<thead>
<tr>
<th>Briefing Guideline*</th>
<th>Private sector</th>
<th>Public sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Investigation of clients</td>
<td>Strategic analysis</td>
<td>-</td>
</tr>
<tr>
<td>Client analysis</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Facilities analysis</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Statement of need</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>b. Identification of requirements</td>
<td>Confirming of need</td>
<td>-</td>
</tr>
<tr>
<td>Functional brief</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>c. Concept design</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>d. Scheme design</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>


In the private sector, briefings are mainly undertaken by external consultancies and the brief is usually given either in a written format or through a combination of a written and verbal format. The briefing generally starts from the functional brief and is followed by the concept design and scheme design, as illustrated in Figure 2. In the beginning, the chairman of the client organization will initiate the process by inviting a consultancy, mainly an architectural firm, to undertake an investigation into project feasibility. The results obtained will be used to formulate a functional brief at the inception stage. An interviewee pointed out that this process is usually free of charge. Moreover, it is very informal. The chairman will provide only a few verbal instructions to the architect even though he has a full set of project requirements in his agenda. These instructions mainly include the number of buildings, size of flats, or similar examples in the market. If the land is secured, the stage of scheme design will proceed, and the architect will translate the project information and requirements from the functional brief into a number of concept designs. The project manager of the client organization will choose one of the designs. The architect will then further develop it into the scheme design, which contains a set of sketch drawings and specifications. These documents will be submitted to the chairman for endorsement and they become a core part of a detailed project brief.
5. PROBLEMS OF BRIEFING

Most of the interviewees believed that the current practices in briefings sound practical in the public and private sectors of the industry. However, the research findings revealed that these practices are not effective in providing a clear understanding of client requirements and preferences. A number of problems have been identified and a detailed discussion of them is given below.

Lack of a comprehensive framework

Research findings reported that briefing is mainly done by experience of brief-takers. No briefing guide or menu is used neither it is done formally or informally. Thus, in the current practice, brief-takers mainly focus on the stages of concept design and scheme design only.

Lack of identification of client requirements

The identification of client requirements is not being done properly in the industry. It is because client requirements change from to time to meet changes in the market, such as the tastes and budgets of the customers, and there are no fixed requirements. This is the major reason why the private clients generally keep their requirements as vague as possible and avoid in providing any detail information to consultancies in the briefing process.

Lack of contribution from clients

Most private clients do not appreciate the importance of briefings and usually rely heavily on professionals to interpret their needs in the process. Clients in Hong Kong usually have a great deal of
bargaining power in the market, which enables them to shift the responsibility to the professionals and maintain an inactive role in the briefing.

6. CONCLUSIONS

The paper has described the practice of the briefing and its limitations in Hong Kong’s construction industry. It improves our comprehension of the nature of client requirements and provides valuable insights into the details of briefings in the public and private sectors of the local industry. The study has revealed that current practices, which have been in operation for a long time, sound practical in the industry. However, they are subject to the constraints of a lack of a comprehensive framework; lack of identification of client requirements; lack of contributions from clients; lack of involvement of stakeholders; and lack of time spent on the briefing. It is concluded that these limitations must be properly addressed by the industry in order to improve the briefing and to avoid subsequent problems in the design and construction phases, and that more resources should be allocated.

ACKNOWLEDGEMENTS

The authors wish to express their sincere gratitude to The Hong Kong Polytechnic University for their financial support of the research project on which this paper is based.

REFERENCES

Building Information Modelling (BIM) – Developing Methodologies for Undergraduate Teaching at Concept and Detail Design Phases

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Keywords
Innovation, Buildings, Information, Modelling

