FLEXIBILITY
Lifecycle focus as a process approach towards “Evolving Buildings” in our “City of Tomorrow”

SAMAN MOHAMMADI
NIEL SLOB

Double Graduation Project
Architecture Hybrid / Tall Buildings
Real Estate & Housing Design & Construction Management
Lifecycle focus as a process approach towards “Evolving Buildings” in our “City of Tomorrow”

Document Information

Double Graduation Project
Title: Flexibility as foundation of Sustainability
Stadium: P5 Final Research Results

University: TU Delft, Faculty of Architecture
Department: Architecture and Real Estate & Housing
MSc Laboratory: Hybrid / Tall Buildings, Design & Construction Management

Lab coordinators: Dr. J.L. Heintz and Ir. R. Cavallo
1st mentor RE&H: Ir. R.P. Geraedts
2nd mentor RE&H: dr. ir. H.T. Remoy
1st mentor Architecture: Ir. R. Bollen
2nd mentor Architecture: Ir. Y.J. Cuperus

Graduation Company: Draaijer + Partners
Supervisors: Ir. L. Wolters (Team Leader: Project Management)
Ir. H. Hellinga (Team Leader: Real Estate Development)
Ing. J. Camphuijsen (Director)

Date: October 2010

Personal
Name: Saman Mohammadi
Studentnumber: 1246046
Adress: Lekstroon 98, 2721 BK Zoetermeer
Telephone number: 06-50742810
E-mail: saman.mohammadi.pr@gmail.com

Name: Niel (Cornelis) Slob
Studentnumber: 1212001
Adress: Veldzoom 8, 2821 ZE Stolwijk
Telephone number: 06-34844588
E-mail: niel.slob@gmail.com

Niel Slob & Saman Mohammadi
Preface

In front of you, you see the Final Research Results (P5) of our double graduation project in the MSc Laboratory Real Estate & Housing Design & Construction Management and Architecture Hybrid / Tall Buildings in the Technical University of Delft.

This report describes the final results for a research in lifecycle focus as a process approach in the construction industry.

We would like to take the opportunity to thank ir. R.P. Geraedts, dr. ir. H.T. Remoy, ir. R. Bollen & ir. Y.J. Cuperus for being our mentors during this graduation project.

We would also like to thank Draaijer + Partners as our graduation company, in special ir. L. Wolters, ir. H. Hellinga, ing. J. Camphuijsen & ir. L. Kemp. Next to Draaijer + Partners we would like to thank LSI, DHV, Claus & Kaan Architecten & Stadgenoot for their cooperation.

Finally we would like to thank the following persons for their interest, feedback and time related to our double graduation project: ir. W.W.L.M. Wilms Floet; dr. L.M. Calabrese; dr. J.L. Heintz; ir. R. Cavallo; dr.ir. M. Prins; ing. P. de Jong; ir. J. Vercouteren; dr. D.J.M. van der Voordt; dr. C.J. van Oel, ir. J.C. Paul, Ir. J.A. Westrik & Dr.ir. A. van Timmeren.

Delft, October the 25th, 2010

Saman Mohammadi & Niel Slob
Summary

Our society and economy are constantly changing. In spite of this the demands and wishes of users also changes. Most of the current building stock is developed as mono-functional buildings to fulfill the demand at a particular moment. They are not designed for the lifespan in which they are useful. Because of their shortcomings in adaptability they are more likely to become vacant as we see in the current Dutch office stock.

So due to the constantly changing requirements, needs and wishes of the client/ market projects can become unfeasible or vacant during their lifespan. If we continue to develop buildings as we did in the past decades then we will remain with the same or even a bigger amount of vacancy in the future. Only if we start considering the total lifecycle of building/areas already from the initiative phase then we can react on this problem. Only in this way we can be really sustainable. The current construction industry needs a method based on a lifecycle focus to tackle this vacancy problem and in this way making the new to be developed real estate sustainable. To fulfill this aim the following research question is formulated:

To what extent and in which way can a process approach based on lifecycle focus optimize a building to make it react on changes during its lifespan?

Studies
There are already existing principles based on lifecycle focus as Drager & Inbouw, Lean Construction, Solids, which are mainly focused on technical, organizational, functional and architectural aspects of flexibility and sustainability. They lack in a holistic process approach towards lifecycle focus in buildings which embodies the process from initiative till demolition.

Forming the manual
According to this literature the process approach was formed and gradually evolved because of our own fictive HighRise design and the critics / possibilities from actors in practice. In spite of this the process approach has undergone several changes throughout our graduation period.

Final Conclusions
Finally a manual is created which can be used by advisors of clients in real estate development on a strategic level. This will guide them question based through the whole design process. In every project development phase the client is made conscious about his decisions in relation to flexibility and sustainability and their impact on technical and financial feasibility. As a result it should make us consciousness about the way we build today and its impact on our ‘City of Tomorrow’.

In this double graduation project the theories are tested on a fictive HighRise project. This HighRise project is used as a test and example of how the theories could be implemented in a design process. Yet, the following and inevitable step is has to be taken namely testing these theories on a project in practice.
# Table of Contents

## Phase I: Project Definition
1 Research Proposal 02
1.1 Motive 02
1.2 Problem Analysis 03
1.3 Problem Definition 06
1.4 Aim 06
1.5 Research Questions 07
1.6 Result 08
1.7 Relevance 08
1.8 Research Design 09

## Phase II: Studies
2 Literature Studies 12
2.1 Drager & Inbouw 13
2.2 Open Building 14
2.3 IFD Building System 15
2.4 Lean Construction 16
2.5 I3Con 21
2.6 Sustainability in Perspective 27
2.7 Biomimicry 28
3 Case Studies 31
3.1 Concept 31
3.2 Identity & Usability 32
3.3 Feasibility 33
3.4 Analyzing the Projects 34
4 Architectural Studies 39
4.1 Form vs. Function 40
4.2 Form & Function vs. Identity 45
5 Results 47

## Phase III: Forming the Manual
6 Development of the process approach 50
6.1 Aim 50
6.2 Flexibility 51
6.3 Process Approach First Draft 53
6.4 Process Approach Second Draft 54
6.5 Process Approach Third Draft 56
6.6 Process Approach Fourth Draft 60
6.7 Process Approach Final Draft 66
7 Implementation into design & manual 67
7.1 Program 67
7.2 Lifecycle Focus 68
7.3 Program of Investor 69
7.4 Design of Frame 70
7.5 Program of User 85
7.6 Design of Infill 86
8 Results 88

## Phase IV: Final Conclusions
9 Conclusions 92
10 Reflection & Recommendations 96

## Sources of Information
11 Vocabulary 100
12 Literature 101

## Appendix
A Article Boss Magazine Risk
B Article Boss Magazine 2020
C Drawings Solid 1 & 2
D Drawings Solid 11
E Drawings HighRise Project
F Urban Analysis Rotterdam
G Thesis Architectural History
Guide

Phase I: Project Definition
In this phase the definition of the double graduation project will be described. The motive of this research, the problem definition, research questions, subjects why it is relevant and how it will be spread out during the different phases will be discussed.

Phase II: Studies
In this phase studies will be done based on lifecycle focus. This phase consists of three different studies namely; literature studies, case studies & architectural studies.

In Literature Studies already existing principles based on lifecycle focus will be described including what they do, how they in theory should perform and what they are missing.

In Case Studies two projects, which carry the same philosophy, will be analyzed in relation to lifecycle focus. In these studies the process and product of these cases will be investigated in depth.

In Architectural Studies a research will be done about the way we design buildings in relation to lifecycle focus. These studies will help to redesigning a process approach which helps to design an on lifecycle focused building(s).

Phase III: Forming the Manual
In this phase the process approach based on lifecycle focus will be formed. This approach is the foundation of the manual. During this phase the results will be evaluated on the basis of our HighRise project. This Manual can be used by different actors within the construction industry.

Phase IV: Conclusions
In this phase the final conclusions will be described and the main research question will be answered, followed by reflections and recommendations.
PHASE I: PROJECT DEFINITION

Content:
Chapter 1: Research Proposal
1 Research Proposal

In this chapter the double graduation project will be described. It will provide information about the subject followed by the aim, research questions, possible result, relevance en finally the research design.

1.1 Motive

‘Perfection means something is complete and stands still and what stands still doesn’t change or evolve and is automatically dead. Everything in the universe changes, evolution implies that the creation is not complete hence the possibility of evolving’¹.

Our society and economy are constantly changing. Hence the demands and so does the wishes of users. Most of the current building stock is developed as mono-functional buildings to fulfill the demand at a particular moment. They are not designed for the lifespan in which they are useful. Because of their shortcomings in adaptability they are more likely to become vacant as we see in the current office stock.

Transformation of existing buildings helps to react on vacancy but is not always possible because of location, legal, technical or financial reasons. Users will leave the existing buildings behind and these buildings become vacant, redundant and obsolete.

Due to the never ending changes from market and users, designs can become unfeasible and need to be adapted in a later stage of the development. Hence delay will occur or sometimes it can result in the elimination of a project. So both building process and product need to react on this dynamic environment.

Today, Sustainability becomes more and more an important part of the construction industry. The current development in sustainability is focused on energy, materials, etc. and less on the lifecycle of buildings. But only if we start thinking in the terms of lifecycle sustainability really becomes feasible. On the other hand there is no point creating a sustainable building if it becomes vacant already at the start or throughout its lifecycle hence flexibility should be its foundation.

If we continue to develop buildings as we did in the past decades then we will remain with the same or even a bigger amount of vacancy in the future. Only if we start considering the total lifecycle of building/areas already from the initiative phase then we can react on this problem. Only in this way we can be really sustainable. The current construction industry needs a tool based on a lifecycle focus to tackle this vacancy problem and in this way making the new to be developed real estate sustainable.

1.2 Problem Analyses

Dynamic environment
Developments and changes constantly influence each other creating the dynamic environment, where the construction industry is a part of. The developments can be categorized in four main groups.

- **Social and Cultural Developments**
  1. Developments or tensions on the labour market, for example in time of crisis, there is less need for labour, hence less need for offices.
  2. Demographical developments, for example aging.
  3. Social developments, for example increased prosperity.
  4. Organizational, for example the way of working and organizing.
  5. Demand change of the client, for example from singular to multiple functions for a broader market.
  6. Sustainability & Durability, for example new energy saving technologies

- **Political Developments**
  1. Law and regulations, for example rigor, complexity or building permits.
  2. Tendering, for example European Tendering regulations.

- **Economical Developments**
  1. Tension in feasibility, for example financial shortcomings.
  2. Financing, for example the municipality can cooperate in making the project feasible.

- **Technical Developments**
  1. Technical innovation, for example shuttle elevators that can improve circulations.
  2. New use by technical innovation, for example ICT-development in the office sector.
  3. Installation innovation, for example when air ducts can be constructed with a smaller diameter then the core in a building can also become smaller.

The main focus isn’t listing up all the different possibilities, but to give a general insight in the kind of development that provoke a dynamic environment wherein developers of buildings and buildings itself should be able to operate. The dynamic environment results in continuously changing demand (requirements, regulations and wishes) of the client and the market.

Development period
Time is a major issue in making the project feasible. The development process of complex projects, takes 5 till 10 years. Huge developments (as mentioned above) can occur during this process that can cause changes and even after realization there will be circumstances that will influence the building.
Time is in direct relation with developments who provoke a necessity of flexibility to build for a buildings lifespan. Time will play an important role in the whole process, because when one wants to respond to developments in time, one should start in the initiation phase. Decisions in this phase shall have huge influence on the design, the use, the maintenance and even the renovation of a building.
Consequences in the building process & product
The Building Process (traditional) decisions about requirements, regulations and wishes which are set in the Program of Requirements (PoR).

“The PoR is a relatively static document in which the client describes the requirements, regulations and wishes. The PoR is a crucial communication method between the sender and receiver. The PoR is intended as a testing tool of quality and costs”.

In the development of buildings all the decisions are beforehand determined in the PoR. According to this document the building will be designed, constructed and delivered. These so called decisions (determined in the PoR) are during the whole process, from initiative till deliverance, of the buildings subjected to developments and changes. Changes in such a process can cause huge delays because the product can not react to these changes. This will for example result in:

- Extra costs above the total investment costs
- Loss of quality, because adaptability of existing components causes a disintegration of the design.
- Annoyance, for all the different parties that are already using the building, actor’s and more.
- Risks, because the development period is from 5 till 10 years a lot of things can change hence causing a lot of uncertainties for the client.

This means that a project sometimes has to start all over again because the demand doesn’t fit in the design at the moment of changes. This is also happening after realization. Most of the building stock can not react on the dynamic environment because they are not designed to, but changes will always occur which mostly end in a higher vacancy risk. This means that by changes in every stage of a buildings’ lifecycle we need to start over again as illustrated in figure 1.

---

Lifecycle focus

There are different approaches to prevent or limit vacancy in the future. Transformation can react on existing vacancy, but it is not preventing it. To prevent we need to start at the initiative phase of building designs. A process approach is needed to develop buildings which can react on the dynamic environment and in this way prevent vacancy of buildings and buildings which are already unfeasible at the start. So this process approach need to be focused on the whole lifecycle of a building/areas. Because of this approach most changes can be solved within every individual project phase. So when major changes appear the design-process doesn’t need to start all over again as is illustrated below.

So we need buildings as dynamic systems which carry the capacity to react on these changes throughout the buildings lifespan. Dynamic system should carry the capacity to accommodate a set of evolving demands regarding time, space & function.
1.3 Problem Definition

According to the problem analysis the following problem is defined:

Due to the constantly changing requirements, needs and wishes of the client/market projects can become unfeasible or vacant during their lifespan.

![Figure 4: Client, Market and Project influence each other](image)

1.4 Aim

The aim of this research is to develop a method (process approach) based on lifecycle focus in order to react on changes during the buildings’ lifespan. By process approach we mean a method of programming & designing including the consequences for people, profit & planet. The process approach is finally developed in the form of a manual which can be used by different actors within the construction industry.

![Figure 5: Control Diagram (de Leeuw, 2002)](image)

To make this clear ‘the control diagram of de Leeuw’ is used. The manual can be seen as the control system which should provide a process approach to design & built for a buildings’ lifecycle. Through this it should be easier to react on changes during this lifecycle. This approach should give an answer to different situations with their own problematic issues, which can be seen as context. They should be presented in such a way that they are user-friendly and combined with a strategic policy as a control unit to be effective. The control unit can be one of the actors within the whole process. All the components in this system work together and influence each other hence evaluating itself.
1.5 Research Questions

Main research question
To fulfill the aim the following main research question is formulated:

- To what extent and in which way can a process approach based on lifecycle focus optimize a building to make it react on changes during its lifespan?

Detailed research questions
To answer the main research question the graduation project is divided in different phases with their own detailed research questions:

Studies
- Which principles based on lifecycle focus do already exist, on which way are they used, in which phase and what are their consequences?
- Which impact do principles based on lifecycle focus have on the way we experience buildings?

These questions will be answered according to literature, case & architectural studies

Forming the Manual
- To what extent are the existing principles based on lifecycle focus useful in redesigning our new process approach?
- What needs to be adjusted in our process approach based on lifecycle focus to fill up the noticed lack?
- What can be improved in our process approach based on lifecycle focus for future research?

These questions will be answered according to research by design & empirical studies
1.6 Result

In this research there will be different results. First of all this research will result in knowledge about already existing principles based on lifecycle focus and knowledge about the way we experience buildings related to lifecycle focus. The principles will be described, analyzed and evaluated. Secondly this research will result in answers about the lack related to the already existing principles and the expectations of the actors within the construction industry.

Finally this research will result into a strategic manual which will provide a process approach based on lifecycle focus to optimize buildings in order to make them react on changes during the buildings’ lifespan. This process approach will be developed according the ‘Action Research’ principle, which means that the process approach should steer the process, consequences and evaluate itself on the basis of gathered information at the end of every project.

1.7 Relevance

Scientifically
This research should contribute knowledge to the departments of Real Estate & Housing and Architecture at the Delft University of Technology. It is a follow up on already existing principles based on lifecycle focus developed in science and practice. Finally this research will result into a strategic manual that will provide a process approach based on lifecycle focus that can be used to optimize buildings in order to react on changes during their lifespan. This research can be used in practice and be a startup for future researches at the Delft University of Technology.

Socially
This research should contribute knowledge to construction industry and society. It is useful for all the actors in the construction industry. More knowledge in lifecycle focus leads to an improvement of design and construction of buildings in relation to changes during their lifespan. This process approach should clarify why some decisions should be taken and what their effect will be on the people, profit & planet. The goal of this process approach based on a lifecycle focus is to tackle the vacancy problem in our society and in this way create a sustainable build environment.

---

3 Action research: is a reflective process of progressive problem solving led by individuals working with others in teams or as part of a “community of practice” to improve the way they address issues and solve problems. Action research can also be undertaken by larger organizations or institutions, assisted or guided by professional researchers, with the aim of improving their strategies, practices, and knowledge of the environments within which they practice.
1.8 Research Design

All the phases within this report are developed simultaneously. The diagram shows all the different processes within the double graduation period. On several points the phases interact.

Research Methodology

Project Definition - From February till June 2009, the research proposal was defined. This provides information about the way the double graduation project is defined and how the end product is formed during the graduation period.

Studies & Forming the Manual - From June 2009 till July 2010, studies were done and the manual was formed. These phases were developed simultaneously and highly interact. The studies provide insight on already existing principles and the way of experiencing buildings related to lifecycle focus. These results are used in forming the manual which is an interaction between forming the process approach and the design of an on lifecycle focused building. The design forms & evaluates the process approach and vice versa.

Manual – In October 2010 the manual is finished. It is evaluated, the main research question is answered and conclusions & recommendations are given. This results in a final graduation report and the manual.
Research Methods & Techniques
In this paragraph an explanation will be given of the main research methods we want to use. The following research methods will be defined: Literature Studies, Case Studies, Architectural Studies, Research by Design & Empirical Studies.

Literature Studies
In the Literature Studies the research will be based on existing principles based on lifecycle focus. These principles will be described including what they do and how they in theory should perform.

Case Studies
In the Case Studies a real life project will be analyzed, in relation to lifecycle focus. In these studies the process and product of this case will be investigated in depth.

Architectural Studies
In the Architectural Studies a research will be done about the way we experience buildings in relation to lifecycle focus. Fundamental issues like identity of buildings will be pointed out.

Research by Design
In Research by Design our process approach will be formed and tested according to the design of an on lifecycle focused HighRise project. The design will evaluate the process approach and vice versa.

Empirical Studies
In the Empirical Studies the formed process approach will be tested by critics from actors in practice. Theories will be tested according to workshops which are simulations of real life projects. The workshop results will evaluate the formed process approach which will help to improve the final product.
PHASE II: STUDIES

Content:
Chapter 2: Literature Studies
Chapter 3: Case Studies
Chapter 4: Architectural Studies
Chapter 5: Results

Discussed research questions:
- Which principles based on lifecycle focus do already exist, on which way are they used, in which phase and what are their consequences?
- Which impact do principles based on lifecycle focus have on the way we experience buildings?
2 Literature Studies

In this chapter principles based on lifecycle focus will be described. These principles are not only related to the construction industry but also other industries.

As described earlier in this report, buildings have to deal with enormous internal and external influences during their total lifecycle. Hence changes have to be done (whether during or after design and construction or on process or product level).

So we need dynamic systems that can offer a solution to these internal and external changes. To be a dynamic system a building needs to be flexible to react on these changes. Many principles are developed in different domains based on flexibility (next to the construction industry, flexibility can also be found in car industry, management structures, etc.). Because of the developments in the construction industry and the community that more and more relates to the individual, the bandwidth of offered principles based on flexibility have grown enormously. Hence the consciousness and need for lifecycle focus has pushed these principles through huge developments.
2.1 Drager & Inbouw (Habraken, 1961)

“Thinking in long terms”[^4].

“Drager en Inbouw” is one of the first principles that has raised personalization and redevelopment in the architecture. It is the idea of Habraken, an inspired way of thinking, focused on the future of buildings. Today, in this dynamic environment and culture, it is more topical than ever. Centralized is how the community relates to the individual and how this relationship is reflected in the built environment.

The Frame (drager) reflects to the collective and has a long lifespan. The Infill (inbouw) reflects to the individual (user) and has a short lifespan. “Drager en Inbouw” should be disconnected in terms of decision-making and technical support. The infill can be changed without changing the bearer. An important aspect in this matter are the installations. These are the main link if the “Drager” can be separated from the “Inbouw” and therefore can provide adaptability.


---

Figure 7 Drager & Inbouw
2.2 Open Building (Habraken & Kendall, 1965)

“New ways of making construction mean new ways of doing business, new services to offer and to be offered and, new relationships among stakeholders”.

The work of Habraken set the foundation for what came to be called Open Building and is later further developed by Kendall. It is based on designing and building according to the analysis of the current requirements and provisions as well as unknown future uses and technical improvements. The method is increasingly applied to medical facilities and follows the theory of system separation.

It is an innovative approach to design and construction that enhances the efficiency of the building process, while increasing the variety, flexibility and quality of the product. In the Open Building perspective, the building is viewed as a well-organized combination of systems and sub-systems, each of which can be carefully coordinated to ensure a better process and product for the homeowner and a parallel positive outcome for the building professionals.

This Open Building strategy is used in the INO Hospital in Bern. The primary structure (facade and bearing structure) was planned and built by one team of architects and constructors, the secondary system (non bearing walls, finishes, technical installations) by another team and the tertiary system (medical equipment) by a third constellation. Three systems were grouped together and form the basis for the theory of the system separation:

- Primary system 50-100 years
- Secondary system 15-30 years
- Tertiary system 5-15 years

Figure 8 Open Building Strategy

---

5 Geraedts, R.P., (2008) Design for Change; Flexibility Key Performance Indicators. TU Delft
7 Imoberdorf, K. (2006) Urban Open Heart Surgery – for the future hospital. The INO project at the University Hospital in Bern, Switzerland. Bern: Itten + Brechbühl
The idea behind the separation of the planning teams was to force them to think from the beginning without limitations. The team for the primary system should not know what was to come, but create a super flexible structure, being able to absorb any medical wish. An open building strategy organizes the project that is based on the expected length of a cluster of subsystems. This is done to prevent other systems in order to optimize conditions to prepare for the long term manageability of the building. This in accordance with the expected changes to reduce the costs of future adaptations. The key to the "open building" philosophy is the recognition of separate categories of design responsibility, and, correspondingly, the distribution of the implementation work.

2.3 IFD Building System (Dutch Government, 1999)

"With IFD Building System the art is to achieve maximum esthetics with a minimum amount of building elements.”

The Industrial, Flexible and Demountable (IFD) Building System can be related to the principles of Open Building by Kendall, which is based on creating different decision levels. These must be independent of each other, so that a decision of a lower level doesn’t affect the higher level. On this way decisions on a lower level can easily be taken. The IFD Building System is based on the same principle.

The Dutch government encourages innovative construction by subsidizing cohesive IFD pilot projects. Industrial building concerns the process-related aspects of production, robotization, mechanization, automation, prefabrication, communication, etc. Flexible building involves products that are made in accordance with customer’s wishes and the possibility to make adjustments when the building is in use. Finally, demountable refers to the sustainability of the building. This program was developed to promote the innovative application of industrially developed and manufactured construction components in the construction and renovation of homes and public utility buildings. IFD building provides an integrated approach to the initiation phase, the design, production and use of buildings, and is characterized by early cooperation between the parties, enabling alignment of the concept, design and execution. The industrial production of components offers increasing opportunities for flexible use. Demountable building enables a separate replacement of components with various lifespans, thereby extending the life of the building as a whole. As such, IFD building is a form of sustainable building. IFD building as a three pronged strategy to innovate the building process: the client (flexible), the manufacturer (industrial) and society (demountable). This is characterized by the following principles: ‘level-thinking’ (building - floor - room - work station), a fixed form and space combined with variable options for the interior, a multidisciplinary design, separate technical systems; dimensioning and nodes; modularity and demount ability.

---

2.4 **Lean Construction (Toyota, 1993)**

"Optimize performance of the production system against a standard of perfection to meet unique customer requirement."\(^{10}\).

"Identify and deliver value to the customer value: eliminate anything that does not add value."\(^{11}\).

Lean construction is like the current practical methods and has the goal of better meeting customer needs while using less of everything. But unlike current practice, lean construction rests on production management principles, the “physics” of construction. The result is a new project delivery system that can be applied to any kind of construction but is particularly suited for complex, uncertain, and quick projects.

"Keep intense pressure for production on every activity because reducing the cost and duration of each step is the key to improvement."\(^{12}\).

"The problem is that production systems just do not work well when every person tries to optimize their performance without understanding how their actions affect the larger web."\(^{13}\).

Lean construction accepts the Ohno’s\(^{15}\) production system design criteria as a standard of perfection. But how does the Toyota system, lean production, apply in construction? The construction industry has rejected many ideas from manufacturing because of the belief that construction is different. Manufacturers make parts that go into projects but the design and construction of unique and complex projects in highly uncertain environments under great time and schedule pressure is fundamentally different from making cars.

The differences in detail flow from a recognition that construction is a project based production where the product is generally a prototype.\(^{16}\)

Lean construction is a “way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value.”\(^{17}\). Designing a production system to achieve the stated ends is only possible through the collaboration of all project participants (Owner, Architects, Engineers, Constructors, Facility Managers, End-user) at early stages of the project. This goes

---

\(^{10}\) Howel, G.A. (1999) *What is Lean Construction*. Lean Construction Institute, USA: Ketchum

\(^{11}\) Idem.

\(^{12}\) The idea of a “physics” of production is borrowed from “Factory Physics”, an excellent text on production management (Hopp and Spearman 1996).

\(^{13}\) Howel, G.A. (1999) *What is Lean Construction*. Lean Construction Institute, USA: Ketchum

\(^{14}\) Idem.

\(^{15}\) Lean production was developed by Toyota led by Engineer Ohno. He was a smart if difficult person dedicated to eliminating waste. The term “lean” was coined by the research team working on international auto production to reflect both the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production


beyond the contractual arrangement of design/build or constructability reviews where constructors, and sometime facility managers, merely react to designs instead of informing and influencing the design\textsuperscript{18}.

Lean construction aims to embody the benefits of the Master Builder concept. Essentially, Lean Construction recognizes that desired ends affect the means to achieve these ends, and that available means will affect realized ends\textsuperscript{19}.

Lean construction supplements traditional construction management approaches with\textsuperscript{20}:

- Two critical and necessary dimensions for successful capital project delivery by requiring the deliberate consideration of material and information flow and value generation in a production system;
- Different project and production management (planning-execution-control) paradigms.

While \textit{Lean Construction} is identical to \textit{Lean Production} in spirit, it is different in how it was conceived as well how it is practiced. The common spirit flows from shared principles:

- whole system optimization through collaboration and systematic learning
- continual improvement/pursuit of perfection involving everyone in the system
- a focus on delivering the value desired by the owner/client/end-user
- allowing value to flow by systematically eliminating obstacles to value creation and those parts of the process that create no value
- creating pull production

\textit{Lean Production} invites a closer look. Certainly the goal of delivering a project that meets the specific customers requirements in zero time sounds like the objective for every project, and the evidence of waste in Ohno’s terms is overwhelming. Waste in construction and manufacturing becomes bigger from the same activity-centered thinking, “Keep intense pressure for production on every activity because reducing the cost and duration of each step is the key to improvement.” Ohno knew there was a better way to design and make things.

Managing Construction under Lean is different from typical contemporary practice because it;

- has a clear set of objectives for the delivery process,
- is aimed at maximizing performance for the customer at the project level,
- designs concurrently product and process, and
- applies production control throughout the life of the project.


\textsuperscript{20} Abdelhamid (2007). \textit{Lean Construction Principles}. Graduate class offering at Michigan State University.
Contemporary Construction Management
The current form of management in construction has the same approach found in mass production and project management. It aims to optimize the project activity by activity, assuming that the clients value has been implemented in the design. Production is managed throughout a project by first breaking the project into pieces, i.e. design and construction, then putting those pieces in a logical sequence, estimating the time and resources required to complete each activity and therefore the project. Each piece or activity is further divided until it is contracted out or assigned to a external actor. Control is achieved by monitoring each contract or activity on the basis of its schedule and budget. The results are translated into a project level reports. If activities or chains along the critical path create delay, efforts are made to reduce cost and duration of the activity that is the cause of the problem or changing the sequence of work. If these steps do not solve the problem, often the schedule is changed working out of the best sequence to make progress which finally will result in additional costs.

Simply put, current forms of production and project management focus on activities and ignore flow and value considerations.

Managing the interaction between activities, the combined effects of dependence and variation, is essential if we are to deliver projects in the shortest time. Minimizing the combined effects of dependence and variation becomes a central issue for the planning and control system as project duration is reduced and the complexity increases. The need to improve reliability in complex and quick circumstances is obvious. New forms of planning and control are required.

Lean Construction as a solution
The first goal of lean construction must be to fully understand the underlying “physics” of production, the effects of dependence and variation along supply and assembly chains. These physical issues are ignored in current practice which tend to focus on teamwork, communication and commercial contracts. These more human issues are at the top of practitioner’s lists of concerns because they do not, indeed cannot see the source of their problems. It is not that these people are stupid, but that they lack the language and conceptual foundation to understand the problem in physical production terms. The development of partnering illustrates this point.

Where Partnering is about building trust, lean is about building reliability. Trust is the human attitude that arises in conditions of reliability. We are not likely to trust one another.
another very long if we do not demonstrate reliability. Reliability is the result of the way systems are designed. Of course people manage systems and in current terms they do a fine job. The problem is that production systems just do not work well when every person tries to optimize their performance without understanding how their actions affect the larger web.

**Lean vs. Contemporary Construction Management**

Companies typically maintain elaborate cost control systems to measure this performance. These systems are the manifestations of the cause and effect theories operating in the company. At the heart of this model the belief is that the crew is essentially independent and that all costs charged to an account arise within from the effort necessary to complete the assignment by the crew.

The lean construction view is different as it views the problem in physical production terms. The crew works at variable rates using resources supplied at varying rates. Matching labor to available work is a difficult systems design problem with a limited number of “solutions.” Lean works to isolate the crew from variation in supply by providing an adequate backlog or tries to maintain excess capacity in the crew so they can speed up or slow as conditions dictate. On occasion, people acting on intuition apply these techniques. Unfortunately neither resource nor capacity buffers reduce the variation in supply and use rates of downstream crews.

These problems are solved by long and predictable runs in the factories. In these stable circumstances managers can predict the work content at each station and shift labor along the line to minimize imbalance. Such factories are mostly dreams that have little to do with construction where we only have some idea of the labor content of activities from previous projects.

People holding current practice dear sometimes to say that they are helpless victims of fate when faced with managing uncertainty on projects. Their view is that uncertainty arises in other activities beyond their control. The lean approach is to assure one should not contribute to variation in work flow and to decouple when one cannot get it under control. In lean construction as in much of manufacturing, planning and control are two sides of the same coin that keeps revolving throughout a project.

- **Planning:** defining criteria for success and producing strategies for achieving objectives.
- **Control:** causing events to conform to plan and triggering learning and replanning.

Lean construction embraces uncertainty in supply and use rates as the first great opportunity and employ production planning to make the release of work to the next crew more predictable, and then it work within the crews to understand the causes of variation. *Where current practice attacks point speed, lean construction attacks variation system wide.*

Under lean, labor and work flow are closely matched when variation is under control and activities de-coupled through capacity or resource buffers when variation is not under control and work content unbalanced. These solutions are directed by the physics of the situation. Where current practice assesses and attempts to control individual
performance, Lean sees the planning system as the key to reliable work flow. Construction is different from manufacturing in the way work is released to the crew. Work is released, moves down the line, in manufacturing based on the design of the factory. In construction work is released by an administrative act, planning. In this sense, construction is directives driven and so measuring and improving planning system performance is the key to improving work flow reliability. Measuring planning system performance reflects our understanding of cause and effect. This is a different mind, a new novel. Once the physics problems at the crew level is understand, all sorts of new issues and opportunities will be seen.

Steps to be taken
The first objective is to bring the flow of work and production itself under control. This effort pays immediate dividends and demands the project delivery system to be changed to a better support reliable work flow. These include changing how work is structured early in the design, organization and function of both the master project plan and look ahead process.

Finally, the expectation is that new forms of commercial contract emerge who give incentives for reliable work flow and optimization at the deliverable-to-the-client level. In this way we move from task to system to organization to contract.

The future has already begun
A pattern is beginning to emerge in implementation. Managers in most companies and on most projects have an inflated view of the reliability of their planning system. This attitude changes once the decision is taken to make assignments to criteria and the results come in. New opportunities are revealed and new demands arise in all directions. Upstream changes typically include changes in the timing and size of deliveries from fabricators. Horizontally, coordination with other specialty contractors shifts from a central controlled push functions to decentralized pull. Downstream, the effect of reliable work flow may be to change the way labor is managed. One contractor now shifts labor between nearby projects because it is possible to predict the actual demand for labor in coming weeks. Hoarding labor is reduced and fewer workers can service more jobs.

Further Research
“Value” is one area of lean that does not rest so directly on some underlying physics. The effort is made to understand how value is created. Lean should help organize and frame the conversation between ends and means so that the implications of early decisions are more explicit. It changes the design process so it will better cope with the contending demands of uncertainty and speed, and respond to the explosion in available technology.

2.5 I3con (European Project, 2006)

"Innovation will only be achieved when it gives value to the user and the environment."

I3CON is a European project, which is part of the 6th Framework Program of the European Commission. I3CON stands for "Intelligent, industrialized, Integrated Construction" and has a duration of four years. At the end of the four years the research results will be demonstrated in a virtual model and a sample project (new project in Madrid, Spain). A total of 26 parties from 14 European countries participate in this project (Figure 9). In I3CON the focus lies on innovation in product, services and process (Figure 10).

Figure 9 Parties related to the I3CON project

Figure 10 Innovation in product, services and process

Intelligent stands for:
• Reduce material
• Self-diagnosis of a building (operational phase)
• Sustainable (future)

Industrialization:
• Adaptability
• Efficiency of the building
• New components and construction

Integration:
• Whole life-cycle of a building
• Integrated building systems

The European construction industry is inherently fragmented with a wide range of professionals, trades and materials suppliers utilized to create a building. This fragmentation is intrinsically inefficient.

The I3CON research project aims to enable the transformation towards the European Construction industry delivering Industrially produced, Integrated processes and Intelligent building systems that will deliver ultra high performance buildings.

But it is not just about construction companies being more productive and profitable; the intention is to create improved life cycle value for the end users where life cycle costs will be reduced by up to 40% with improved flexibility, reduced energy consumption and improved comfort and security.26

The I3con book contains sixteen papers grouped into seven chapters, covering some of the concepts and initial research work carried out within the I3CON project. These seven chapters are:

1. Stakeholder requirements
2. Metrics
3. Services
4. Processes
5. Systems
6. Modeling
7. Demonstration and Training

The seven chapters can be summarized as followed:

1) **Stakeholder Requirements**

*The Sustainability Monitor – the way to a better future*

Key stakeholders in Europe were asked for a vision of the construction industry that would result in extra stakeholder value. From the answers received, six performance criteria (customer orientation, energy management, comfort, flexibility, life cycle costing, and building process) were established for sustainable high performance buildings. In this instance, sustainability refers to harmonising a building’s original design purpose with its actual long-term use. This paper defines these criteria, how they offer increased stakeholder value, and how this approach differs from that currently adopted by the construction industry.

2) **Metrics**

*Performance Measurement*

This paper discusses classification, rating, and confirmation methods for building performance factors and presents a “CREDIT” indicator system arising from an efficiency formula of output / input. Where output is equivalent to the categories of location and architecture, building performance, and real estate business. These categories can be further subdivided. One of the objectives of this paper is to determine the most significant amongst the numerous indicators in these categories. A case study is given as an example.

3) **Services**

*The I3CON Service Engineering Approach - A Modular Approach for Developing New Construction Services*

The I3CON service engineering systematic process was developed specifically for the construction industry and is based upon the idea that problems with services often arise not from implementation but rather from the conceptualization. The process is presented in this paper and can facilitate service innovation in a structured, modular, step-by-step way. The process builds on the idea of the Fraunhofer-Institut Arbeitswirtschaft und Organisation (IAO) modular concept for service engineering which has been used in other industries, and also the Construction Services Engineering Concept developed by GDW. The final version of the approach consists of 5 phases. Each phase contains modules which in turn contain tools. This approach was validated with the I3CON partners using either existing or potential examples.

---

Optimizing Information Exchange Between Building Services and Users
The issue for building services is to get the right information from the building and make it public to the right people and applications. This paper discusses the development of a four step model to find out what information is needed for a safe, sustainable and intelligent building. This model emphasises the stakeholders’ need to collect the right information and delineates the building’s performance indicators.

Configuration of Product-Centric Services
This paper addresses the life cycle cost of buildings in terms of product configuration and solution life cycle management. Configuration of product centric services improves the management and planning of buildings in terms of overall cost and energy efficiency. Only life cycle considerations give enough parameters to plan buildings in terms of sustainability. Companies are moving from development oriented Product Data Management (PDM) towards enterprise wide and collaborative Product Life cycle Management (PLM). Current PLM tools need to be enhanced with solution life cycle management. Modelling service aspects into the product knowledge base demonstrates that an integrated configuration of goods and services is more likely to result in a more optimal solution.

4) Processes

Integral Planning of New Components and Production Methods for BSS Installations
An assessment of construction manufacturing practice. This paper introduces the integrated Pathway Solutions concept. Being a concept characterised by the Off Site Manufacturing (OSM) and services integration principles, the term “Pathway Solutions” deals with the way in which building services are routed through a building. This approach takes advantage of all the capabilities of factory production to address the two aspirations of faster and cheaper buildings. Life cycle reductions are also addressed by seeking new approaches that require less energy to perform the same function, and also by seeking enhanced opportunities for recycling manufacturing resources. The construction industry can apply techniques already exploited in other industries.

Technology Monitoring in the Construction Sector: Industry Requirements
A description of the construction industry’s requirements for monitoring technological developments in order to improve on the planning and integration of these developments and their application in the built environment. This is a key factor for project based construction companies to remain competitive in the operational business. These requirements were collected in a study with the major European construction companies in 2007.