Abstract
Object oriented design uses the powerful medium of IT to generate 3D CAD models which are constructed to represent components, assemblies and whole buildings in a virtual environment. In effect, this means that because the mode of representation is transposed from 2D into 3D, the ensuing visualization looks like the real thing. This paradigm shift adds value to architectural and engineering practice by extending the domain for knowledge and understanding of building construction representation beyond AEC professionals and into a new field which includes clients and building users. The addition of a fourth dimension to the object oriented model offers huge potential for developing process tools associated with whole life aspects of building design, construction, use and recycling. Effectively, the object oriented approach is a sub-set of the broader paradigm of building information modelling (BIM). The building information model is based on the generation of a structured alphanumeric database which can be initiated and continuously updated for a building or infrastructure under design and developed as the building evolves through its life cycle. The model should be accessible to a range of participants including clients, professional disciplines, contractors, facilities managers and building users. This paper will discuss aspects of the application of object orientated design and building information modelling techniques to teaching and course development for an architectural technology undergraduate programme. Reference will be made to student project work (Fig. 1) as case studies for developing innovative teaching and learning techniques with a particular focus on the generation and management of digital information at concept and detail design phases.

Figure 1. Virtual model of timber post and beam structure designed for disassembly
Developing Object Oriented Teaching Strategies

Prototyping
Since the mid 1990s, prototyping has been embedded in our pedagogy of encouraging built environment undergraduates to engage with the processes of concept and detail design through experiential learning. Particularly in the early years of study when students have little or no knowledge of how buildings are conceived, developed and made, these simulation techniques (Fig. 2) have made a significant contribution to the delivery of construction technology modules and integrative project work. The prototypes incorporated into project based learning have ranged from small scale mock-ups (Fig. 3) to full size physical models of elements of modular buildings. The availability and increasing use of 3D printers (rapid prototyping) means that physical models of components (Fig. 4), assemblies and whole buildings can now be produced directly and accurately from digital data for analysis and evaluation during the early stages of design. (www.zcorp.com). Developing these techniques has called into question the generic nature of the design process, in particular, areas of overlap between architectural technology, engineering and industrial design. (Cross, 1997). As building concepts develop shape and structure, detail design introduces iterative and dynamic elements to the process of information gathering, review and assimilation which must be guided and updated as projects take shape. Increasingly this control and direction providing is being facilitated using IT. The nature of detail design is also changing as the emergence of software based tools for predictive analysis (Anon, 2003) and development of building structure can be deployed and incorporated at a much earlier stage of the design process than ever before. Change in these aspects of process management will be accelerated by new developments in telecommunications technologies (Flanagan et al, 2001) and new generations of ubiquitous computing.

<table>
<thead>
<tr>
<th>2D representations</th>
<th>Non-functional 3D prototypes</th>
<th>Functional 3D prototypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>Dynamic</td>
<td></td>
</tr>
<tr>
<td>Concept sketches</td>
<td>Mock-ups</td>
<td>Physical mock-ups</td>
</tr>
<tr>
<td>Design drawings</td>
<td>White models</td>
<td>CAD models</td>
</tr>
<tr>
<td>Detail drawings</td>
<td>Site models</td>
<td>Animations</td>
</tr>
<tr>
<td>Generally require some understanding of syntax</td>
<td>Emphasis on form. More accessible to non-experts</td>
<td>May require specialist IT knowledge</td>
</tr>
<tr>
<td></td>
<td>Emphasis on functionality + interaction with user</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Categorisation of prototypes (after Leonard and Barton) (von Stamm, 2003)

Figure 3. Physical concept mock-up of flat packed house designed for disassembly
The Changing Role of Information Technology

When developments associated with the adoption of information technology into the construction industry were reviewed as a preamble to refreshing our undergraduate course structures, in the late 1990s, it became apparent that visionary paradigms viewed CAD as being much less a digital medium for generating production information and more:

- the originator of a project based data model
- a root for developing computer integrated construction (CIC).

This view of CAD as the heart of a Computer Aided Design Informator (CADI) was identified as being the core around which we should develop our pedagogic model for the teaching of IT. The educational perspective was deemed discipline inclusive and sprung from contemporary developments in object oriented programming, conceptual modelling and theoretical deployment of integrated information systems and collaborative working (interoperability) on a global scale. In the UK, many of these topics have been sponsored by industry (CICA, 1993) or Government initiatives such as Construct IT (1995), Continuous Acquisition and Life Time Support (CALS, 1997), Open Systems for Construction (OSCON, 1997) and Integrated Databases for Design and Construction (ICON, 1999).

CADI Course Model to Support Teaching and Learning

Acceptance of the ideas outlined pointed towards the evolution of an appropriate vocational model which could demonstrate fusion between technical competence and knowledge/understanding of both product and process using virtual object based models defined on the basis of whole life objectives. Whilst the development of modeling skills in CAD may be course specific, there is commonality in the need for all built environment undergraduate disciplines to acquire academic knowledge and understanding of CAD as the informator in preparing for the application of their skills to attaining Government, business and user goals for built environment development over the next 20 years. These included the contextual basis upon which CAD based collaborative global working could develop through concepts of interoperability.
| Year 1 | Demonstrate the role of graphical representation in the generation, presentation and management of project information. Practical introduction to object based CAD software. Creation of 3D models and orthographic projection from models for domestic scale buildings, visualisation and rendering. |
| Year 2 | Explain the rationale supporting the application of object oriented CAD software to problem solving in the built environment. Construct a 3D model of a medium rise building and represent through animation. Produce a range of orthographic projections from the model. Demonstrate protocols for information layering. Introduction to object orientation, specification and information management. |
| Year 3 | Argue that CAD is the basis for an integrated project information system. Explain methodologies supporting the principles and operation of an object oriented CAD system. Understand CADI as an integrative information system. Create, modify and evaluate CAD objects. Generation and application of intelligent systems. |
| Year 4 | Critically evaluate aspects of Global collaborative working and CAD model integration with other systems. Appraise future developments in CAD modelling and information systems. Specialisation through dissertation. |

**Figure 5. Object based CADI model illustrating educational objectives**

Realisation of these objectives was exemplified by the course model for the undergraduate programme in Architectural Technology. (Figure 5) which illustrates a developing knowledge and skills base of CAD as students’ progress through undergraduate levels. The model was based on the acquisition of practical skills through a combination of CAD based teaching workshops and application through project work which simulates workplace experience. Figure 6 shows a virtual model from a Year 4 project constructed at concept design stage to develop aspects of site masterplanning for an urban renewal site in the city centre of Dundee on the east coast of Scotland.

**Figure 6. Year 4 project - concept design of new build student housing as rich database of graphical and alphanumeric information within single project model**
Transition from CADI to BIM

Reflection on the CADI model

The CADI model has been subject to constant review and revision at the end of each academic year but, in principle, remained as originally envisaged. However the literature suggested that evolution and progress of the CADI paradigm was gradually been superseded by development of the concept of Building Information Modeling (BIM) as evidenced by the emergence of numerous new object oriented softwares marketed by companies such as Bentley Systems (Bentley Architecture, Bentley HVAC, Bentley Structural), AutoDesk (Architectural Desktop, Revit) and Graphisoft (ArchiCAD, Virtual Construction). In the UK, the principles associated with 3D object oriented design for the built environment were also validated by the most recent version of the UK Production Information Code. (CPIC, 2003) As a School, we found it appropriate during the summer of 2004 to consider moving forward from the local and wholly academic CADI model towards the more inclusive and possible future AEC industry standard offered by the concept of BIM. As with adoption of the CADI model, it was deemed key that the pedagogic approach should not be driven by software specific determinants.

Defining Building Information Modelling (BIM)

BIM has been described is a means of representing buildings on the computer very differently from traditional CAD technologies with revolutionary consequences on how buildings are designed, constructed, and operated. Khemlani (2003), outlined a scenario which described traditional CAD as utilising abstract 2D geometric entities (eg lines, circles, rectangles) to represent building objects. With this approach, the end product is represented by phased drawing series appropriate to sequential stages of the design process (eg concept, outline proposals, detail design and production drawings). Each phase of the complete drawing series for a project may use discrete conventions for representation of graphic information (eg design drawings tend to be pictorial and may lack dimensions). Within a design team, each discipline may produce concurrent sets of drawings to cover a particular phase of the complete drawing register for a project. Historically, the process of transposition of information across disciplines and between drawing phases has been a common source for errors and omissions.