5) Systems

Concept for Overall Building Services Systems Architecture
Building services architecture intended for offices and residential buildings, both when new and renovated, is presented in this paper. This is based on a generic approach that can be specifically refined. Introduces the building services architecture and environment, and then describes the building services systems, the building automation
and control systems (BACS), and location. Concepts are explained and the principal conclusions are reported.

*Building Services and IT Integration Through Enterprise Architectures*

An outline of the development and use of a service-oriented architecture (SOA) for integrating Building Management Systems (BMSs) applications for more effective management of the enterprise. This is not restricted to building management systems but also applies to wider applications in the enterprise infrastructure. Novel architectures that allow for integrating BMSs and supporting building automation and control enable the building manager to have a single point of interaction to integrally control facilities. In this respect, the notion of facilities management is defined similarly to prEN 15221 (2005), European Committee for Standardization (CEN), Facility management – Terms and definitions. This is in contrast to traditionally independent and less flexible systems.

*Integrated Solution for Ventilation and Cooling for Indoor Comfort.*

A combi cooling system i.e. an integrated system for ventilation and cooling comprising the three components of air handling unit (AHU), cooler, and chilled beams (CB) is described in this paper. This system can control the volume of the supply airflow through Comfort Control (CC) and its direction through Flow Pattern Control (FPC). Examples using these control strategies are given. Advantages and limitations of the system are also given. The correct water temperature is essential to avoid condensation and indoor rain. This system can be used for normal office buildings in Nordic parts of Europe and has potential for use in Mid-Europe.

*Energy Consumption: Under floor Heating vs Radiators*

Under floor heating (UFH) and radiators were compared for energy consumption in a reference building and the results are outlined in this paper. The reference building was a dwelling in a multi-storey building in Spain, the calculations for heat loads are also given. It is concluded that the air temperature used in the calculation of thermal loads is different in each system because a different air temperature is required to reach the same operative temperature (i.e. the temperature felt by the occupants otherwise known as comfort temperature). As the air temperature needed in a radiator heating system is higher than in an UFH system, the thermal loads therefore are higher as well. In this reference building the heat loads for the UFH system were found to be 33% lower than the radiator system, this is due to the insulation in the UFH system and the ratio of this additional insulated area to the overall area of the dwelling.

*Thermal Comfort - State of Art*

A review of accepted knowledge relating to thermal comfort and indoor air quality is undertaken in this paper. It notes the current respective regulations and places particular emphasis on Finland and Poland. Local thermal discomfort is also covered. This topic merits more attention in today’s climate, as it remains important to consider and maintain the occupiers’ health and productivity whilst reducing energy consumption. It is concluded that it is still difficult to define thermal criteria despite the number of standards available and the designer must also choose between the numerous methods available for calculating indoor air quality.
6) Modeling

Building Performance Simulation Within I3CON
This paper presents an overview of a new building simulator based on the existing commercial building simulator IDA Indoor Climate and Energy (IDA ICE) from Equa. The simulator is introduced for the inexperienced reader and the benefits and improvements are elaborated upon for the more experienced. This enhanced simulator includes the simulation language called Modelica.

Intelligent Catalogues
This paper looks at the automation of the design and operation of buildings through the use of intelligent catalogues. This is particular to the early design phase and applies rule-based logic that handles inter-part dependencies as opposed to parametric generation of geometric shapes. This approach is expected to decrease the user’s input into the routine design element and improve design simulation accuracy, arriving at a more satisfactory conclusion when taking into account multiple design criteria.

Ambient User Interfaces to Building Data
There is a need for building related information to be communicated to operational services personnel through highly intuitive interfaces, thus a minimal interaction overhead can be achieved. This paper considers the development of these integrated ambient user interfaces, including methods and tools for their implementation for operative and building service applications. Such interfaces are to exploit a variety of modalities, including visual and audible ones. It is stated that a multilateration method for target tracking with use of active RFID tags with a maximum speed constraint for moving targets proves to be a viable low-cost solution. Future improvements should focus on following both hardware and software issues.

7) Demonstration & Case Studies

Demonstration of RTD Results in Real-Life Buildings
The authors of this paper are from EMVS, this is a company that develops social housing in Madrid. EMVS has provided the I3CON project with two real buildings in which the rest of the I3CON partners can demonstrate what they are researching and developing. There are two types of buildings used as demonstrators, a “New Building” Demonstrator and a “Retrofitting Building” Demonstrator. This paper discusses the technologies to be demonstrated in these buildings and their possible uses in the future.

Training Industrialised, Integrated, Intelligent Construction Training Concept
This paper details the I3CON European research project “training concept”. This training concept aims to establish a set of modules (subject areas) to provide education and training in the construction sector. The modules were identified, classified and prioritized amongst key training and education areas from the same project. A review of latest training techniques was also performed. The training concept is to be implemented through a combination of these techniques. These modules are to be piloted in order to test and evaluate their content before adoption by the European construction industry.
2.6 Sustainability in perspective (Draaijer+Partners, 2009)

"Don’t formulate a Program-of-Requirements. A Program-of-Requirements is too traditional and in the document all the requirements are fixed while the world changes constantly."  

On the basis of interviews with stakeholders different themes have emerged.

The six main themes which have emerged from the interviews are:
- Customer-orientated
- Environmental Management
- Lifecycle costs
- Process Forms
- Flexibility
- Comfort

Figure 11 The six themes form ‘Sustainability in perspective’

Customer-orientated

Key-words: User-centred, demand, critical, organizational objectives, choice, catalog, ambitions, workshops, Wish Living, professionalization of the market, housing consumption Article

The construction industry is currently mainly supply driven. There should be more focus on the customer and their needs. The first step is to consider buildings as consumer products, which are subject to trends. Finding out what these trends are should be a main focus. Making a better match between customers (users) needs will influence the users satisfaction and thus might be satisfied longer with the building, creating a higher level of durability. Some examples of customer orientation, in relation to a building is giving the users insight in what they can choose, for instance having a catalogue with which an “à la carte” building can be created, based on the customers preferences. And furthermore, it is important to ‘educate’ the customers on what they can demand. So not only the choices should be offered, but also insight on the financial and technical consequences of their choices, or the level of sustainability. Another part of customer orientation is to define the core of the problem definition, and cover all aspects, including external factors, such as location, finance, etc.

Environmental Management

Key-words: Environment, wind energy, solar energy, soil heat and geothermal, climate change, ecology, natural resources, Pollution, Heating in the floor, CO2 emissions, Cradle 2 Cradle, dust, erosion, waste, depletion, energy efficiency, sustainable energy, lifecycle focus and areas

---

Environmental management involves all environmental aspects in relation to buildings, such as energy usage and efficiency, focus on climate changes (and solutions to solve this), usage of materials (in relation to availability of resources) and ecology (e.g. the quality of areas in which a building stands through usage of green areas (creating park like environment). The environmental performance must be looked at in a broad perspective (see the items stated above), and also in relation to financial performance. This is also enclosed in the Cradle 2 Cradle theory by Michael Braungart and William McDonough, which handles the main aspects of People, Profit and Prosperity in their environmental theory. An example of environmental management in relation to spaces is having a Building Information System, which gives information of what the energy usage is. Not only smart solutions during the construction are found to save energy, but also during the operational phase of the building by educating the end users on how to save energy while using the building. Another example of environmental management is influencing the quality of areas by looking at the ecology of the surroundings of a building. For example: creating a park around a building influences the (aesthetical) quality of a building and makes it more pleasant. But a very sustainable building that is empty because of its social insecurity environment, is of course not sustainable at all.

**Lifecycle Costs**

*Life cycle, integrated, investment, operating costs, housing expenses, revenues, valuation, feasibility, performance, long-term, awareness, financial, investor, exploitation focused design, Total Cost of Ownership*

The financial aspects of buildings are currently mostly considered only on investment basis. Important is to consider buildings for their total life cycle and the accompanying costs. Some measures (e.g. for energy saving) can lead to higher initial costs, but will save costs during the use of buildings. For example, having solar panels might require a higher investment, but saving energy or even producing more energy then a building needs during the use of buildings lead to lower exploitation costs. Therefore the total life cycle of buildings must be considered.

**Process Forms**

*Trust, cooperation, risk, defragmentation, construction, responsibility, liability, joint and integral, (performance)contracts, tender forms, vision, life, design*

The traditional way of managing projects in the construction industry is to focus on construction time, -costs, etc. But a new way of organizing the building process is demanded to create extra value. This item of the building process is one that crosses through all the 6 themes. For instance: reasoning from the total life cycle of buildings, can result in that it is useful to involve financial organisations (that own and maintain buildings) in the design phase of a project: this knowledge about the exploitation phase is inserted in the design. Or customer orientation might lead to involving end users in the design of buildings, through use of catalogues with which they can design their own house.
Flexibility

Strachable buildings, new wishes, new user or new use, partitioning, adaptabile product to diverse wishes, choice, flexibility, re-use, multifunctional, functional flexibility, scale, adaptability, modularity, future-proof.

The level of flexibility of a building is important in relation to the changed use of buildings, or change of users, which have different demands. The higher the uncertainty about what the demands will be in e.g. 10 years, the more profit you will have if buildings or spaces are flexible. There are several ways of creating flexibility in buildings for example: creating adaptability; having a building that can easily be changed when needed. Or over-dimensioning buildings: for instance designing building systems that have a higher capacity then needed, because of potential change in use. Or dimensioning the floor height so that it can be used for any type of function (office, residential, etc.). This leads to lower costs of changing a building when the demand is different.

Comfort

Perception, color, temperature, feeling, psychology, convenience, individual adjustable indoor, design, productivity, 'healing environment', satisfaction, acoustics, intelligent systems.

The comfort (performance) level of buildings and spaces relates to the internal environment (temperature/ air quality/ etc.), the design (e.g. comfort level of furniture), and the user-friendliness of buildings (easy to use = comfortable). It also involves the consequences of the internal environment, such as productivity, which mainly applies to office buildings: an uncomfortable indoor environment in the office could influence the productivity of the related workers. Another example is comfort in hospitals: studies have been made of the influence of indoor climate & design in hospitals and how it influences patients in their healing process.

All the objectives described above can be seen as a way to create value for the users/ owners and clients.
2.7 Biomimicry

We are now more than ever facing the biggest challenge of our century. We are a part of a brilliant planet, surrounded by geniuses. We need a way to remind our self’s those geniuses and to somehow meet them again. We should be in touch with this incredible models, this elders that have been on this planet far, far longer than we have and hopefully with their help we learn to live on this earth and on this Home that is ours but not ours alone.  

Biomimicry is the examination of nature, its models, systems, processes, and elements to emulate or take inspiration from in order to solve human problems. The term biomimicry comes from the Greek words bios, meaning life, and mimesis, meaning to imitate. Humans have always looked to nature for inspiration to solve problems. One of the early examples of biomimicry was the study of birds to enable human flight. Although never successful in creating a "flying machine", Leonardo da Vinci (1519) was a keen observer of the anatomy and flight of birds, and made numerous notes and sketches on his observations as well as sketches of various "flying machines." The Wright Brothers who finally did succeed in creating and flying the first airplane in 1903, also derived inspiration for their airplane from observations of pigeons in flight.

Otto Schmitt, an American academic and inventor, coined the term biomimetics to describe the transfer of ideas from biology to technology. The term biomimetics only entered the Websters Dictionary in 1974 and is defined as "the study of the formation, structure, or function of biologically produced substances and materials (as enzymes or silk) and biological mechanisms and processes (as protein synthesis or photosynthesis) especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones." Biomimicry is defined as a "new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems." Benyus suggests looking to Nature as a "Model, Measure, and Mentor" and emphasizes sustainability as an objective of biomimicry.

Nature can teach us about systems, materials, processes, structures and aesthetics (just to name a few). By delving more deeply into how nature solves problems that we experience today, we can extract timely solutions and find new directions for our built environments. As architects, we can benefit from biomimicry to make buildings better by pushing for more natural, integrated, effective and healthy solutions. We also need to take a look at the role aesthetics plays in nature – with the way function and form so synergistically merge. Perhaps this is a way for buildings to harmonize with nature in renewed ways – making built environments more environmentally sound and healthy for occupants.

---

30 Benyus, 1997
3 Case Studies

In this chapter two projects will be analyzed, designed & constructed according to the Solids principle of Stadgenoot which is based on lifecycle focus. In these studies the process and product of these cases will be investigated in depth. The information is gathered according to literature, drawings and interviews with key participants of Stadgenoot; Mr. Bijdendijk, Mr. Roelofs and Mr. Doomen.

3.1 Concept
'A city within a building'

Solids are a new construction concept creating durable buildings which can react to the changes of users during their lifecycle. The idea is the result of a perspective with regard to buildings and the people who live/work in them. Tenants are completely free to choose how they want to use the space for living or working. They are in any way free to shape or form the infill. This makes the Solid become a mix of different functions. Each building could practically accommodate an entire city, acting as ‘a city in a building’. The first Solid is currently under construction in IJburg, and more are soon to follow in Amsterdam. In conjunction with Kristal Property Development, Stadgenoot develops these buildings. These Buildings are inspired by the monumental classic buildings and modern architecture.

Inspiration
In 1983, director Frank Bijdendijk of Stadgenoot, made acquaintance with Tetterode squatters and their ideals. For them living, working and recreation were inseparably linked and all three were conducted within the confines of one building. They were people with a variety of different desires and objectives who thrived on autonomy and the freedom to do as they pleased with their personal space. They were very consequent in dividing up and designing their own spaces to suit their needs. The result of their ideals was Tetterode, a beautiful building that, to this day, still houses a large variety of people and jobs under one roof. Another source of inspiration was the monumental canalside buildings that have fulfilled a whole range of functions throughout the centuries, for example, as warehouses, residential houses, offices or shops. They are beautiful buildings with which people from Amsterdam feel a strong connection.

These were two good examples of buildings that accommodate the changing demands that will be placed on them over time. Furthermore, they are very special because they characterize the city and people feel attached to them.

Philosophy
In their philosophy Solids needs to accommodate the wishes of both residents and users. Keeping in mind that people and their requirements are constantly changing. These Solids have two key characteristics: versatility and homeliness.

With versatility they mean building a structure that can adapt the ever-changing demands placed upon it. Buildings that make it possible to perfectly accommodate people and their various and changeable needs.
Homeliness is synonymous with the quality of a building. In their belief people want to be able to establish an emotional attachment to the house, to identify with it. A great sense of homeliness is realized by means of the facades and the meticulous details. All Solids are built using materials that optimally stand the test of time.

3.2 Identity & Usability
‘The user decides what the best is’

With Solids, the interior and exterior walls are owned by different parties. The principle is based on an investor (Stadgenoot) which owns the main structure of the building and determines the identity of this building. The tenants are the owners of Solid interiors and their identity. Stadgenoot charges a basic rent for usage of the area. Everybody designates their particular use for the premises in accordance with guidelines agreed between Stadgenoot, the council and residents organizations. Freedom of purpose means that the users may decide whether they will live or work in a Solid, or both. This decision are not related to the owner of the Solid or determined by a zoning plan. Tenants can do anything: start a business, combine living and working, or set up a hotel, office, family home or loft. Solids are provided simply as an outer shell, and the users design the inner shell (interior layout) to suit their taste.

Individual units
The individual units are separated by well-isolated walls on places determined by m2 that a user wants to rent. Differences in rentable areas are based on the grid system which relates to the window system (daylight entrance). Each unit has a door and a shaft containing connection points for electricity, water, ventilation and drainage. The tenants are responsible for the interior design and structure of their unit. This includes factors such as interior walls, installation of a bathroom, kitchen and electrics. They are also responsible for their flows of installations to the connection points in the core of the Solid.

If a tenant decides to leave a Solid, he can sell the interior materials to the next tenant. Moveable walls, floors and electrics are useful for this purpose. This flexibility will make it easier for all the users to expand, shrink or redesign the premises, if desired. Moving the interior equipment/materials can be done through the windows or the elevators in the core if the dimensions mach.

Auction
The rent of a tenant is arranged during an digital based auction and relates to the size/price of the rental space. The minimum floor area of a Solid unit is 90 m2. Via an online rental system a tenant indicates how many square meters he wishes to rent and the price he wants to pay.

As a housing association with their social responsibilities, Stadgenoot believes that the Solids are for everybody. This is one of the conditions of the auction. Solids are not part of the public rental sector, which cannot apply for housing benefit. Instead of this, a personal discount is available, based on the income of people.
3.3 Feasibility

‘Optimizing by value needs a total different way of thinking’

An investor is used to divide the estimated first year rent by the activated investment costs (return on investment). The result of this calculation is the so called Gross Initial Yield (GIY). For example the GIY for residential functions is lower than for offices. This is caused by different risk profiles. Solids are constructed for a large market because of the possibility of different functioning. When aiming on a larger market the risk of vacancy becomes lower. In this case the GIY for different functions become the same. This means that Solids can be optimized according to the rent and the investment costs. A lower GIY with similar market prices means an additional fee used for the general investment, which decides the feasibility of Solids.

The same calculation can be made looking at the total lifecycle of Solids using the net present value (NPV) to be even more secure. Stadgenoot uses a lifecycle of 50 years for the buildings calculations. Looking at the market prices Stadgenoot predicts an average rent of 10 euro/m² a month (social housing included). The current generic risks of functions differ with a minimum of 6% for social housing and a maximum of 7.25% for offices. As explained before the Solids generic risk equals the lowest one (6%). So using the investment costs, estimated exploitation costs and estimated average rent the internal rate of return can be calculated which needs to be at least 6% to make a Solid feasible. Other benefits can be noticed because of their flexibility in less cost of transformation, maintenance and the fact that the lifecycle of the structure can be even more then 100 years instead of 50.

As explained before the investor of Solids is Stadgenoot as a housing association which will have the building in their property for the whole lifecycle. Other people can invest indirectly in Solids by buying shares which makes us to come to the following conclusion. Solids are feasible for active investors (housing associations, government, and so on) because they are not focused on short time investment periods. For the passive investors (share holders, organizations, and so on) it’s more beneficial to buy shares from these active investors instead of investing in projects like the Solids because they are interested in short investment periods.
3.4 Analyzing the Projects

Solid 1 & 2
In IJburg, a variety of Solids are under construction with a total floor area of 40,000 m². On Haveneiland-West, in collaboration with Kristal Property Development, Stadgenoot is developing a design by the Austrian architect Dietmar Eberle. Areas can be hired of 90 m² and above. The conditions of this location are suitable for as well residential functions and offices because of the accessibility. There are easy accessible through the highway and the centre of Amsterdam.

Solid 1 and 2 have a classical/monumental character. An arcade connects the various parts of the building among each other and the entrance halls are invitingly regal. On the façade there will be an eye catching clock, which will give a dignified greeting to all who enter IJburg. The interior of the building can be arranged in a countless number of ways. Various layouts can be employed on each storey (a floor area of between 360 m² and 480 m²). The total Gross Floor Area (GFA) will be around +/- 10,000 m². All kinds of establishments can be arranged around one central point (the core), such as shops, restaurants, businesses and housing. In the analyzed drawings below the dimensions, installation flows and appearances of the buildings are illustrated.

Figure 12 Appearance Solid 1 & 2
Figure 13 Typical Plan & Section Solid 1 & 2 (drawings on scale can be found in the appendix)
Solid 11
In Amsterdam Oud-West, Stadgenoot is developing 7000 m² of Solids in conjunction with Kristal Property Development. Areas can be hired of 90 m² and above. The conditions of this location are suitable for both residential and offices functions because of its accessibility. The location is situated between the ring road and the centre of Amsterdam.

Solid 11 will be an alluring construction, with an entrance hall on the ground floor and walkways leading to different storeys. This Solid is design by the English architect Tony Fretton. Each wing offers at least 24 different locations in which a front door can be placed. The large column free areas and the small number of load-bearing points allow a large degree of flexibility to the interior layout. Five shaft areas will be created on each wing for drainage and electricity, gas and water supplies. This means that a shaft will be available no matter how the layout is designed. In the drawings below the dimensions, installation flows and appearances of the buildings can be seen.

Figure 14 Appearance Solid 11
Figure 15 Typical Plan & Section Solid 11 (drawings on scale can be found in the appendix)
Conclusions
Analyzing these projects determines that both projects are horizontally flexible in the residential and office function. For the dimensions of the floors the offices are decisive for the floor height and the residential functions are decisive for the depth (minimum daylight entrance). For the dimensions of the installation shaft the offices are decisive in air flows and the residential functions are decisive in water and gas flows.

To offer flexibility to the smallest unit the installations shafts are divided in a fixed part (situated in the cores) and flexible part (installations for the infill) which can be linked to every unit in the building.

The appearances of the buildings are both in style of their surroundings and designed according to the homeliness philosophy; using materials that optimally stand the test of time. So in the Solid the façade is designed for the total lifespan of the building. But the main question remains that everything changes so why should the façade stay the same. Even the canalside houses which are now called monumental buildings don’t fulfill the minimum required floor height, depth, and daylight entrance of the current time. At the end a monument becomes the imprisonment which the infill has to deal with.

Missed opportunities can also be found in the way the floors are constructed as fixed. Vertical flexibility isn’t possible in the Solids. What if a tenant wants to hire a certain amount of square meters divided on three different floors which need to be linked internally. Vertical flexibility can offer quality to the different functions within the building.

Another important fact is the way sustainability is implemented in these projects as figured out in the interviews. They are using an Aquifer Thermal Energy Storage and the building is CO² neutral which is sustainable on this moment. But if the Solid is developed for 100 or 200 years than we can’t notice the lifecycle philosophy in the way the sustainable measurements are implemented in these buildings. What today seems to be sustainable isn’t sustainable tomorrow so the building should provide a ground in which sustainability can evolve during the buildings lifespan.

34 Koolhaas stated: “the stronger identity, the more it imprisons, the more it resist expansion, interpretation, renewal, contradiction.” See Chapter Architectural Studies.
4 Architectural Studies

In this chapter a research is done about the way we experience buildings related to lifecycle focus. HighRise is used as an example for these architectural studies.

“The Generic City is the city liberated from the captivity center from the straitjacket of identity. The generic City breaks with this destructive cycle of dependency: it is nothing but a reflection of present need and present ability. It is the city without history. It is big enough for everybody. It is easy. It does not need maintenance. If it gets too small it just expends. If it gets old it just self-destructs and renews. It is equally exciting or unexciting everywhere. It is ‘superficial’ like a Hollywood studio-lot, it can produce a new identity every Monday morning. The Generic City is not only multiracial but also multicultural. The Generic City is on its way from horizontality to verticality.”

Dynamic system are carrying the capacity to accommodate a set of evolving demands regarding time, space & function. So dynamic systems should also be a reflection of present need and present ability.

According to Koolhaas it seems that people think, convergence is only possible at the price of shedding identity. That is usually seen as a loss. This chapter is about identity in relation to lifecycle focus: the way we experience flexible buildings. This will be an important factor the development of a process approach based on a lifecycle focus.

---

4.1 Form vs. Function

On the basis of their functioning, buildings can be categorized in mono-functional & multi-functional buildings. The mono-functional building can be defined as mainly one function within a single structure. The combination of multiple functions within a single structure can be defined as a multi-functional building. These functions can be related to form in different ways.

**Mono-functional office buildings**

When looking at mono-functional office buildings, we can start with the first HighRise ever build. The Home Insurance Building was constructed in 1984 and is a good example of a mono-functional office building. The building had a rectangular shape with a central core in order to allow maximum daylight in the building. The form of this HighRise was defined by the dimensions of its plot. The office function was poured into this form.

The Seagram Building is located in New York. The layout of this HighRise consist of a square in which the core is placed on the back side of the building. The plan is designed to allow maximum daylight entrance hence all the distances to the façade are minimized. It is made following the principles of ‘Form follows Function’.

“It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function. This is the law.”

**Figure 16**

Home Insurance Building, optimized by plot

**Figure 17**

Seagram Building, optimized by function

---

To Sullivan, “function” didn’t mean merely “utility” or “pragmatic use.” Instead, it meant something like “life force.” His “form follows function” dictum expressed a kind of essentialist vitalism. The “essence” of a thing in nature (an eagle, a cloud, a river) is its life force. This life force results in the outward form of that thing. In Sullivan’s own words, “Unceasingly the essence of things is taking shape in the matter of things.” 37 Form follows function is one of the long-standing slogans of modern architecture. Its use was pioneered by turn-of-the-century skyscraper architect Louis Sullivan, complemented by Adolf Loos’ 1908 assertion that ‘Ornament is crime’, adapted by Frank Lloyd Wright and adopted by Modernists and Bauhaus designers such as Mies van der Rohe (‘Less is more’), Walter Gropius etc. Originally meant to be defiantly honest (let the form of a building or product result from its function) and no more and anti-style, it eventually evolved into yet another set of un-interrogated conventions, and is now being both challenged and re-worked.

The Petronas Towers are located in Kuala Lumpur. In comparison to Home Insurance Building and Seagram Building the floor plan of this HighRise is created through complex repetition of a basic figure which shows great respect for the Islamic culture. The two towers taper on their way up hence all the floor plans have different dimensions.

Concluding mono-functional office buildings, at the beginning the plot defined the form and the function was poured into this form. Later on this changed tremendously introducing the Modernism into HighRise. Form follows function was the fundament of this typology. HighRise Buildings, as the Seagram building, were optimized according to the standards of that function in that particular period. Later on it could be different also by introducing challenging geometries. For example looking at the Petronas Towers a symbol for the Islamic culture was used to set up the basic plan. It seems that the office function could adept itself into this or any other form.

Mono-functional residential buildings
When looking at mono-functional residential buildings, we can start with the Lake Shore Drive Apartments. This HighRise is a good example of a mono-functional residential building. The building has two identical towers with a rectangular shape. Eight apartments are situated around the central core. The grid shapes the apartment layouts with their own width and depth. The form within this HighRise is optimized according to the function.

The Lake Point Tower was also constructed in Chicago. In comparison to Lake Shore Drive this HighRise has a organic form but with less variety of apartment units. Nevertheless all the distances from the corridor to the façade are more or less the same. The clover-leaf shaped tower has a triangular central core. This shape allows a maximum daylight entrance with a minimal footprint. The function was optimized according to the clover-leaf shaped form.

Highcliff & The Summit is a residential tower in Hong Kong. In comparison with the Lake Point Tower this HighRise has also a organic form but with a high variety of apartment units. All the distances from the corridor to the façade differ. The layout of this HighRise consist of two ellipses that are shifted into each other. The function was optimized according to the ellipse shaped form.
So the same conclusion, as mentioned with mono-functional office buildings can be drawn for the mono-functional residential buildings. Both mono-functional residential and office buildings are a combination of the form and function. Sometimes the form is optimized on the basis of the function and vice versa.

**Multi-functional buildings**

When looking at multi-functional buildings, we should start with Downtown Athletic Club. This HighRise is the apotheosis of the Art Deco skyscraper aesthetic, because each floor is devoted to a different function. The main idea was to make every floor represent a total new world. The buildings two major functions are the athletic club and hotel. The athletic club in the lower portion of the building is comprised of single and double height rooms containing billiard and card areas, squash and handball courts, a putting green, a bowling alley, a gymnasium, swimming pool and baths. The Hotel in the upper portion is organized around the perimeter of the building. The rooms vary in size as the tower floors diminish in area. Restaurants, kitchens and lounges, located in the intermediary zone of the building, are shared by both the club and the hotel. All these different functions require different floor plans. These different function with each their own requirements are made possible because of the buildings basic rectangular form with a irregularly placed setbacks, creating the impression of tree-rings. This is not to be measured in terms of the contemporary comparison with the classical tripartite division into base shaft and capital of Beaux-Art aesthetic. The setbacks create a diversity of floor plans which make different functions possible within the same building.

![Figure 22 Downtown Athletic Club, optimized by function](image-url)
The John Hancock Centre is a multifunctional HighRise in Chicago. Because of its tapering shape it makes a kind of functions possible. Functions that need more square meters and less daylight are situated in the lower part of the HighRise and functions which require more daylight and less square meters are located in the higher part of the HighRise. Again we can notice that the form of the HighRise allows the different functions to exist as we have seen in the Downtown Athletic Club. The functions are optimized by the tapering iconic form.

Turning Torso is a multifunctional HighRise in Malmo. In comparison to Downtown Athletic Club and John Hancock Center this HighRise has a organic form with only two functions namely: apartments and offices. The main difference between these and the other two multifunctional HighRises is the fact that Turning Torso integrates two total different function within the same floor plan. The functions are optimized according to the same form.

In multi-functional buildings the form and ‘functioning’ (more functions) instead of function are optimized among each other. Sometimes the form is optimized on the basis of the functioning and vice versa.
4.2 Form & Function vs. Identity

Form & Function both relate to the identity of a building. As noticed in the analysis coming to a design is an interaction between form and function. Following strictly the function means a form which is optimized to that function and vice versa.

Looking at the analyzed buildings we can identify another important factor: we need to make a distinction between two categories of identity, namely: outer and inner identity.

Outer identity is conceptual formed by the surrounding area of a building. Functions can affect the public space but are not in direct relation to it. The outer identity can be seen as the face of the building towards the outside world as a part of the public realm.

Inner identity is conceptual formed by the function of a building. The public space can affect the function but are not in direct relation to the inside. The inner identity can be seen as the way we experience spaces related to a particular function.

Designing means finding the optimum between these inner and outer identity.
• Focusing more on the outer identity, the more it imprisons the inner identity.
• Focusing more on the inner identity, the more it shapes the outer identity.

Finally the form determines the basics for both identities in a building. With the restrictions of the form an inner identity can be formed for a particular function and an outer identity can be formed towards the outside world.

Figure 25 Outer & Inner Identity
How can the form of a lifecycle focused building be defined, which can last for 5 or even 100 years? 

“Thinking about users means thinking of buildings as spaces, their outsides as boundaries to spaces. Space is to live in. Objects are frozen thoughts.”

Focusing on the form related to the inner identity is focusing on functions. Functions are designed for a particular moment on the basis of requirements in that period of time. The function within a building is not a static snapshot but changes throughout the lifespan of a building. Everything changes, for instance, we are working and living different as we did 50 years ago and shall keep changing on our way in to the future. Functions should have the ability to evolve hence inner identity should have this possibility. A building should provide a shell for the total lifecycle of a building which will further grow its soul because of its possibility of evolving.

“The building serves merely as a framework for individual uses and no longer as a shell with a precise content. Architecture no longer has the task of developing scenarios, of manifesting values, planning can only limit life processes. Form is thus no longer the representation of a specific function, but is a direct translation of highly diverse, mixed functions.”

As mentioned before focusing on the form related to the outer identity is focusing on the public space. Christopher Day is referring to history. The outer identity should be designed following dearness.

“Soul-sustaining environment isn’t just eco-by-product. It’s vital for sustainability. Places of beauty, especially those we’ve taken part in making, we value. What we value, we maintain and protect. Value is the root of longevity. Building and place longevity give durable roots to our surroundings. These give society a stable framework.”

On the other hand Koolhaas is referring to the present referring to the outer identity. An identity can be obtained through time and not on a particular moment. So it is very difficult to design a outer identity for a buildings lifespan.

“Identity is like a mousetrap in which more and more mice have to share the original bait, and which, on closer inspection, may have been empty for centuries. The stronger identity, the more it imprisons, the more it resist expansion, interpretation, renewal, contradiction.”

An outer identity designed for the total lifespan of a building always limits the evolution of the inner identity. So both identities should be created in such a way that they allow each other to evolve. All buildings are predictions and predictions are mostly bound to be wrong, so also both identities are bound to be wrong. With the possibility of evolving buildings’ can optimize an inner and outer identity through their total lifecycle.

---

5 Results

In this chapter the answers of the literature, case and architectural studies will be defined. Answers are given to the first two detailed research question.

Detailed research question 1: Which principles based on lifecycle focus do already exist, on which way are they used, in which phase and what are their consequences?

For this research six principles based on lifecycle focus in and outside the construction industry through the last decades are used namely:

1. Drager & Inbouw (Habraken, 1961)
2. Open Building (Habraken & Kendall, 1965)
3. IFD Building System (Dutch Government, 1999)
4. Lean Construction (Toyota, 1993)
5. I3con (European Project, 2006)
6. Sustainability in perspective (Draaijer+Partners, 2009)
7. Biomimicry

These principles mainly focus on technical, organizational, functional, architectural, etc. aspects of flexibility and sustainability. They lack in a holistic process approach towards lifecycle focused in buildings which embodies the process from initiative till demolition.

For this research two projects are analyzed which are designed & constructed according to the Solids principle of Stadgenoot which is based on lifecycle focus.

- Solid 1 & 2, IJburg
- Solid 11, Amsterdam Oud-West

Solids are a new construction concept creating durable buildings which can react to the changes of users during their lifecycle. Tenants are completely free to choose how they want to use the space for living or working. They are in any way free to shape or form the infill. This makes the Solid become a mix of different functions. Each building could practically accommodate an entire city, acting as ‘a city in a building’. The first Solid is currently under construction in IJburg, and more are soon to follow in Amsterdam. But these buildings lack in three things namely:

- The façade is constructed as monumental/fixed which isn’t flexible
- The solids are only horizontally flexible and not vertical which can offer more quality to the inner functions
- Sustainable measurements are snapshots at t=0, which can’t evolve during the lifespan of the building.

These three issues will become more and more important during the lifecycle of the building and need to be taken into account.
**Detailed research question 2:** Which impact do principles based on lifecycle focus have on the way we experience buildings?

*For this research the identity of on lifecycle focus HighRise projects are analyzed. Identity can be categorized in two groups namely:*

1. **Inner Identity:** The inner identity is conceptual formed by the function of a building. The public space can affect the function but is not in direct relation to the inside. The inner identity can be seen as the way we experience spaces related to a particular function.

2. **Outer Identity:** The outer identity is conceptual formed by the surrounding area of a building. Functions can affect the public space but are not in direct relation to it. The outer identity can be seen as the face of the building towards the outside world as a part of the public realm.

Designing means finding the optimum between these inner and outer identity.
- Focusing more on the outer identity, the more it imprisons the inner identity.
- Focusing more on the inner identity, the more it shapes the outer identity.
PHASE III: FORMING THE MANUAL

Content:
Chapter 6: Developing the process approach
Chapter 7: Implementation into design & manual
Chapter 8: Results

Discussed Detailed Research Questions:
- To what extent are the existing principles based on lifecycle focus useful in redesigning our new process approach?
- What needs to be adjusted in our process approach based on lifecycle focus to fill up the noticed lack?
- What can be improved in our process approach based on lifecycle focus for future research?
6 Developing the Process Approach

In this chapter the development of the process approach will be described. It will start with the aim of the research and end with the final draft of the process approach.

6.1 Aim

As already discussed in the project definition the aim of this research is to develop a process approach based on lifecycle focus in order react on the dynamic environmental changes and in this way reducing vacancy of buildings to a minimum. This process approach should also offer possibilities for buildings to become feasible which are already unfeasible at the start. So this process approach needs to focus on the whole lifecycle of a building. By process approach we mean a method of programming & designing including the consequences for people, profit & planet.

This process approach must offer the ground for changes to be solved within every individual project phase. So when major changes appear the design-process doesn’t need to start all over again as is illustrated below.

![Figure 26 Changes in a process approach based on lifecycle focus]

So we need buildings as dynamic systems to react on these changes throughout a buildings lifecycle. ‘Evolving Buildings’ is our definition we give to such dynamic systems.

“Evolve: To develop or cause to develop gradually”

The diagram illustrates the concept of ‘Evolving Buildings’. The diagram illustrates a conceptual frame in which any program fits. The frame also links the different functions among each other. The philosophy is the fact that every function is replaceable.

![Figure 27 Concept of an Evolving Building]

- Yet, how can ‘Evolving Buildings’ react on changes throughout a buildings lifecycle?

---

42 Van Dale Dictionary
6.2 Flexibility

"Flexibility is the power to react to unexpected circumstances. This means circumstances of which we reasonably can expect that they can appear, but we are uncertain about the time of appearance and in what extent."

"Flexibility" is a broad concept, even if it’s defined to be flexibility in the construction industry. Flexibility is used as a container concept for all that can change and adapt. Because of the multitude of terms related to flexibility the significance seems to fade. Eventually, all variations on the same concept of flexibility will achieve for the user and the developer more options and more choice. How this choice is reached and the degree of freedom is different in concepts of flexibility.

Flexibility can be translated into the product and the process. So there is a difference between Product-Flexibility and Process-Flexibility.

Product-Flexibility

"Product-Flexibility is in an interrelation with the spatial and technical appearance of the product."

Product Flexibility can be seen as the flexibility that a product has. This product can be a separated element. In the context of this graduation project the final design of the HighRise building can be seen as the product. A flexible product is by means of a building that may undergo changes during the entire lifecycle. The amount of possible flexibility with this definition is still substantial. There are a lot of different ways of how one can perceive flexibility. Moreover, it can for example be related to:

- horizontal or vertical flexibility;
- horizontal or vertical extendibility;
- horizontal or vertical demountable;
- positioning of the core;
- how to arrange the logistics

When the product needs to be flexible, the process should automatically steer the flexible design starting from the initiative phase. Hence the possibility remains to take decisions and choices in a later stage.

Process-Flexibility

"Process-Flexibility refers to flexibility in the decision making process. For example, the decision-making within organizations and which is related to the primary production or core business. Process-Flexibility also covers the development of buildings, from the initiative and design to implementation and management."

References:

44 Geraedts, R. (1996) Flexis, Communicatie over en beoordeling van flexibiliteit tussen gebouwen en installaties, SBRpublicatie, Rotterdam
45 Geraedts, R. (1996) Flexis, Communicatie over en beoordeling van flexibiliteit tussen gebouwen en installaties, SBRpublicatie, Rotterdam
Flexibility in the process means that the different actors work together to keep the process "open". Decisions and choices can be postponed in comparison with a traditional process. In a traditional, common practice the different actors largely depend on each other, and certainly in terms of planning and coordination activities influence each other. In spite of this a good cooperation is essential to keep the process flexible.

When we talk about flexibility in the process we divide the process in parts with critical point of decision making. From initiative phase the design will be flexible but throughout the process more decisions about the solidity of elements in the design will be taken. This is like pouring cement, in the beginning it is liquid and through time it becomes hard.

Together, Process & Product Flexibility can be illustrated in the following diagram.