The building information model is an innovative approach to project data integration. It replaces electronic and paper-based documents with a knowledge base describing the entire project. Participants have real-time access to the model throughout the life of the project, contributing their own knowledge and data, and using information contributed by others. Each discipline within the project team uses its own specific software for performing its own aspects of the work, and these tools have the ability to draw from and contribute to the common pool of data and information that is the model database. The key change from present conventional CAD practice is that all discipline specific software can exchange information with the shared building model, ie deploying interoperability within the model environment.

According to Newton (2003) building information modeling epitomizes the synergistic coming of age of several technologies: 3D objects, parametric design, change management, information reuse for the project lifecycle, and project collaboration.

Once the building information model is created, all other requirements including 2D documentation, schedules, reports, 3D renderings, and animations can be derived from it. Also, if changes and alterations are made, they are automatically reflected in all individual views and documents within the model environment, therefore eliminating inconsistencies. Furthermore, the building information model can check for conflicts such as spatial interferences (clash detection) between individual building elements. Cohen (2003), eloquently describes the shared model as “becoming almost a living organism that can be accessed asynchronously by its many contributors”. According to Seletsky (2003), “The single building
model reflects the future paradigm for most architects and large scale design firms. Properly utilised it saves hours of last-minute construction document changes”.

BIM has the potential to save the client in excess of twenty percent of the outturn project cost, says Richards (2000). However, “At present the building information model has not been widely adopted and one reason for this is that practices are simply unaware that the technology is available. Another reason is fear of change because BIM requires you to do things differently. It requires you to describe 100% of the project upfront rather than the 50% you could get away with in 2D”. Fletcher (2000).

Dakàn (2003), raises the valid question as to whether ‘BIM’ is “just the three letter acronym intended to generate interest and sell products” - an issue which must be addressed. Day (2003) adds that “while there is a need to educate users on new technologies, introducing a new three-letter acronym will not necessarily be of benefit to their understanding, its just another label”.

Literature regarding the current barriers to the application and implementation of building information modelling is scarce. (Thomson, 2004) Promotional material for software gives understandably little regard to the negative aspects of the technology or the potential obstacles which stand in its way, focusing primarily on why a step change towards a BIM approach is needed within the AEC industry and the advantages and benefits which will result. (Anon, 2003)

**Evolution from a CADI to BIM Teaching Model**

Notwithstanding the difficulties, we decided to modify the CADI teaching model to take account of BIM principles during the 2004/5 and 2005/6 academic years. Figure 7 shows the current teaching model as it has been updated between years 1 and 4 on the BSc(Hons) Architectural Technology undergraduate programme. The generally acknowledged front loading of project information at concept and detail design stages (Fletcher, 2000) embedded in developing a BIM approach is deemed to be beneficial from Year 1 onwards by acting as a discipline which encourages students to take a realistic approach to both process and product through using virtual build and predictive analysis techniques at concept and detail design stages.

**Conclusions**

• Prototyping can make a significant contribution to the process of steering the design dynamic. Increasingly, IT has a key role to play in the phases of concept and detail design. This shift needs to be reflected in pedagogic theory and practice during undergraduate education.

• Current developments in AEC practice suggest that although the CADI model proved valid at a local level, the literature suggests that the concept of BIM is adopting wider currency within the AEC industry globally. It is important that education takes a lead in this field.

• Observational and anecdotal evidence from the workplace suggests that BIM principles applied to AEC practice may validate some of the benefits suggested by the literature although these perceived conceptual and efficiency gains may be, at present, only applicable to large and complex projects.

• In updating the CADI model for the undergraduate teaching of Architectural Technology, it was considered appropriate to extend the frame of reference beyond academia and into current practice in the field of BIM. Clearly the principal challenge lies in the transposition of BIM concepts across a wider spread of AEC participants, particularly at concept and detail design stages where the most significant changes to working practices may be involved.
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Climate Adaptation – Interaction between institutions in the construction process

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KEYWORDS
Building process, building defects, climate adaptation, climate change, moisture in buildings

Summary
The severe climate of the northern hemisphere is one of the most important challenges the Norwegian building industry face on a day-to-day basis. The present Norwegian building stock suffer from a high degree of process induced building defects. Amendments of the building legislation combined with economical development and demands for efficiency and productivity are important causes of a change in institutional organisation in the construction industry. New technology, changing materials and changes of practice simultaneous with changing ways of living and different user demands are additional factors that lead the architectural style in new directions. This paper is intended to illuminate new ways of thinking in the construction process, by investigating how application of experience-based knowledge and local adaptation to climate is presently handled, and by examining the extent to which technical and scientific knowledge and information is exchanged between the different institutions involved in the construction process.

1 Principal objectives and scope

This paper is based on an ongoing study of adaptation to climate variability and climate change in the prefabricated housing industry of Norway [Øyen et al. 2005] and [Eriksen et al. 2005]. It is established that the present Norwegian building stock suffer from a high degree of process induced building defects. The study of adaptation to climate change investigates to what extent experience-based knowledge of climate adaptation is incorporated in the design and production of prefabricated housing, and whether barriers between actors of the construction process constrain climate change adaptation and use of better technical solutions. The paper has the following objectives:
- Identify how application of experience-based knowledge and local adaptation to climate challenges is presently handled;
- Identify the extent and nature of the exchange of scientific and technical knowledge and information between actors and institutions involved in the construction process;
- Identify main factors that encourage or constrain the implementation of adaptation measures.

The use of local knowledge and adaptation to the large spatial variations in climatic conditions and extreme weather in Norway in the design and construction of buildings are given special attention.
2 Background

It is becoming increasingly clear that adaptation to climate change is necessary and inevitable within the construction industry [Lisø et al. 2003]. In the building sector, on a public level like building standards or planning- and building legislation, it is a huge challenge to attend to such climate variations. It is also a highly complex matter to deal with the differences on a local administration level through planning and handling of building applications. The pre-fab housing industry is dominated by organisations with a nation-wide field of operation and a general range of products designed for the average of geographical localization. A critical question that emerges is whether or not adaptation to climate change is actually carried out in practice. Norway provides a particular instructive case because the climate is harsh and climatic variations between different parts of the country are extreme. Furthermore, current adaptation to these conditions provides an indication of the ability to adapt to present climate challenges and changes in the future.

In environment, development and global change discourses as well as in practical decision-making vulnerability has emerged as a crucial concept [Watts & Bohle 1993] and [Blaikie et al. 1994]. Economical or institutional changes in the sector, such as reorganisation of enterprises due to amendments of the legal framework, may be drivers of vulnerability in the construction industry. In particular, such changes may make the construction industry more or less well equipped for adapting to current climatic conditions, allowing for variations between different areas and extreme events (Øyen et al., 2005). Making adjustments to reduce negative impacts and take advantage of potential positive effects of climate change, therefore concerns fundamental institutional and economic conditions as well as the actual technical adjustments [O’Brien et al. 2004]. It has been observed that the existence of a technical and legal framework is often not sufficient to ensure that necessary adjustments in practice also take place [Næss et al. in press].

Increasing demands in the construction industry for profit and shorter construction periods, combined with extremely varied climatic impacts during the construction process, enhance the strain in the construction process [Lisø et al. 2003] and [Lisø et al. 2005]. Investigations carried out by the SINTEF Building and Infrastructure indicates that the cost of repairing process induced building defects in Norway amounts to 5% of the annual capital invested in new buildings [Ingvaldsen 1994]. Ingvaldsen also found that this estimate was in good agreement with 13 corresponding investigations or sources of information in other European countries (with a mean estimate varying between 3-5%). Correcting faults and repairing defects in buildings during the construction process is estimated to cost roughly the same amount as repairing buildings in use, e.g. another 5%.