![Diagram of Process & Product Flexibility](image)

**Figure 28 Product & Process Flexibility**

In order to react on changes throughout a buildings lifecycle a ‘Evolving Building’ must be flexible during the entire buildings lifespan.

- **Yet, how can we integrate Process & Product-flexibility into a process approach?**
6.3 Process Approach First Draft

To integrate Process & Product-flexibility into the process approach we need to start with entering the quantities and ratio’s of a project in the form of program & location. This usually happens in the initiative phase of a project. So in the first stage the program is defined.

Then, two activities will take place, simultaneously. These two activities are: forming the scenarios & mass studies. The mass studies will provide the basic shapes for the building / area on the basis of the contextual analyses. The scenarios consist of thematic groups based on a general program. Three design scenarios will be formed and should put the investment costs vs. the costs / revenues during the total lifespan of the project. The three scenarios are:

- The whole program is the totally fixed program of the client.
- One part of the program is fixed; the other part of the program is variable.
- The whole program is variable.

Next, the mass studies will be tested on the basis of the three design scenarios to see which mass study is the most obvious for the given location. The chosen variant (most obvious mass study) will be elaborated according to the three design scenarios that are formed in the previous phase. These three design scenarios should be elaborated simultaneously until the decision is made to choose one of the three. This decision moment can be taken at any moment during the design-process.

By using these three design scenarios the time between the decision making and deliverance of a building becomes shorter hence the project is a shorter period of time exposed to external changes which lowers the vacancy risk to a minimum. But as already mentioned this is a solution based of process-flexibility. To react on changes during the entire lifecycle of a building/area we need to be flexible in our program as well as product. This is only possible within the third scenario.

- Yet, how can we integrate a totally variable program into a process approach which carries the philosophy of the lifecycle approach?
6.4 Process Approach Second Draft

The problem with a totally variable program is the fact that most clients think it will cost more. Clients think in short investment periods, while buildings will finally be there for a long time. We can learn several things from “Sustainability in Perspective”, which is used and evaluated. This resulted in the Second Draft as illustrated below.

Lifecycle focus
The financial aspects of buildings are in current days mostly considered only on basis of investment. Important is to consider buildings for their total lifecycle and the accompanying costs. Some measures (e.g. for example flexibility) can lead to higher initial costs, but will save costs during the use of buildings. For example, monofunctional flexibility can require a higher investment, but it is for instance easier to change to another layout after five years, which will lower the costs at that specific moment. Therefore the total lifecycle of buildings must be considered.

When the client is made conscious about the lifecycle of the building/area we fall into the inner ring. In this part the process is divided into two parts namely: ‘Demand Based Realization’ (method-of-programming) & ‘Flexibility’ (method-of-designing).

Figure 30 Process Approach Second Draft

---

Demand Based Realization (method-of-programming)
The construction industry is currently mainly supply driven. There should be more focus on the customer and their needs. The first step is to consider buildings as consumer products, which are subjected to trends. Finding out what these trends are should be a main focus. Making a better match between customers (users) needs will influence the users satisfaction and thus when satisfied they might stay longer with buildings, creating a higher level of durability. And furthermore, it is important to ‘educate’ the users on what they can demand. So not only the choices should be offered, but also insight on the financial and technical consequences of their choices, or the level of sustainability during the lifespan of buildings.

Flexibility (method-of-designing)
The level of flexibility of a building is important in relation to the ever changing use of buildings, or change of users. The higher the uncertainty about what the demands will be in e.g. 10 years, the more profit you will have if buildings or spaces are flexible. This leads to lower costs of adapting a building when the demand is different. Being flexible in process & product requires a new innovative process with, for instance, new contract forms, changes in the land-use-plan, and so on. When approaching a project in this way we reach the core of our second process approach draft namely: ‘Comfort’ & ‘Sustainability’.

Comfort
The comfort (performance) level of buildings and spaces relates to the internal environment (temperature, air quality, etc.), the design (e.g. comfort level of furniture), and the user-friendliness of buildings (easy to use = comfortable). It also involves the consequences of the internal environment, such as productivity, which mainly applies to office buildings: an uncomfortable indoor environment in the office could influence the productivity of the related workers. Another example is comfort in hospitals: studies have been made of the influence of indoor climate & design in hospitals and how it influences patients in their healing process.

Sustainability
Sustainability (environmental management) involves all environmental aspects in relation to buildings, such as energy usage and – efficiency, focus on climate changes (and solutions to solve this), usage of materials (in relation to availability of resources) and ecology (e.g. the quality of areas in which a building stands through usage of green areas (creating park like environment). The environmental performance must be looked at in a broad perspective (see the items stated above), and also in relation to financial performance.

All the objectives described in the process approach diagram based on lifecycle focus can be seen as a way to create value for the users & owners.

Yet, following a set of inevitable questions arise:

- Who is the client who should become conscious about the lifecycle focus?
- What happens to the program-of-requirements of the client?
- What is programming & designing according to this process approach?
- What do we achieve with this way of approaching a process?
6.5 Process Approach Third Draft

To answer the previous questions which appeared as critic on the second draft we used several literature, case & architectural studies. Finally it resulted in the Third Draft as illustrated below.

![Diagram showing process approach]

**Client**

In the construction industry there are nine categories of clients\(^\text{47}\) as illustrated in the diagram below. All of them can be potential clients of lifecycle focused buildings. As a result from several workshop with project managers and actors within the construction industry it appeared that Private Developers, Housing Associations, Financial Institutions & Companies are the most common clients which needs to be conscious about the lifecycle focus in buildings.

\(^{47}\) Formed by I3Con & two workshops with project managers and advisors within Draaijer+Partners
Program of Requirements
In the Traditional Building Process decisions about requirements, regulations and wishes are set in the Program of Requirements (PoR).

The PoR is a relatively static document in which the client describes the requirements, regulations and wishes. The PoR is a crucial communication method between the sender and receiver. The PoR is intended as a testing tool of quality and costs.

In the development of a building all the decisions are beforehand determined in the PoR. According to this document the building will be designed, constructed and delivered. These so called decisions (determined in the PoR) are during the whole process, from initiative till deliverance, of the building subjected to developments and changes. This means that a project sometimes has to start all over again because the demand doesn’t fit in the design at the moment of changes. So the first step is to change the scope of the program-of-requirements as illustrated in the third draft of the process approach diagram. The Client comes with a standard program-of-requirements. The advisors (Architect, Project Manager, etc.) make the client conscious about the lifecycle focus. The requirements will transform into wishes. The client can expect what he wants but the program can react on changes in the future. So the program is not a requirement but a wish on that particular moment. In this way the program-of-requirements changes in a program-of-wishes.

Programming & Designing
As already mentioned we need to design flexible to achieve a process approach based on lifecycle focus. Literature Studies showed us different kind of principles:

Drager & Inbouw - The main idea is to make an architectural and technical design distinction between:
- bearer and infill level,
- collective and individual,
- fixed and variable,
- long lifespan and a short lifespan,
- Proper alignment between bearer and interior.

Open Building - This strategy is the hierarchical structuring of real estate objects in different levels. Each level can be adjusted individually without interfering the others. It is coupled with a hierarchical structure of management which includes separate levels of design responsibility. Three systems were grouped together and form the basis for the theory of the system separation:

<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
<th>Lifespan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary system</td>
<td>facade and bearing structure</td>
<td>50-100 years</td>
</tr>
<tr>
<td>Secondary system</td>
<td>inner walls, finishes, techn. installations</td>
<td>15-30 years</td>
</tr>
<tr>
<td>Tertiary system</td>
<td>infill</td>
<td>05-15 years</td>
</tr>
</tbody>
</table>

IFD Building System - This system has a three pronged strategy to innovate the building process: the client (flexible), the manufacturer (industrial) and society (demountable). This is characterized by the following principles: ‘level-thinking’ (building - floor - room - work station), a fixed form and space combined with variable options for the interior, a multidisciplinary design, separate technical systems; dimensioning and nodes; modularity and demount ability.

Human Anatomy⁴⁹ - In order to understand flexibility we can refer to nature. Nature has, does and shall always amaze us by its ability of evolving hence enriching itself. We as humans are the living prove of a rich history of evolution. The human anatomy can be seen as a perfect metaphor for programming, designing and constructing in separated building layers regarding the functioning and variety in lifespan.

Every human consists of different organic layers with each their own functioning. The frame design of a ‘Evolving Building’ should be constructed according to these layers. According to these studies we created the first draft of the building layers for flexible designing, which are illustrated below.

<table>
<thead>
<tr>
<th>Structure</th>
<th>50-100 years</th>
<th>Durable</th>
<th>Bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facade</td>
<td>20-30 years</td>
<td>Sustainable</td>
<td>Skin</td>
</tr>
<tr>
<td>Infill</td>
<td>05-10 years</td>
<td>Sustainable</td>
<td>Muscles</td>
</tr>
<tr>
<td>Main Building System</td>
<td>20-30 years</td>
<td>Durable</td>
<td>Large Veins</td>
</tr>
<tr>
<td>Secondary Building System</td>
<td>05-10 years</td>
<td>Sustainable</td>
<td>Small Veins</td>
</tr>
</tbody>
</table>

People, profit, planet
Finally this process approach should result in improvements for the clients & users:

People:  
Client Flexible to react on changing users
End-users Flexible to react on changing wishes

Planet:  
Client Durability: structure is future proof
End-users Sustainability: infill modules are demountable

Profit:  
Client Higher residual value, less vacancy
End-users Infill modules rent / sale is variable

⁴⁹ We were always inspired by nature and its ability to evolve. The most common example is our own anatomy. In spite of this we have read some literature about the human anatomy and decided to use it as an example when talking about flexibility in buildings.
Yet, again a set of inevitable questions arise:

- **Is the client the same as investor?**
- **Are ‘Evolving Buildings’ financial feasible for clients?**
- **What happens to the program-of-wishes of the client?**
- **What is the role of client & user in relation to the different building layers?**
6.6 Process Approach Fourth Draft

To answer the previous questions which appeared as critic on the third draft we used several literature, case & architectural studies. Finally it resulted in the Fourth Draft as illustrated below.

![Process Approach Fourth Draft](image)

**Figure 35 Process Approach Fourth Draft**
Investor

The real clients in a ‘Evolving Buildings’ are the one who invest. They decide whether they want to invest in such a project or not hence it is important to make them conscious about their choices. The investors can be divided in two categories namely:\(^{50}\):

Active Investors: Housing Cooperation’s, Developing Stakeholders, Local Authorities and Government.

Passive Investors: Financial Institutes, Private Developers and Companies and Organizations.

The following step would be to make the investor consciousness about lifecycle focus and proof the financial feasibility of ‘Evolving Buildings’. An investor is used to divide the estimated first year rent by the activated investment costs. The result of this calculation is the so called Gross Initial Yield (GIY). The GIY for residential functions for example is often lower than for offices. This is caused by the different risk profiles.

The ‘Evolving Buildings’ are constructed for a larger market and in spite of their degree in flexibility they can react on changes throughout the buildings lifecycle. When aiming on a larger market the risk of vacancy becomes lower, so the GIY decreases. This means that the ‘Evolving Buildings’ can be optimized according to the rent and the investment costs. For example when we assume that the ‘Evolving Buildings’ lower the GIY from

---

\(^{50}\) This categorization is achieved after a set of interviews with persons involved in the ‘Solids’ concept. The ‘Solids’ concept is analyzed in detail in Chapter 3
6% to 5% an additional fee of approximately 15% can be invested in flexibility on above the general investment. This is possible if the rent stays on the same level as normal market prices. This additional fee above the general investment decides the feasibility of these ‘Evolving Buildings’.

When looking at the total lifecycle of a ‘Evolving Buildings’ many other benefits can be noticed. If we assume that the market, requirements and needs of the users or regulations change every 20 years than the costs of transformation, maintenance, risk of vacancy, etc. decreases.

Optimizing by value needs a total different way of thinking. The ‘Evolving Buildings’ are optimized by value which finally translates itself in a higher exit yield throughout the buildings lifespan. In this way the ‘Evolving Buildings’ become close to nature because the nature always enriches itself and does never retrench.

Program-of-wishes
As already discussed the process usually starts with a general program according to the vision of the investor, advisors and local authorities, this can be seen as the general program. Making the investor consciousness about lifecycle focus means injecting a certain degree of flexibility and sustainability into the general program hence forming the program-of-wishes.

Two different degrees of flexibility can be chosen namely: Mono or Multi-functional:

- Mono-functional flexibility: This ‘Evolving Building’ is flexible in one and the same function.
- Multi-functional flexibility: This ‘Evolving Building’ is flexible in multiple functions and allows them to be transformed among each other.

For example if a building has a lifespan of 100 years on a location with much potential for multifunctional use it is recommended to choose for an ‘Evolving Building’ with Multi instead of Mono-Functional Flexibility. In this way the ‘Evolving Building’ can react on the changing requirements and needs of its users throughout its lifespan. In this stadium also sustainability can be linked to the degree of flexibility.
As already mentioned for flexibility it is necessary to design and program in different layers. The relation between buildings layers and frame and infill can be described as followed. An ‘Evolving Building’ should be separated in to different parts according to the investor & user, namely: Frame & Infill.

The investor owns the frame. The user can choose to develop the temporary infill and become the owner or the investor develops and rents the temporary infill to the user. In this case the user pays a additional fee to the investor. The user chooses the design and the period of use of the infill. In some situations the investor and the user can be the same. The user has a direct influence on these costs. The total rent of the user consists of the basic rent of the frame and the costs of the infill. In this way one creates and keeps the value of the ‘Evolving Building’ throughout its lifespan.

Because the ‘Evolving Buildings’ are separated into two main parts, the program also needs to be divided in two different parts. For the design and construction of the frame we need a Program-of-Investor. This part of the program and design is as we call it the ‘Static’ part which belongs to the investor and has a long lifespan.

For the design and construction of the infill we need a Program-of-User. This part of the program and design is as we call it the ‘Dynamic’ part which belongs to the user and has a short lifespan. Because of the short lifespan of the infill this process can be repeated many times throughout the lifecycle of these ‘Evolving Buildings’.

**Programming & Designing**
Designing & Programming a ‘Evolving Building’ can roughly be divided in three phases, namely: urban design, design of the frame & design of the infill.

Referring to the human body (biomimicry) the urban design can be compared with the humanity. The design of the frame can be compared with the human anatomy. The design of the infill can be compared with the ability of the human to accommodate and react on external circumstances.

*The Humanity as the Urban Design*
Every human in a democratic society has the freedom and ability to make decisions within the limits of the governmental laws and regulations. The urban design should provide a frame with basic regulations and laws in which every building can decide its own degree of flexibility and sustainability.
The Human Anatomy as the Frame

The skin forms the façade as the face of a ‘Evolving Building’ towards the outside world. The façade is the image conceived from the outside which makes it a part of the public space. The façade can either have a long or a short lifespan. This depends on the degree of flexibility.

The muscles & skeleton are together forming the structure. The muscles are subjected to tension and the skeleton is subjected to load forces which are also the case in the structure of a building. Like the muscles and skeleton in the human body the structure is normally build up in the first years for the buildings’ total lifespan.

The heart & the organs together form the transfer & installations in a ‘Evolving Building’. Like the heart with the blood, the transfer pumps the people throughout the building. Like the organs with nutrition’s, the installations pumps to and subtract the different needs like water, energy, etc. from the building. In the human body the heart and the organs are irreplaceable because of their unique character the same can be said about the transfer & installations, hence a long lifespan.

The veins form together the building system of a ‘Evolving Building’. Like the veins, the building system links and provides all the levels in their needs, with goods, energy, people, etc. The building system can be separated in two parts namely: the main and secondary building system. The main building system is not easily adaptable hence a long lifespan like the arteries. The secondary building system can be more easily adaptable like the veins hence a short lifespan.

The brain & nerves form together the control system of a ‘Evolving Building’. Like the brains, the steering unit in a ‘Evolving Buildings’ controls all the conditions like the general temperature, lighting, humidity, etc. The sensors are like the nerves, which operate as the control unit. They measure all the conditions and give input to the steering unit. The steering unit gives input to the building system.

Figure 39 Human Anatomy vs. Building Layers
The Ability of the Human as the Infill

Every human has the ability to accommodate and react on external circumstances because of its unique adaptable body. The human has the possibility to sit when there is a chair, jump when there is an obstacle, answer when there is a question, in short the ability to be the frame which makes almost everything possible. Designing according to the human anatomy will provide a ‘Evolving Building’. As discussed before a ‘Evolving Building’ has the ability to accommodate and react on external circumstances. It has the ability to accommodate the infill which is formed by external circumstances like the market changes, requirements and needs of users or regulations through its lifecycle.

The infill is designed for a particular moment on the basis of requirements in that period of time. The infill isn’t a static snapshot but change throughout the building’s lifespan; it has the ability to evolve and is related to the inner identity. As seen in the architectural studies this inner identity in a lifecycle focused building has the possibility to evolve. A building should provide a shell for the total lifecycle of a building which will further grow its soul because of its possibility of evolving.

The outer identity is different. For example Koolhaas & Day both have a different meaning as seen in the architectural studies. On the one hand Day states that a ‘Evolving Buildings’ should create dearness to the public realm, which is also the case with the Solids. On the other hand Koolhaas states that an identity can be obtained through time and not on a particular moment. So it is very difficult to design an outer identity for a building’s lifespan. Finally both inner and outer identity should be created in such a way that they allow each other to evolve.

Yet, again an inevitable question arises:

- If we create on lifecycle focused buildings what are the benefits and for whom?
6.7 Process Approach Final Draft

To answer the previous question which appeared as critic on the fourth draft we used several literature, case & architectural studies. Finally it resulted in the Fifth Draft as illustrated below.

This version of the process approach is in many ways similar to the previous one but the word investor changed in program because the process approach is described in products and not in actors. Another thing that changed is more evitable.

The construction industry created terms to define sustainability. People, Profit and Planet is currently the most familiar symbol for sustainability. These three pillars capture an expanded spectrum of values and criteria for measuring organizational and societal success: economic, ecological and social. These three pillars are created in a world which is led by people with a conservative way of thinking. In the current construction industry the projects are mostly driven by finance. Stakeholders are focused on short investment periods. But Profit can’t be separated from People and Planet hence we introduce the terms Home and Humanity.

Home is our planet and the cities where our houses are located. Humanity is where we build for. Constructing for human beings means thinking of buildings as adaptable spaces for living, working, and so on. In the ‘City of Tomorrow’ Profit should be seen as the inevitable result of value creating lifecycle thinking and so it is integrated in both.
7 Implementation into Design & Manual

Firstly in this chapter the implementation into design will be described, including their consequences on the theories. Secondly the final theories will be transformed into question for an on question based decision making process approach. Each of the process approach components has its own questions to form their final result. Finally these questions will be the fundament of our strategic manual.

7.1 Program

The first phase of a design project is forming the Program. The Program should express the general components and decisions in planning and designing a project. The program is formed by the requirements and wishes of the client and / or user (market). The advisor should gather the first general information about the reason, ambition and goal of the client in relation to the new project. In this phase the first impression of the total amount of square meters which is thought to be required by the client should be formed. When there is already a potential location this program can also already be influenced by the urban context and market.