Building features originating from climate adaptation has through history transformed into aesthetic characteristics of the local architectural style, presently often apprehended as inherent qualities of the local building traditions. Knowledge on climate adaptation has evolved from being common, hands-on competence amongst farmers and self-builders, through the shaping of a trade of craftsmen/carpenters to the present situation of dissemination of knowledge to different actors of the construction process. This development of specialisation has lead to a division of competence, skills and liabilities, thus demanding a much higher level of communication between the actors involved and overview of fields of responsibility. The demand for a well-functioning effectuation of the statutory system with incorporated local provisions through the local government authorities is equally important.

Several efforts have been launched to decrease the amounts of building defects or damage, both on an enterprise level, branch level and on a national level through a change of the planning and building legislation and the application of the law. The Technical Regulations under the Norwegian Planning and Building Act clearly states that moisture problems in buildings and poor indoor climate are unacceptable, and the statutory provisions of the Building Regulations establish requirements to ensure the quality of what is being built. Yet climate adaptation in general and moisture problems in the construction process in particular does not have a distinct foundation or description in the
planning- and building legislation. The Planning and Building Legislation does not solely consolidate a sufficient attention of process related moisture problems in buildings, yet the regulations establish that indoor climate should not unnecessarily increase the risk or severity of illness or injury. Still, systematic evaluation of protection against moisture-related building defects has not commanded sufficient attention in the construction industry [Lisø et al. 2003]. There are several challenges for the professionals to consider and determine through the planning and design of a building project. Thus, technical issues concerning climate adaptation and moisture in buildings are regarded as only one of several problematic areas of the construction process.

The local authorities’ decisions through administration and implementation of the building approval system affect and direct the development of the built environment. This applies to all the conditions the local authorities emphasize through their planning and handling of building applications, climatic challenges and attention of such being one aspect [Øyen 2005]. Through the reformed Norwegian Planning and Building Act (PBA) of 1997, the professional actors of the construction process are legally responsible for the quality of their work and its accordance with the legislation. The intensions of the introduction of a liability-based system was to apportion the responsibility to the actual performers of the trade, to the architects, the engineers, the contractors etc., and thus secure a higher quality of the built environment. This has lead to a range of changes within the organisation, management, responsibility and control of the construction process. Furthermore it has increased the attention on technical topics emphasized by the new appliance and responsibility system and introduced a new process of appliance- and approval of planning and building applications.

3 Summary of experience from the case study – present practice

Methodology

It is evident that the Norwegian construction industry struggles to cope with a versatile problem of process induced building defects, and that there is a clear need for assessments of origins and casual relations in order to take measures to avoid future corresponding mistakes, and comply with predicted aggravated climate conditions. The described study within the “Climate 2000”-programme is an effort to map present conduct and practice in the construction industry, and thus strengthen the robustness of the construction industry through responses and proposals of adequate measures.

The methodological approach of the described study is bisected. The first part of the project is a qualitative case study of four manufacturers of pre-fabricated housing. The drawn sample of cases covers a variety of geographical and topological situations, different climate zones and a diversity of organizational patterns. There are three larger Norwegian pre-fab housing manufacturers spread over the country, and one smaller manufacturer operating in a confined area where three climate zones meet. Documentation and information of current interest has been collected, including interviews of key position personnel. Issues like organization, management, process and practice are addressed through interviews in each case. Important factors in planning include the availability of knowledge and technology; time scarcity; informal work; rules and regulations; economic and financial framework of building projects; availability of inputs and preferences for buildings. The actors include designers/architects, technical engineers, and the builders or manufacturers of pre-fabricated houses. This first part of the study forms the basis of this paper.

The second part of the study is also a qualitative case study, whereas the cases represent the public side of the sector; the local government administration and the interface towards the construction industry. The cases are geographically located accordingly to the cases of the first part of the study. This part has just commenced, with the major part of collecting empiricism yet to be done. The main focus is to establish to what degree adaptation to climate challenges and climate change is taken into consideration and managed through planning, building approval/planning permission system, property management etc. This second part also involves interviews of two branch offices of the Norwegian
State Housing Bank (Husbanken), to establish the signification of their influence in the respect of this study’s issues.

Summary of results

Information-flow was investigated for each of the four case companies, focusing on decision-making processes, craftsmen (carpenters) involvement in the development of technical solutions in construction, use and distribution of information from external sources, reporting and feedback routines within the companies and similar aspects of information flow within each separate company and in each chain/company as a whole. The four cases include an independent company, a company with district offices and two chain corporations with member companies, with a geographical spread as shown in fig. 1, to reflect both geographical diversity and changing climate challenges.

Figure 1. Geographic spread and climatic variation of interview sites. The national map is based on the Köppen Climate Classification System, and is developed by the Norwegian Meteorological Institute (www.met.no), using weather data (annual and monthly averages of temperature and precipitation) from the reference 30-year period 1961–1990

The organizational structures are different in the four cases; this evidently affects the information flow in the companies. Where the major part of the production is based on self-developed projects, and projects designed by local, external architects on a repetitive basis, the dissemination of knowledge has a shorter run between the detail producers and detail performers. In such projects it may seem like the adaptation to local climate challenges was easier to obtain. In the chain-based projects, with centralized designer companies, the processing of information has an equal long way to go. Thus details that are considered not appropriate (concerning local climate adaptation) are either built as designed, against better judgement, or improved at the construction site and carried out without the approval or knowledge of the designers, and so not performed according to the statutory framework. This was apparently caused by the organizational distance between the actors, and also due to the fact that the design is to be determined at the time of construction. If literally complying
with the legislation, local climate adaptation at the time of construction is not possible. In the chain companies there were few formal mechanisms that effectively captured local carpenter knowledge and experiences or incorporated these in technical development processes of standardized solutions within the chain office procedures.

In two of the cases investigated, the emphasis on continuity of staff implied the important role of personalized knowledge among carpenters in the construction industry, as a form of local knowledge. Despite the common emphasis on continuity of staff and retaining of personalized local expertise, one of the main sources of the variation of attention of experience based or personalized knowledge was the differing organization of the companies. The absence of systematic attention of such knowledge is evident. This indicates a clear need not only for a raise of awareness, but the need for a mandatory system of evaluation of practice and methodical documentation of mistakes, origins and sources, experiences and good solutions. According to the requirements of the system of liability apportionment (according to the PBA), a company that has a consent of liability is supposed to posses and employ a quality assurance and control system. It may seem as if such systems are not properly implemented or in use, thus the possibilities to attend to local, experience based knowledge intercepted through each new building project vanishes. This impression is in accordance with a SINTEF Building and Infrastructure report on the subject project control and public supervision, and applies varying more or less for all categories of actors in the construction process [Nørve 2005].

The system of apprenticeship is considered to be important in most of the case companies, both in the sense of bringing new ideas and perhaps new technology into the company, but also as in communicating and forwarding competence and knowledge on e.g. local climate conditions. The apprentices’ merely hold basic skills, and the training of the apprentices may result in cementing and conserving existing knowledge rather than developing new such. Meanwhile, horizontal exchange of information externally was highly valued, mainly achieved through collaboration with other companies or short-term hired carpenters on larger housing projects in the case of periodically increased employment. In the independent company, horizontal flow of information with other carpenters in external companies may have been fairly low, as the construction process and organization was tight and self-contained. Formalized mechanisms that effectively updated carpenters with new technical information available from research or head office development were also lacking. This was the case in several of the companies interviewed.

A common experience in all of the four cases was the evident lack of requirements or interest in climate concerning issues in the purchaser/owners brief. Issues like kitchen design, colours, living room view and design trends were far more superior. It was pointed out in the survey that only skilled people with occupational background in the construction industry were likely to be concerned about the quality of technical, climatologically or energy related matters.