In this fictive HighRise project we have the following general program:

<table>
<thead>
<tr>
<th></th>
<th>m² BVO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail (showcase)</td>
<td>15,000</td>
</tr>
<tr>
<td>Congress</td>
<td>13,000</td>
</tr>
<tr>
<td>Casino</td>
<td>34,000</td>
</tr>
<tr>
<td>Offices</td>
<td>140,000</td>
</tr>
<tr>
<td>Clubs</td>
<td>1,000</td>
</tr>
<tr>
<td>Hotel</td>
<td>23,000</td>
</tr>
<tr>
<td>Housing</td>
<td>23,000</td>
</tr>
<tr>
<td>Transfer</td>
<td>8,000</td>
</tr>
<tr>
<td>Restaurant</td>
<td>4,000</td>
</tr>
<tr>
<td>Installations</td>
<td>12,000</td>
</tr>
<tr>
<td><strong>Total gross floor space</strong></td>
<td><strong>273,000</strong></td>
</tr>
<tr>
<td><strong>Parking facilities</strong></td>
<td><strong>90,000</strong></td>
</tr>
<tr>
<td><strong>Total (incl. parking)</strong></td>
<td><strong>363,000</strong></td>
</tr>
</tbody>
</table>

**Questions:**
To generalize this phase (program) we should ask the following questions in the final manual:
- What is the main reason to start this project?
- What kind of experience do you have with these kinds of building projects?
- What kind of ambitions and goals do you have as a client in this project?
- What is the total m² of program that is required?
7.2 Lifecycle Focus

Before writing a program of investor the general program should be tested on validity. In this phase the reason behind decisions in the general program will be tested. This will finally result into three scenarios based on the lifecycle of the project.

In this fictive HighRise project the location is the Schiekadeblok in Rotterdam near the Central Station. The plot allows the following functions: Retail, Leisure, Offices, Residential and Restaurants. On the basis of a market research it is not reasonable to say that the users of the different functions will stay into the project for the total lifespan of the project and functions like offices are very sensible for market changes. In this matter there is a high potential possibility that the ratio of functions will change in the project because of market changes. Finally can be drawn that offices, residential functions and hotels are mainly situated in the tower and the public functions are mainly situated in plinth. In this matter it is preferred to mix the tower functions and mix the plinth functions separately. Finally parking and congress are very specific functions where no mixture is needed.

Questions:
To generalize this phase (lifecycle focus) we should ask the following questions in the final manual:

- Do you have a location?
- Does the location contextually allow multiple functions?
- When we look at the period of use of the building and the total buildings’ lifespan, will there be a high potential possibility of other functional use in the building because of unknown market changes?
- Is this high potential possibility of other functions plausible for all square meters?

Figure 42 Lifecycle Focus
7.3 Program of Investor

When programming an ‘Evolving Building’ a clear path has to be drawn in order to separate the design into a *Frame* and *Infill*. As already discussed the process usually starts with a general program according to the vision of the client. Like the design, the Program also needs to be separated in two main parts namely: *Program-of-Investor and Program-of-User*. The *Program-of-Investor* is the combination of the general program in square meters and the lifecycle focused wish.

In this fictive HighRise project the general program can be easily transformed according to the lifecycle focused wish. Finally it will be the following multi & mono functional flexible program:

<table>
<thead>
<tr>
<th>Category</th>
<th>Functionality</th>
<th>Square Meters (BVO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offices, Hotel, Housing</td>
<td>Multi-functional Flexible</td>
<td>186,000</td>
</tr>
<tr>
<td>Retail, Restaurant, Transfer</td>
<td>Multi-functional Flexible</td>
<td>27,000</td>
</tr>
<tr>
<td>Casino, Club</td>
<td>Multi-functional Flexible</td>
<td>35,000</td>
</tr>
<tr>
<td>Congress</td>
<td>Mono-functional Flexible</td>
<td>13,000</td>
</tr>
<tr>
<td>Installations</td>
<td>Mono-functional Flexible</td>
<td>12,000</td>
</tr>
<tr>
<td>Parking facilities</td>
<td>Mono-functional Flexible</td>
<td>90,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>363,000</strong></td>
</tr>
</tbody>
</table>

**Scenarios:**
To generalize this phase (program of investor) we should ask the following scenarios in the final manual:

- Based on the results on lifecycle focus the general program needs to be transformed into Multifunctional Flexible program.
- Based on the results on lifecycle focus the general program needs to be transformed into Mono & Multi-functional Flexible program.
- Based on the results on lifecycle focus the general program needs to be transformed into Mono-functional Flexible program.
7.4 Design of Frame

When designing an ‘Evolving Building’ a Frame needs to be created in which different Infill’s can be accommodated. At first we should start with a sketch design just as in a normal process which we also created for our fictive project.

Questions:
To generalize this part of design of frame we should ask the following questions in the final manual:
- What are the Urban Restrictions on the location?
- How does the plot relates to its context?
- What is the Concept & Mass Design?

Secondly we should use the building layers. How should every building layer be designed to come to this frame which is related to the sketch design? All the different building layers will be elaborated separately at first.

Figure 43 Human Anatomy vs. Building Layers
7.4.1 Structure (Muscles & Skeleton)

Structure: Theory V1

If we look at the structure of High Rises five variants can be defined namely\(^{51}\):

- **Tube in Tube and Tubes:**
  Static core and facade with a Dynamic plan

- **Stability Core and Bracing in Façade:**
  Static core with a Dynamic / Static façade and a Dynamic plan

- **Frame System:**
  Static core with a Dynamic plan and facade

If we focus on the dimensions of the width and depth of the building layout and the height of a building level the following can be concluded\(^{52}\):

---


\(^{52}\)The minimal angle is defined on the basis of the minimal required height and depth in the Netherlands. This quantities and ratios can be found in the Dutch Building Code. The minimal quantities and ratios of offices and dwellings are used to form this formula. This angle was: \(\tan(\frac{2.6\ m}{7.2\ m}) = 20\ \text{grades}\)
In this philosophy the storey height is defined on the basis of the Angle that is minimally required to have enough daylight entrance. So the larger the distance from the core to the façade the higher the storey. The width is a dynamic variable in this philosophy and can be defined by the architect in order to get optimal offices or dwellings.

**Structure: Implementation V1**

![Structure Diagram](image)

**Figure 46 'Evolving Buildings’ HighRise, Structure**

In our design we used the Frame System principle. In this way we had maximum flexibility in the layout and façade. The core was used to stabilize the tower.

The problem with this way of approaching a building’s structure is the fact that flexibility should be found in the way the structure is used instead of the principle on which it is based.

According to the grid of 10.5 m we could also use our formula to calculate the level height. The calculation was as followed: $\text{TAN}(20) \times 10.5 = 3.8$ m

The problem with this formula is the fact that this principle is based on a single space. If we look at offices and dwellings we have to deal with multiple rooms. Not every room needs to have direct daylight. In spite of this one creates an enormous unnecessary level height which isn’t efficient.
Structure: Theory V2

On the basis of the previous results & criticism the following philosophy can be formed when looking at the structure of an ‘Evolving Building’:

The structure should make the chosen height, with and depth possible no matter which structural principle is used in the design.

But what are the dimensions of the width and depth of the building layout and the height of a building storey?

The minimum width of a grid based on the minimum daylight entrance can be calculated according to the Building code\(^{53}\). In this document the minimal dimensions are given for offices, dwellings, hotels, etc. The spaces which require daylight are also defined and should be taken into account. In this way a set of diagrams as illustrated in figure 47 can be developed in order to find the proper width in relation to the minimal daylight entrance in a ‘Evolving Building’.

In this way the smallest unit\(^{54}\) can be defined. In mono-functional ‘Evolving Buildings’ only one function needs to be elaborated while in Multi-functional ‘Evolving Buildings’ multiple functions should be analyzed and the smallest grain size has to be chosen. The width of the grid should be minimized until the smallest grain size in which all the chosen functions are made possible.

In a similar way the depth of the grid can be calculated. In this way again a set of diagrams as illustrated in figure 48 can be developed in order to find the proper depth in relation to the minimal daylight entrance in a ‘Evolving Building’.

Once the minimal dimension of the grid is calculated, the storey height can be defined. To define the ‘pleasant storey height’ the next steps should be taken:

1. Define the minimum floor height according to the building code for the multi-functional ‘Evolving Building’. The largest height among the different functions should be chosen.
2. Making a set of sketches in which a space (according to the defined grid) is illustrated. In the set of sketches the ceiling height should gradually be lifted. This can be done with different area sizes in order to get a insight in what the most pleasant height will be.

\(^{53}\) This is a document in which according to the law of a country minimum required dimensions are given.

\(^{54}\) A unit offers the smallest grain size with dimensions in which different chosen functions can be adapted.
Structure: Implementation V2

According to the Dutch Building code, the minimum dimensions of the grid (based on the minimum daylight entrance in hotels, dwellings and offices) is calculated. In our HighRise design the grid is 0.6 m x 0.6 m. This is gained on the basis of the minimal width and depth of the smallest grain size namely:

1. Width is 1.8 m
2. Depth of the layout is 7.8 m (6.0m rentable floor area + 1.8 m circulation area).
Than the ‘pleasant storey height’ is defined. In the figure 49 the next results are gained when elaborating the two steps as mentioned before:

1. The minimal storey height according to the building code is 2.6 when looking at hotels, dwellings and offices.
2. In our example four different space sizes are elaborated. These space sizes are linked to minimal and maximal areas in hotels, dwellings and offices.

From these set of sketches we conclude that the floor height of 3.0 m is the most pleasant height for a multi-functional ‘Evolving Building’ which embodies hotel, residential and office functions.

Structure: Conclusion

*The structure should make the chosen height, with and depth possible no matter which structural principle & material is used in the design.*
7.4.2 Façade (Skin)

Façade: Theory V1
When looking at the façade of an ‘Evolving Building’ the following three variants can be defined namely:

Replaceable Façade  Short lifespan  Dynamic
This façade principle is demountable and not load bearing. The materials in this façade can be very sustainable with a short lifespan. The façade has the full ability to react on the requirements and wishes of the market, users, government, etc. through the buildings lifecycle.

Multifunctional Façade  Long lifespan  Static
This façade principle is when once build operational for the buildings total lifespan. The materials in this façade can be very sustainable with a long lifespan. The façade should be over dimensioned in order to make different function possible within a ‘Evolving Building’. The facade isn’t adaptable.

Customizable Façade  Long & Short Lifespan  Static & Dynamic
This façade principle is a mixed variant between the Replaceable and the Multifunctional Façade. The façade frame is when once build operational for the buildings total lifecycle. The materials in the frame of the façade can be very sustainable with a long lifespan. The facade frame isn’t adaptable. The façade infill is demountable and not load bearing. The materials of the façade infill can be very sustainable with a short lifespan. The infill provides the full ability to react on the requirements and wishes of the market, users, government, etc. through the buildings lifecycle.

Figure 51 Three Façade Principles
Façade: Implementation V1

In our design we used the replaceable facade principle. In this way the façade wasn’t load bearing. The façade could be changed in different collars, materials, and so on hence being utter flexible.

*The problem with this way of approaching a facade is the fact that flexibility should be found in the way the facade is used instead of the principle on which it is based.*

Façade: Theory V2

In a ‘Evolving Building’ the façade should be demountable and adaptable as a separate layer. If we take a closer look in to the three mentioned façade principles we can conclude that replaceable facade is the only principle that fits in this profile of flexibility.

Façade: Implementation V2

According to this philosophy we designed a new façade variant. In our ‘Evolving’ HighRise design we use a double skin façade and hang the façade with tension cables that were connected to the outriggers. The outriggers were carried by the core.

Façade: Conclusion

*Flexibility should be found in the way the facade is used. There are infinite ways to be flexible in the façade. The degree of flexibility and sustainability in the façade should be found in an on lifecycle focused way of decision making by the client. He should be made conscious about his decisions and impacts for the total lifecycle of the ‘Evolving Building’. The overall feasibility relates to the clients choices and the technical and financial impacts of the taken decisions.*
7.4.3 Transfer

Transfer: Theory V1
The transfer in a ‘Evolving Building’ pumps to and subtracts the people and the different resources like water, energy, and so on throughout the building. This is the main circulation area in the ‘Evolving Building’ and the installation floors are linked to this area. The transfer level refers to the public street in the city with retails, restaurants, entrances to offices or dwellings, etc.

Transfer: Implementation V1
The ‘Evolving’ HighRise consist of different Transfer Levels as illustrated in figure 47. In red the circulation area and underneath this area the installation floors are illustrated in beige. This is only illustrated in the tallest HighRise tower.

Transfer: Conclusion
At the end the transfer level can be seen as a general storey with another infill and functioning. So we have come to the conclusion that the transfer level shouldn’t be seen separately as a building layer.
7.4.4 Building System

Building System: Theory V1

Installation Flows
The building system links and provides all the levels in their need for energy, water, and so on. The building system can be separated in two parts namely: the main & secondary building system. The main building system is not easily adaptable hence a long lifespan. The secondary building system can be more easily adapted hence a short lifespan. The secondary building system principles can be divided in the following three groups:
In the first group the secondary building system is linked to one floor and provides at the same time the upper and under level from water, electricity, etc.
In the second group the secondary building system is not provided in advance but the area underneath the floor or ceiling allows the users to manually install the secondary building system the way they want them to be.
In the third group the secondary building system is a combination of the other two variants. The secondary building system is installed partly in advance and the other part can be manually installed by the user.

Figure 56 Installation Flows

Figure 57 People Flows

People Flows
The circulation of people throughout the ‘Evolving Building’ is divided in two parts:
1) Fast Pathway (Street from transfer to transfer level)
2) Slow Pathway (Office and Residential circulation)
Building System: Implementation V1
In figure below the building system flow are illustrated for the tallest HighRise tower. The Main Building Systems are the three vertical shafts and the Secondary Building Systems are the horizontal shafts in the lowered ceiling.

In figure below the people flow is illustrated for the tallest HighRise tower. The fast pathway is illustrated in red for the connection between the different transfer levels, the slow pathway for offices in blue and dwellings in yellow.

This way of approaching the circulation within a ‘Evolving Building’ makes different functions possible. So the test on our ‘Evolving’ HighRise design proofed that this is indeed the proper way to approach the circulation within a ‘Evolving Building’.
Building System: Theory V2
In a ‘Evolving Building’ the secondary building system should be demountable and adaptable as a separate layer. If we take a closer look in to the three mentioned principles we can conclude that the second variand fits the best in the profile of flexibility which we want to achieve. For a ‘Evolving Building’ total flexibility is needed. When looking at the Solid concept we find a similar solution for the way a building system should be. In the solids the main building system is linked to the building shafts (with elevators and staircases). The secondary building system is not provided in advance but a technical cabinet is added in every unit. This technical cabinet is a direct link to the main building system and can be linked to any secondary building system that exists hence making the secondary building system an individual choice of the tenant.

Building System: Implementation V2
According to this philosophy we designed our next variant. In our ‘Evolving’ HighRise design we use the technical cabinet to provide water and electricity to the every unit. Because we use a smart facade the air supply is provided through the facade.

Building System: Conclusion
We can conclude that in a ‘Evolving Building’ the main building system is linked to the building shafts (mostly the core with elevators and staircases). The secondary building system is not provided in advance but a technical cabinet is added in every unit. This technical cabinet is a direct link to the main building system and can be linked to any secondary building system that exists hence making the secondary building system an individual choice of the tenant.

There are infinite ways to be flexible in the creation of the building system. The degree of flexibility and sustainability in the building system should be found in an on lifecycle focused way of decision making by the tenant. The tenant should be made conscious about his decisions and impact for the total lifecycle of the ‘Evolving Building’. The overall feasibility relates to the tenants choices and the technical and financial impacts of the taken decisions.
7.4.5 Control System

Control System: Theory V1

The Steering Unit\textsuperscript{55} in a ‘Evolving Building’ controls all the conditions like the general temperature, lighting, humidity, and so on. The sensors operate as the Control Unit. They measure all the conditions and give input to the steering unit. The steering unit gives input to the building system.

Control System: Implementation V1

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure61.png}
\caption{‘Evolving Buildings’ HighRise, Control System}
\end{figure}

Individual control of the building system based on the dimensions of a \textit{unit}:

- The steering unit is located in the installation floors underneath the transfer levels (public areas)

- The control units are the sensors which measure the conditions per \textit{unit} in the ‘Evolving Building’ and give input to the steering unit. This is also individual adjustable (private areas).

\textit{This way of approaching the building control system within a ‘Evolving Building’ makes different functions or users with their own requirements and needs possible. But this can be seen as a part of the building system.}

Control System: Conclusion

\textit{We can conclude that in an ‘Evolving Building’ the control system is a part of the main building system. So we have come to the conclusion that the control system shouldn’t be seen separately as a building layer.}

\textsuperscript{55} The building control system is related to the same principle as explain by the Control Diagram, de Leeuw, 2002
7.4.6 Conclusions

According to research by design the following can be concluded about the building layers within an ‘Evolving Building’:

**Structure:**
The structure should make the chosen height, with and depth possible no matter which structural principle & material is used in the design.

**Facade:**
Flexibility should be found in the way the facade is used. There are infinite ways to be flexible in the façade. The degree of flexibility and sustainability in the façade should be found in an on lifecycle focused way of decision making by the client. He should be made conscious about his decisions and impacts for the total lifecycle of the ‘Evolving Building’. The overall feasibility relates to the clients choices and the technical and financial impacts of the taken decisions.

**Building System:**
We can conclude that in a ‘Evolving Building’ the main building system is linked to the building shafts (mostly the core with elevators and staircases). The secondary building system is not provided in advance but a technical cabinet is added in every unit. This technical cabinet is a direct link to the main building system and can be linked to any secondary building system that exists hence making the secondary building system an individual choice of the tenant.

As seen before there are different ways to be flexible in every building layer with different degrees. The degree of flexibility and sustainability should be found in an on lifecycle focused way of decision making by the client. The client should be made conscious about his decisions and impact for the total lifecycle of the ‘Evolving Building’. The overall feasibility relates to the clients choices and the technical and financial impacts of the taken decisions. In this matter the manual should provide question with conditions for the three different building layers. Questions with conditions in dimensions and degrees of flexibility and sustainability. The degree of sustainability is formed according the philosophy of biomimicry. Like in nature resources flows are linked among eachother hence their is no surpluses or waste. At the end the client is made conscious about his own decisions and their impacts.

**Questions:**
To generalize this phase (design of frame) we should ask the following questions in the final manual:

- What is the minimum height of the chosen combination of functions and which height is decisive (the function with the largest floor height)?
- Do you accept this minimum height?
- Do you want an additional height on above the minimum required which can provide extra quality which at the same time can have financial consequences?
- What is the width for minimum daylight entrance of the chosen combination of functions and which function is decisive (the function with the largest minimum daylight entrance)?
• What will be the minimum unit area which can be rented for this decisive function and what will be its maximum depth using its minimum width for daylight entrance?
• What will be the minimum width when taking into account the chosen depth and minimum area of the decisive function?
• Do you accept this minimum width of the façade in relation to your chosen depth?
• Do you accept the related grid or do you want to adjust it? Do you also agree with its rentable units and financial consequences?

• In what degree does the building need to be flexible in the positioning the cores?
• In what degree does the building need to be flexible in the logistics of the Infill?
• In what degree does the building need to be flexible horizontally?
• In what degree does the building need to be flexible vertically?
• In what degree does the building need to be extendable horizontally?
• In what degree does the building need to be extendable vertically?
• In what degree does the building need to be demountable horizontally?
• In what degree does the building need to be demountable vertically?

• Is the degree of flexibility that is chosen technically possible for every building layer?
• Does the investor agree with the financial consequences?

• What can be done to the surpluses and waste of material flows which are created or used in the different building layers separately during the lifecycle of the building?
• What can be done to the surpluses and waste of energy flows which are created or used in the different building layers separately during the lifecycle of the building?
• What can be done to the information flows which are created or used in the different building layers separately during the lifecycle of the building?
• What can be done about the mutual relation among flows of materials, energy and information in every building layer in relation to the building itself, the plot and the city?

• Is the degree of sustainability that is chosen technically possible for every building layer?
• Does the investor agree with the financial consequences?
7.5 Program of User

The Program-of-User should be constructed according to the wish of the user and need to fit into the design of the Frame. The user gets an amount of square meters within the building envelope. The program should fit in terms of Mono or Multi functionality of the building. Two different typologies exist in relation to the building program:

1. Single Tenant: In this building typology the total rentable square meters are rented to one tenant.

2. Multiple Tenants: In this building typology the rentable square meters are rented to different tenants. It starts with the smallest rentable unit until an entire story or building.

The Program-of-User can be repeated throughout the lifecycle of the building. Every time a tenant leaves the building the investor makes the square meters which are vacant (sometimes also in combination with other available square meters in the building) available for the next tenant.

In our fictive project we have multiple tenants with all sorts of different programs in the hotel, residential and office functions. All the potential tenants should provide their requires and wishes in relation to the amount of square meters, the price they are willing to pay and the area of the evolving building they wish to occupy.

When all this information is gathered decisions can be made on two ways: digitally or face to face. Digitally, we can think about auctions based on computer programs. Face to face we can think about a meeting with all the potential tenants in which the project manager decides about the users and the use of the evolving building.

Finally each user has its own program that needs to be formed. This program needs to be defined and forms the fundament for an architect by the design of the infill.

Questions:
To generalize this phase (program of user) we should ask the following questions in the final manual:

- Is the user of this project a single tenant?
- Which part of the building does tenant 1 / tenant 2 / tenant x wish to occupy?
- What is the program that is required for each user?
7.6 Design of Infill

Infill: Theory V1
Designing according to the human anatomy will provide a ‘Evolving Building’. As discussed before a ‘Evolving Building’ has the ability to accommodate and react on external circumstances. It has the ability to accommodate the infill which is formed by external circumstances like the market changes, requirements and needs of users or regulations through its lifecycle.

Because the secondary building systems are demounted from the structure of the building and operate separated, the Cubic’s like the bathroom, toilet and kitchen can be loaded everywhere within the frame of the ‘Evolving Building’. In figure below two Cubic’s are randomly placed on the diagrammatic layout of a building.

Infill: Implementation V1
In figure below the infill of a residential and an office floor level is illustrated for the tallest HighRise tower. We can notice that within the same frame two different functions are possible.

The problem with this way of approaching the infill is the fact that one is limited to flexibility on one and the same level with a fixed height. In this way there is no way to interlink floors among each other. So the test of this theory on our ‘Evolving’ HighRise design proved that this is indeed the proper way to approach the infill within a ‘Evolving Building’ but not the way floors should operate.

Figure 62 Infill

The term Cubic is used as a synonym for the so-called wet areas in the ‘Evolving Buildings’ like the bathroom, kitchen and toilets.

Figure 63 ‘Evolving Buildings’ HighRise, Infill

56 The term Cubic is used as a synonym for the so-called wet areas in the ‘Evolving Buildings’ like the bathroom, kitchen and toilets.
Infill: Theory V2
The ‘Evolving Building’ as discussed before is separated in two different parts namely: *Frame & Infill*. The investor owns the frame. The user can choose to develop the temporary infill and become the owner or the investor develops and rents the temporary infill to the user. In this case the user pays an additional fee to the investor. The user chooses the design and the period of use of the infill. In some situations the investor and the user can be the same. The user has a direct influence on these costs. The total rent of the user consists of the basic rent of the frame and the costs of the infill. In this way one creates and keeps the value of ‘Evolving Buildings’ throughout their lifecycle.

In an ‘Evolving Building’ the floors and walls should be demountable and adaptable as a separate layer. Two kinds of floors and walls can be categorized namely: *Unit Dividing Floor / Wall & Infill Dividing Floor / Wall*. The user has a direct influence on these costs. The rent of the user contains the basic rent of the Unit Dividing Floor / Wall and the costs of the Infill Dividing Floor / Wall.

Infill: Implementation V2
According to this philosophy we designed our next infill variant. In our ‘Evolving’ HighRise design we use boxes which contained 15 floors. These 15 floors can be interlinked among each other as illustrated in figure 56.

![Infill Design](image)

*Figure 64 ‘Evolving Buildings’ HighRise, Infill*

Infill: Conclusion
*We can conclude that in an ‘Evolving Building’ the infill is an individual choice of the tenant. There are infinite ways to be flexible in the creation of the infill. The degree of flexibility and sustainability in the infill should be found in an on lifecycle focused way of decision making by the tenant. The tenant should be made conscious about his decisions and impact for the total period of use. The investment costs and or rent relate to the tenants choices and the technical and financial impacts of the taken decisions.*

Questions:
To generalize this phase (design of infill) we should ask the following questions in the final manual:
- Does the user want to hire the predefined architect of the client?
- Does the user want to hire the infill of the client?
8 Results

In this chapter the answers of development of the process approach and implementation into the design & manual will be defined. Answers are given to the next three detailed research questions.

Detailed research question 3: To what extent are the existing principles based on lifecycle focus useful in redesigning our new process approach?

For the construction of our process approach we have used many aspects from different existing lifecycle approaches which are elaborated in phase II: studies. In short the following aspects were useful:

Drager & Inbouw (Habraken, 1961)
- Dividing the design into Frame & Infill.

Open Building (Habraken & Kendall, 1965)
- Dividing the Frame & Infill in different building layers based on their lifespan.

IFD Building System (Dutch Government, 1999)
- Relating the design to a unit (grain size) which is demountable.
- Optimally flexible as well as sustainable.
- Because of demount ability materials can be reused hence sustainable.

Lean Construction (Toyota, 1993)
- Flexible process of programming.
- Identify & deliver value to the customer.
- To deliver quality actors should have a holistic approach towards the entire design and construction process. Processes do not work well when every person tries to optimize their performance without understanding how their actions affect the larger web.

I3con (European Project, 2006)
- Holistic approach towards industrial intelligent integrated constructions.
- The design of a flexible infill in relation to the entire building.
- Potential clients of ‘Evolving Buildings’.

Sustainability in perspective (Draaijer+Partners, 2009)

Biomimicry
- Use the output (surpluses and waste) as input
- Separate resources in three categories, namely: material, energy and information flows.

Solids (Stadgenoot, 2010)
- Disconnect the main and secondary building system. Link the main building system to the unit (grain size) and the secondary building system is seen as a part of the infill.
- The amount and price of rentable floor area can be decided by the tenant himself. This also decides the feasibility.
Detailed research question 4: What needs to be adjusted in our process approach based on lifecycle focus to fill up the noticed lack?

As elaborated in chapter 6, our process approach is formed according to literature and gradually evolved because of our own design and the critics / possibilities from actors in practice. In spite of this the process approach has undergone several changes throughout our graduation period. The improvements can gradually be found back in chapter 6. The following aspects were adjusted to fill up the noticed lack:

- Integrating product & process flexibility.
- Dividing the Program-of-Requirements into Program-of-Investor & Program-of-User.
- How to design the depth, width, height & grid of the unit
- Seeing flexibility and sustainability as conditions which fit in any type of structure, façade, building system, and infill.
- Translate lifecycle focus on the scale of the building & city
- Translation People, Profit, Planet into Home & Humanity.
- Not only horizontally but also vertically flexibility as a possibility
- Not seen sustainability as measurements but thinking in flows of material, energy and information. Sustainability should have the possibility to evolve.
- Defining Lifecycle focus as: ‘Flexibility as foundation of sustainability’.

Detailed research question 5: What can be improved in our process approach based on lifecycle focus for future research?

Firstly, our process approach is tested on a fictive HighRise project. This HighRise project is used as a test and example of how the theories could be implemented in a design process.

Secondly, this process approach can be used in the form of workshops with more fictive projects in order to get more inside in its usability.

Finally, the following and inevitable step is to test these theories on a project in practice.
**PHASE IV: FINAL CONCLUSIONS**

*Content:*
Chapter 9: Conclusions
Chapter 10: Reflection & Recommendations

*Discussed Main Research Questions:*
- To what extent and in which way can a process approach based on lifecycle focus optimize a building in order to react on changes during the buildings’ lifecycle?
9 Conclusions

In this chapter again the conclusions of the detailed research questions will be given. Finally an answer will be provided to the main research question.

**Detailed research question 1:** Which principles based on lifecycle focus do already exist, on which way are they used, in which phase and what are their consequences?

For this research six principles based on lifecycle focus in and outside the construction industry through the last decades are used namely:

- Drager & Inbouw (Habraken, 1961)
- Open Building (Habraken & Kendall, 1965)
- IFD Building System (Dutch Government, 1999)
- Lean Construction (Toyota, 1993)
- I3con (European Project, 2006)
- Biomimicry
- Sustainability in perspective (Draaijer+Partners, 2009)

These principles mainly focus on technical, organizational, functional, architectural, etc. aspects of flexibility and sustainability. They lack in a holistic process approach towards lifecycle focused in buildings which embodies the process from initiative till demolition.

For this research two projects are analyzed which are designed & constructed according to the Solids principle of Stadgenoot which is based on lifecycle focus.

- Solid 1 & 2, IJburg
- Solid 11, Amsterdam Oud-West

Solids are a new construction concept creating durable buildings which can react to the changes of users during their lifecycle. Tenants are completely free to choose how they want to use the space for living or working. They are in any way free to shape or form the infill. This makes the Solid become a mix of different functions. Each building could practically accommodate an entire city, acting as ‘a city in a building’. The first Solid is currently under construction in IJburg, and more are soon to follow in Amsterdam. But these buildings lack in three things namely:

- The façade is constructed as monumental/fixed which isn’t flexible
- The solids are only horizontally flexible and not vertical which can offer more quality to the inner functions
- Sustainable measurements are snapshots at t=0, which can’t evolve during the lifespan of the building.

These three issues will become more and more important during the lifecycle of the building and need to be taken into account.
**Detailed research question 2: Which impact do principles based on lifecycle focus have on the way we experience buildings?**

For this research the identity of on lifecycle focus HighRise projects are analyzed. Identity can be categorized in two groups namely:

- **Inner Identity:** The inner identity is conceptual formed by the function of a building. The public space can affect the function but is not in direct relation to the inside. The inner identity can be seen as the way we experience spaces related to a particular function.
- **Outer Identity:** The outer identity is conceptual formed by the surrounding area of a building. Functions can affect the public space but are not in direct relation to it. The outer identity can be seen as the face of the building towards the outside world as a part of the public realm.

Designing means finding the optimum between these inner and outer identity.
- Focusing more on the outer identity, the more it imprisons the inner identity.
- Focusing more on the inner identity, the more it shapes the outer identity.

**Detailed research question 3: To what extent are the existing principles based on lifecycle focus useful in redesigning our new process approach?**

For the construction of our process approach we have used many aspects from different existing lifecycle approaches which are elaborated in phase II: studies. In short the following aspects were useful:

**Drager & Inbouw (Habraken, 1961)**
- Dividing the design into Frame & Infill.

**Open Building (Habraken & Kendall, 1965)**
- Dividing the Frame & Infill in different building layers based on their lifespan.

**IFD Building System (Dutch Government, 1999)**
- Relating the design to a unit (grain size) which is demountable.
- Optimally flexible as well as sustainable.
- Because of demount ability materials can be reused hence sustainable.

**Lean Construction (Toyota, 1993)**
- Flexible process of programming.
- Identify & deliver value to the costumer.
- To deliver quality actors should have a holistic approach towards the entire design and construction process. Processes do not work well when every person tries to optimize their performance without understanding how their actions affect the larger web.

**I3con (European Project, 2006)**
- Holistic approach towards industrial intelligent integrated constructions.
- The design of a flexible infill in relation to the entire building.
- Potential clients of ‘Evolving Buildings’.
Sustainability in perspective (Draaijer+Partners, 2009)

Biomimicry
- Use the output (surpluses and waste) as input
- Separate resources in three categories, namely: material, energy and information flows.

Solids (Stadgenoot, 2010)
- Disconnect the main and secondary building system. Link the main building system to the unit (grain size) and the secondary building system is seen as a part of the infill.
- The amount and price of rentable floor area can be decided by the tenant himself. This also decides the feasibility.

**Detailed research question 4: What needs to be adjusted in our process approach based on lifecycle focus to fill up the noticed lack?**

As elaborated in chapter 6, our process approach is formed according to literature and gradually evolved because of our own design and the critics / possibilities from actors in practice. In spite of this the process approach has undergone several changes throughout our graduation period. The improvements can gradually be found back in chapter 6. The following aspects were adjusted to fill up the noticed lack:
- Integrating product & process flexibility.
- Dividing the Program-of-Requirements into Program-of-Investor & Program-of-User.
- How to design the depth, width, height & grid of the unit
- Seeing flexibility and sustainability as conditions which fit in any type of structure, façade, building system, and infill.
- Translate lifecycle focus on the scale of the building & city
- Translation People, Profit, Planet into Home & Humanity.
- Not only horizontally but also vertically flexibility as a possibility
- Not seen sustainability as measurements but thinking in flows of material, energy and information. Sustainability should have the possibility to evolve.
- Defining Lifecycle focus as: ‘Flexibility as foundation of sustainability’.

**Detailed research question 5: What can be improved in our process approach based on lifecycle focus for future research?**

Firstly, our process approach is tested on a fictive HighRise project. This HighRise project is used as a test and example of how the theories could be implemented in a design process.

Secondly, this process approach can be used in the form of workshops with more fictive projects in order to get more inside in its usability.

Finally, the following and inevitable step is to test these theories on a project in practice.
Answer to the main research question:

According to the answers of the detailed research questions the main research question can be answered.

To what extent and in which way can a process approach based on lifecycle focus optimize a building in order to react on changes during the buildings’ lifecycle?

The manual which provides a process approach based on lifecycle focus can be used by advisors of clients in real estate development on a strategic level, which will guide them question based through the whole design process. In every project development phase the client is made conscious about his decisions in relation to flexibility and sustainability and their impact on technical and financial feasibility.

The manual provides a tool, a guide that can be applied in order to design buildings / areas which are flexible and able to react on changes causes by the dynamic environment.

Every project (no matter what scale) can be divided into a frame and infill. For both the process approach can be used to define an on lifecycle focused program and design.

Nevertheless when programming and designing the frame regulations are created in which the infill should operate. So the regulations of the frame always reduce the degree of flexibility and sustainability towards the infill.

At the end the more flexible and sustainable the frame is the more flexible and sustainable the infill can be.

Finally the Strategic Manual should make us consciousness about the way we build today and its impact on our ‘City of Tomorrow’.
10 Reflection & Recommendations

Reflection
The Strategic Manual isn’t intended to be a definitive work on the flexibility and sustainability in architecture. There are a number of other texts that have already done a wonderful job of bringing this kind of information to our awareness today. Some of them we have referenced here - Habraken’s Drager en Inbouw, Kendall’s Open Building and Frank Bijlendijk’s Solids. Each of these represents a powerful new way to see our world, and we recommend them all.

Mies van der Rohe stated: ‘To make something simple a lot of effort is needed’. Again and again we use a lot of effort to simplify the manual. As illustrated in chapter 6 & 7 (forming the manual) we have tried to illustrate the ongoing never-ending simplifying process towards an appropriate process approach. The last evaluation of our process approach towards lifecycle focused evolving architecture was a workshop in which we tested the strategic manual. The workshop was planned with advisors from the project management office Draaijer+Partners. During this workshop we used one of the currently active projects. The workshop concluded several attention points which are:

- The infill needs the same process approach as the frame
- The questions within the strategic manual chapter lifecycle focus were too short hence not clear enough to be used by others.
- We also noticed that many aspects in the manual are clear in our own mind because of our knowledge about this subject but sometimes not easy to understand for people which have not yet deal with this kind of thinking.

According to this attention points we redesigned our process approach as illustrated below. In this process approach we aim to create an approach towards every real estate project which scale.

Figure 65 Final Process Approach
Finally the strategic manual is intended to be a useful tool, a guide that can be applied as a process approach towards our everyday building constructions. For this reason we have chosen to focus more on a strategic level, rather than getting bogged down with too many technical details.

Nevertheless when programming and designing the frame regulations are created in which the infill should operate. So the regulations of the frame always reduce the degree of flexibility and sustainability towards the infill. At the end the more flexible and sustainable the frame is the more flexible and sustainable the infill can be.

In all honesty our intentions were to create a manual how to design a flexible and sustainable HighRise project. During our research and relation to practice (Draaijer+Partners) we realized that our research results were related to the whole construction industry. At that moment we decided to take the manual one step further, namely making the strategic manual appropriate in use for any kind of real estate. This long process of again and again redesigning the process approach to make it fit to any kind of real estate projects again broad us the inevitable question, namely: Why can we not use the same strategy towards any object which includes and process and product? Unfortunately the time is like always our enemy. Hence we don’t say that we know everything about flexibility and sustainability. Science doesn’t have all of the answers in all honesty. We could study this subject for another hundred years and still not find all the answer.

In addition to describing the theories about lifecycle focus, this strategic manual takes us one step further: it provides a process approach on the basis of questions which aims to implement how those discoveries can help us become better people and build a better world together.

We’ve written this strategic manual for one reason: to offer a sense of hope, possibility, and empowerment in a world that often makes us feel small, ineffective, and helpless. And our goal is to do so in a simple question based conversational style that describes the awesome insights of the new process approach towards sustainable buildings in a way that’s interesting and easy to understand.
Recommendations
In this double graduation project the theories are tested on a fictive HighRise project. This HighRise project is used as a test and example of how the theories could be implemented in a design process. What we do know, however, is that there is enough theorized about this subject Yet, the following and inevitable step is has to be taken namely testing these theories on a project in practice. This subject should find it’s through identity starting with pilot projects. This pilot projects should finally give us practical concept on which we can structure our future. The decisions that we take, makes of us who we are. It’s not about the amount of proper decisions that we take but the decisions that help the world on a sustainable way.

‘Be the change you want to see in the world’

To really make the difference we, Draaijer+Partners and the Delft University of Technology are seeking for a proper way to continue this research in the form of a PhD to test the formed theories in practice.