4 Interaction between institutions

Economic developments as well as reform of the regulatory framework within the sector are factors affecting adaptation to climatic factors, and by extension, future change. The slump in the housing market in the 1990s led to the disappearance of many of the smaller local companies. Larger companies, such as the south-eastern company in case 1, bought up smaller companies in the area. The sector therefore has fewer and larger companies than previously. These changes are reinforced by the regulatory changes that placed the responsibility for quality control on the construction company rather than the local authorities. This reform has entailed an increase of paper work and formal routines for construction companies. Smaller companies cannot easily handle such a bureaucratic burden, and therefore closed down, merged or were bought by larger companies. Especially in a transitional phase, routines to ensure that the companies’ own quality control function well are not fully accomplished. Poorly adapted solutions may not easily be captured in the current quality controls.
The fact that buyers seldom are well informed or interested in aspects concerning climatic robustness of a house, emphasizing instead costs, construction time, and aesthetic features, shows a general lack of attention on climate adaptation and the fact that attention to climate challenges is substantial to are present and future built environment. The economic trends result in an increased centralization of decision-making regarding the design of buildings, thus it is likely that an organization model of member chain companies is becoming more prominent. Large distances and vertical poor information flow between the carpenter and the management/designer may have a negative effect on solutions and the adaptation to local climatic conditions. Evidently, attention of local knowledge and extended information flow both vertically and horizontally are issues that will affect the development of solutions well adapted to climate strain and climate challenges in a positive direction.

In reality, the company with the shortest physical distance between designers and carpenters had the most successful interaction and interception of locally adapted solutions in the industrialized production. In the production of housing for local architects (not pre-fab production for the chain), one of the other interviewed companies revealed a similar process. This indicates that both the internal and external interaction of knowledge that has the apparently best process and results, are more dependant on short physical distance than organisation fellowship.

The organisational structure of the sector is a major influencing factor on information flow and use of local knowledge. Economic development as well as the reform of the regulatory framework within the sector, has led to recent structural changes, in particular the disappearance of smaller companies. This has resulted in a centralization of decision-making regarding the design of buildings. Large distances and vertical poor information flow between the carpenter and the management/designer may affect development of design solutions that are well adapted to local climatic conditions. The use of web-based internal systems to distribute the common basis of documents, standards, building design sheets, handbooks etc. was mutual through all of the cases. A characteristic finding was that especially the designers of the different design companies had web-based information exchange and a relatively high degree of intercommunication between each other, partially independently of the company division. Seemingly, this communication was initiated by a common development project of a Quality System and Control-handbook, activated by the branch association of housing manufacturers, Boligprodusentene. The branch association also holds a strong position as knowledge supply source.

Another source of knowledge frequently used by all of the interviewees is SINTEF Building and Infrastructure, primarily represented through the widespread use of the Building Research Series. Of coming importance is also the archive of building defect assignments, representing one of Norway’s most important sources of knowledge on types of process induced building defects and related causes. A bulk of the defects is related to moisture, and many types of building defect cases are recurring items, which indicate a general lack of knowledge concerning fundamental principles of building physics, but also a wide range of classical problems has been recorded [Lisø et al. 2006]. The findings of Lisø et al. [2006] are supporting earlier investigations concluding that the construction industry is not able to learn from past experience and that the exchange of knowledge in construction projects is not satisfactory.

5 Concluding remarks

Prefabricated housing is an increasingly popular way of constructing smaller residential housing. Such manufactured buildings are standardized products, but with room for local adaptations. At the same time, the more standardization, the higher the quality requirements directed to the buildings will be. This is only natural, due to the great spatial variations in the climatic conditions in Norway. If a standardized building, designed to endure the extreme edges of demanding climate conditions, the dimensioning loads will most probably lead to a by far exaggerated construction in the driest, calmest and most stable climate zones of the country. Thus, incorporation of local knowledge in defiance with the principles of industrialization is highly required. Accordingly, the information flow between the
producer and the carpenter is crucial to the vulnerability of houses, both in terms of incorporation of local knowledge on climate conditions, as well as adaptations made in the production and advice passed to carpenters.

6 Acknowledgements

This paper has been written within the ongoing SINTEF research & development programme “Climate 2000 – Building Constructions in a More Severe Climate” (2000 – 2006). The authors gratefully acknowledge all construction industry partners and the Research Council of Norway. A special thanks to the interviewees and Boligprodusentenes Forening.

7 References