At the end of this research we can assure you one thing with certainty:

*All buildings are predictions and all predictions are bound to be wrong. The more flexible we are causes less prediction. The less we predict the more sustainable we are.*

---

57 Mahatma Ghandi
Content:
Chapter 11: Vocabulary
Chapter 12: Literature
# 11 Vocabulary

<table>
<thead>
<tr>
<th>Vocabulary</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program of Requirements</td>
<td>A document with the requirements, demands and wishes of the client.</td>
</tr>
<tr>
<td>Strategic Manual</td>
<td>A book which describes the process approach on a strategic way.</td>
</tr>
<tr>
<td>Method-of-Programming</td>
<td>Programming according to guidelines.</td>
</tr>
<tr>
<td>Method-of-Designing</td>
<td>Designing according to guidelines.</td>
</tr>
<tr>
<td>Static &amp; Dynamic</td>
<td>‘Static’ are the solid elements in a design or program and ‘Dynamic’ are the flexible elements in a design or program.</td>
</tr>
<tr>
<td>AR</td>
<td>Architecture</td>
</tr>
<tr>
<td>RE&amp;H</td>
<td>Real Estate &amp; Housing</td>
</tr>
<tr>
<td>UR</td>
<td>Urbanism</td>
</tr>
<tr>
<td>DCM</td>
<td>Design &amp; Construction Management</td>
</tr>
<tr>
<td>HB</td>
<td>Hybrid Buildings</td>
</tr>
<tr>
<td>TB</td>
<td>Tall Buildings</td>
</tr>
<tr>
<td>BT</td>
<td>Building Technology</td>
</tr>
<tr>
<td>TU Delft</td>
<td>Technical University of Delft</td>
</tr>
</tbody>
</table>
12 Literature


APPENDIXES

Content:
A  Article Boss Magazine Risk
B  Artiele Boss Magazine 2020
C  Drawings Solid 1 & 2
D  Drawings Solid 11
E  Drawings HighRise Project
F  Urban Analysis Rotterdam
G  Thesis Architectural History
Lifecycle focus as a method of programming & designing

‘Perfection means something is complete and stands still and what stands still doesn’t change or evolve and is automatically dead. Everything in the universe changes, evolution implies that the creation is not complete hence the possibility of evolving’. (Osho, 1985)

Sustainability becomes more and more an important part of the construction industry. Only if we start thinking in the terms of lifecycle sustainability become possible. Adaptability has to be seen as the foundation of sustainability. This article defines the theories about lifecycle focus as a method-of-programming & designing in the construction industry. These are the results from of our double graduation project between Architecture and Real Estate & Housing and will finally be published in the manual ‘The Anatomy of the Hybrids’ during the summer of 2010.

Philosophy

‘Built environment is the product of an ongoing, never ending, design process in which environment transforms part by part’ (Habraken, 2002).

Beside the built environment the demands an wishes of users also change all the time. Most of the current building stock is developed as mono-functional buildings and even not adaptable within their own specific functions. Because of their shortcomings in adaptability they are more likely to become vacant as we see in the current office stock. There is no point in creating a sustainable building if it becomes vacant throughout its lifecycle.

‘Hybrid: The offspring of two animals or plans of different breeds, varieties, species, or genera, esp. as produced through human manipulation for specific genetic characters’ (L. Hybida, 1595).

We need dynamic systems to become optimally sustainable throughout a buildings lifecycle. Hybrid is the definition we give to such dynamic systems. So we use the word Hybrid in its purest form like when it was defined in 1595-1605. Hybrids are carrying the capacity to accommodate a set of evolving demands regarding time, space & function.
Hybrids
The main question remains how can we achieve a dynamic system like the Hybrids? Are their specific heights and floor plans for each function or can we really design a dynamic system? Does ideal plans exists?

For example when looking at HighRises we can assume that there are mostly two main functions in the tower namely a residential or an office function. Other functions are mostly located in the plinth or tower levels with their own specific requirements. Because we focus on the main functions in the Hybrid HighRise the tower needs to be analyzed.

To make the analysis simple we demonstrate two random office, two residential and one multifunctional HighRise plans. When analyzing different types of mono functional offices tower plans through time we can conclude that every plan has its own quantities and rations. Depth, Height and Form differs from time to time and from HighRise to HighRise.

The same can be said about the mono functional residential towers. Real similarities are hard to be found. This can be explained quiet easily when we look at the developments in the past decades. Everything changes, we are working and living different as 50 years ago and shall keep changing on our way to the future.

Some actors within the construction process already accepted the fact that a ideal plan for a mono functional building doesn’t exist. Looking at the Multifunctional HighRise plan we see almost the same basic floor plan but the functions differ within the tower. The tower is divided into a lower residential and a higher office part. The only thing that’s missing in these HighRise tower typologies is that they cannot be transform among each other mainly because of the limitations they have in their installations and elevator configurations.

According to lifecycle analysis in these HighRise towers one important lesson can be learned:

*Form shouldn’t follow function, but functioning* (Bijdendijk 2006).

Process Approach
In order to achieve maximum sustainability in Hybrids the process of programming and designing has to be approached in a total different way than we are used to. The conservative way of thinking (thinking in short term) in the construction industry has to be changed. The vicious circle of blame has to be broken by making the different actors conscious about the lifecycle approach and its benefits for the people, profit and planet. By making them conscious about the lifecycle approach means also making them transdisciplinary (understand the role and actions of other actors within the same process).

The process has to be approached as illustrated in figure 2. The process starts with the outer ring in blue which relates to the investor (financier) of the project. The investor comes with a program (m² offices, residential, public, etc.). His advisor(s) (project manager, project developer, architect, etc.) make him conscious about the lifecycle approach and its benefits. To achieve sustainability two different Hybrids can be chosen namely: Mono & Multi-functional Hybrids. When the investor chooses for one of these two Hybrids his program starts changing into a so called ‘Program of Wishes’ (more flexibility in the buildings program).

By making the program more flexible the program of requirements and the design can be divided in two separated parts namely: Frame and Infill. The frame (orange) should be developed according to the Program-of-Investor which means that the frame will be financed, programmed, designed and constructed for a long period of time for example 100 years (Static).
The infill (blue) should be developed according to the Program-of-User which means that the infill will be financed, programmed, designed and constructed for a short period of time for example 10 years (Dynamic). Because of the short lifespan of the infill this process can be repeated many times throughout the life cycle of these Hybrids.

The different layers in the program and design make the building utterly flexible. Every layer has its own lifespan. Sustainability can be poured into every layer separately. In this way maximum sustainability can be achieved per layer.

**Investors Consciousness**

The Hybrid is as discussed before separated in two parts namely frame and Infill. The investor owns the permanent function free frame. The user is the owner of the temporary infill or the investor rents the temporary infill to the user. The investor ask a basic rent for this frame. The user can choose to develop the infill or to ask the investor to do this for him. In this case the user pays a additional fee to the investor. The user decides the design of the infill and the period of use. This causes to cost of the user.

The user has a direct influence on these costs. The total rent of the user consist of the basic rent of the frame and the costs for the infill. In this way one creates and keeps the value of the building. In some situations the investor and the user can be the same.

The main question remains what does sustainability in the form of flexibility cost the investor?

An investor is used to divide the estimated first year rent by the activated investment costs. The result of this calculation is the so called Gross Initial Yield (GIY). For example the GIY for residential functions is lower than for offices. This is caused by the different risk profiles.

The Hybrids are constructed for a large market because of their degree of flexibility. When aiming on a larger market the risk of vacancy becomes lower. In this case the GIY for different functions within the Hybrids becomes the same. This means that the Hybrids can be optimized according to the rent and the investment costs. For example we can assume that when the Hybrids lower the GIY with 1% an additional fee of 15% can be invested in flexibility on above the general investment. This is possible if the rent stays on the same level as normal market prices. This additional fee above the general investment decides the feasibility of this Hybrids.

When looking at the total lifecycle of a Hybrid many other benefits can be noticed. If we assume that the market, requirements and needs of the users or regulations change every 20 years than the costs of transformation, maintenance, risk of vacancy, etc. become much lower.

Optimizing by value needs a total different way of thinking. The Hybrids are optimized by value which finally translate itself in a higher exit yield throughout its lifecycle. In this way the Hybrids become close to nature. The nature always enriches itself and does never retrench.
Programming for Investor & User

When programming a Hybrid a clear path has to be drawn in order to separate the design into a frame and infill. As already discussed the process usually starts with a general program according to the vision of the investor, advisors and local authorities.

According to the lifespan of a building the degree of sustainability in the form of flexibility can be formed. For example if a building has a lifespan of 100 years on a location with many potentials for multifunctional use it is recommended to choose for a Hybrid with Multi instead of Mono-Functional-Flexibility. In this way the Hybrid can react on the changing requirements and needs of its users throughout its lifecycle.

To make the design of the Hybrid possible we have to reverse the process and translate the Program of Wishes into requirements in order to be able to design & construct. Because the Hybrids are separated into two main parts, namely frame and infill, the program has also to be divided in two parts.

For the design and construction of the frame we need a Program-of-Investor. This part of the program and design is as we call it the ‘Static’ part of the design which belongs to the Investor and has a long lifespan.

For the design and construction of the infill we need a Program-of-Users. This part of the program and design is as we call it the ‘Dynamic’ part of the design which belongs to the User and has a short lifespan.

The Program-of-Investor & User has to be formed according to the design theories which are explained in the next paragraph. These two documents need to be based on the different layers within a Hybrid.

Designing for Investor & Users

To design the Hybrid according to the Program-of-Investor & User one thing has to be understood. Designing can roughly be divided in three parts, namely: the urban design, the design of the frame and the design of the infill of the Hybrid.

To make this three parts clear we have used the metaphor of the human. The urban design can be compared with the humanity. The design of the frame of the Hybrid can be compared with the human anatomy. The design of the infill of the Hybrid can be compared with the ability of the Human to accommodate and react on external circumstances.

The Humanity

Every human in a democratic society has the freedom and ability to make decisions within the limits of the governmental laws and regulations. The urban design should provide a frame with basic regulations and laws in which every building can decides its own degree of sustainability and flexibility.

The Human Anatomy

Every human consists of different organic layers with each their own function and lifespan. The frame design of the Hybrid should be constructed according to these layers, as we can see in figure 5.

The skin forms the façade as the face of a Hybrid towards the outside world. The façade is the image which is conceived from outside which makes it a part of the public space. The façade can either have a long or a short lifespan. This depends on the degree of sustainability in the form of flexibility.

The muscles & skelet are together forming the structure. The muscles are subjected to tension and the skelet is subjected to load forces which is also the case in the structure of a building. Like the muscles and skelet in the human body the structure is build op in the first years for the buildings total lifespan.

The heart & the organs form the transfer & installations in a Hybrid. Like the heart with the blood, the transfer pumps the people throughout the building. Like the organs with different nutrition’s, the installations pumps to and subtract the different needs like water, energy, etc. from the building. In the human body the heart and the organs are irreplaceable because of their unique character and the same can be said about the transfer & installations, hence a long lifespan.

The veins form together the building system of the Hybrid. Like the veins, the building system links and
Every human has the ability to accommodate and react on external circumstances because of its unique adaptable body. The human has the possibility to sit when there is a chair, jump when there is an obstacle, answer when there is a question, in short the ability to be the frame which makes almost everything possible. Designing according to the human anatomy will provide a Hybrid. As discussed before a Hybrid has the ability to accommodate and react on external circumstances. It has the ability to accommodate the infill which is formed by external circumstances like the market, requirements and needs of the users or regulations trough the Hybrids lifecycle.

The Ability of the Human
Every human has the ability to accommodate and react on external circumstances because of its unique adaptable body. The human has the possibility to sit when there is a chair, jump when there is an obstacle, answer when there is a question, in short the ability to be the frame which makes almost everything possible. Designing according to the human anatomy will provide a Hybrid. As discussed before a Hybrid has the ability to accommodate and react on external circumstances. It has the ability to accommodate the infill which is formed by external circumstances like the market, requirements and needs of the users or regulations trough the Hybrids lifecycle.

In 'The Anatomy of the Hybrids' these theories will be tested on a HighRise design. This HighRise project is used as a test and example of how the theories work throughout the manual. 'The Anatomy of the Hybrids' will be published in the summer of 2010. The following and inevitable step is to test these theories on a pilot project in practice.

But one thing we can assure you with certainty: All buildings are predictions and all predictions are bound to be wrong. The less you predict the more sustainable you are.

Saman Mohammadi & Niel Slob are currently graduating for the double master course Architecture (Hybrid and Tall Buildings) and Real Estate & Housing (Design & Construction Management) at the faculty of Architecture in Delft.

For Real Estate & Housing they are researching lifecycle focus as a method of programming & designing. To prove the benefits of a lifecycle approach in terms of People, Profit & Planet, they use flexibility as a tool to achieve maximum sustainability throughout the buildings lifespan. For Architecture they test their research results on a HighRise design.

In forming 'The Anatomy of the Hybrids' they use the expertise of the following consultants from TU Delft: ir. R.P. Geraedts, ir. R. Bollen, ir. H.T. Remoy, ir. Y.J. Cuperus, dr. ir. A. van Timmeren & ing. P. de Jong

In order to shorten the distance between their findings and the practical way of developing they corporate with project management office Draaijer+Partners (d+p). d+p is involved in a European project called I3Con (Industrial, Integrated, Intelligent Constructions) which highly overlaps and interacts with their theories. The interaction between their Manual and I3Con is the interaction between theory and practice. The following advisors from d+p are involved: ing. J.H. Camphuijsen, ir. L.D.M. Kemp, ir. H. Hellinga & ir. L. Wolters.

They also use the expertise of the following participants from practice: ir. C.H.C.F. Kaan, dipl.-Ing. B. Schummer (Claus & Kaan Architecten), ir. F.Ph. Bijdendijk (Stadgenoot), ing. R.M. Valk (LSI) & ir. J.A. Westrik (Municipality Rotterdam).
In current cities, most of the buildings are realized as mono-functional snapshots. The ‘City of Tomorrow’ should consist of buildings which can evolve during their lifecycle. It should provide a life-web which interlinks all the material, energy and information flows among buildings. In this way the city becomes an ‘ecosystem’ in which terms like surplus and waste will disappear for all times. This article defines the theories about lifecycle focus on the scale of city and building.

Perfection means something is complete and stands still and what stands still doesn’t change or evolve and is automatically dead. Everything in the universe changes, evolution implies that the creation is not complete hence the possibility of evolving’ (Osho, 1985).

In every seed there is, more or less, a pure plant, an archetype. As the plant grows, the individuality of its surroundings, soil, climate and so on causes it to modify this archetype. If you look closely, even two adjacent clumps of grass are different. Trees can be so different that we recognize them as individualities. Even development in time is a metamorphic process: young and mature early and late leaves have different shapes. When we build objects that don’t evolve, we deny this life process and this response to surroundings. We impose dead ideas, often ideas which aren’t even modified by materials (in the way that clouds often form the shape of a landscape, itself made up of a metamorphic series of forms).

Most of the current building stock is developed as buildings that don’t evolve, not even within their own specific function. On the scale of the city we can notice that there are different layers like the infrastructure, green, buildings and so on. On the scale of the building we also have different layers like the structure, façade, installations and so on. All these different layers have their own lifespan and they are separately connected to flows of material, energy and information. If we want to be lifecycle focused, we need a dynamic system which interlinks all the buildings with their flows of material, energy and information on the scale of the city. In this way we create evolving buildings which carry the capacity to accommodate a set of evolving demands regarding time, space & function.

Flexibility as foundation of Sustainability

‘Like strong colours, repetition leaves us un-free. It’s hard not to give ourselves over to repetitive music. Rhythm brings the first transformative influence of life; flexibility carries it further’ (Day, 2004).

Designing and maintaining systems in a dynamic contemporary environment requires a rethinking of how systems provide value to stakeholders over time. Developing flexible instead of classically robust systems are needed to create an evolving construction industry. This means that we need to be flexible as well in the way we implement sustainable measurements. Buildings need to be sustainable during their lifecycle, which means that sustainability also should have the possibilities to evolve. To be really sustainable we need to think about flows of material, energy and information based on the difference in layers and lifespan. Hence flexibility provides the ground for an evolving sustainability.
Dead Architecture

‘Built environment is the product of an ongoing, never ending, design process in which environment transforms part by part’ (Habraken, 1961).

Beside the built environment the demands and wishes of users also change all the time. Most of the current building stock is developed as mono-functional buildings and even not adaptable within their own specific function. Because of their shortcomings in flexibility they are more likely to become vacant as we see in the current office stock. These buildings are ‘dead’ and yet the question arises: Do we want to make more ‘dead’ architecture?

The Beginning

‘Thinking in long terms’ (Habraken, 1961).

‘Drager en Inbouw’ is one of the first principles that had raised personalization and redevelopment in the architecture. It is the idea of Habraken, an inspired way of thinking, focused on the future of buildings. Today, in this dynamic environment, it’s more topical than ever. Centralized, is how the community relates to the individual and how this relationship is reflected in the built environment. In his idea, the frame (drager) reflects to the collective and has a long lifespan. The infill (inbouw) reflects to the individual and has a short lifespan. “Drager en Inbouw” should be disconnected in terms of decision-making and technical support. The infill can be changed without changing the frame throughout the lifespan of a building.

Evolving Architecture

‘Change is the only constant factor in Universe’ (Asimov, 1992).

There is no point in creating a sustainable building if it becomes vacant throughout its lifecycle. We need dynamic systems to become optimally sustainable throughout a buildings lifespan. Unfortunately, the neoclassical environmental and resource economics have an approach towards buildings as objects, which can be used and extracted from. We are not the first once to build on this planet. How does nature build? What if every inventor, at the moment of creation, could ask: How does nature solve this? By approaching nature as a model we may find a holistic approach how to overcome our environmental problems. In the 1960s, Forrester started describing the world as a ‘series of interwoven systems’. Although systems are non-physical, they seem to provide structure to our whole reality. All living species are self-regulative systems, interconnected by networks, and thereby forming larger ecosystems. An ecosystem in nature connects individual flows of material (knowledge of chemistry), energy (physics & thermodynamics) and information (systems theory) into a life-web among organisms hence there are no surpluses and waste. When building our ‘City of Tomorrow’ the biggest challenge would be to regulate flows of materials, energy and information compatible with similar flows inherent in a natural ecosystem. This philosophy can be made possible when these flows are interconnected among the building-layers or in buildings mutually.

According to Keitsch, the most sustainable systems are those which are most complex and open. More complex systems seem to be more ‘intelligent’ and more flexible for (unforeseen) changes. Inside these complex systems we have to come up with simple solutions. From this point of view we can definitely pursue that the best strategy is to primarily build upon effectiveness not on efficiency. Dynamic open systems provides the ground for evolution hence being utter effective. Efficiency mostly implies static close systems.

In the current cities all the buildings use resources like water, cooling, heating and so on without reusing their surpluses and or waste. The ‘City of Tomorrow’ should provide intelligent systems in which buildings cooperate mutually and share their different resources like an ecosystem does. On the scale of building the flows of materials, energy and information should be interconnected among the different building-layers with each their own lifespan. The building should provide a shell for the total lifecycle of a building which will further grow its soul because of its possibility of evolving.

Identity

But what is becoming the identity of our ‘City of Tomorrow’ with it’s evolving buildings? Are we making a characterless city with soulless architecture?

To answer these questions we need to identify identity. When looking at buildings we can conclude that they consist of an inner and outer identity. The outer identity is conceptual formed by the public realm and the inner identity by the functions (infill) within the building. The inner identity can be seen as the way we experience spaces related to a particular infill and the outer identity as the face of the building towards the outside world as a part of the public realm. The infill can affect the public realm and vice versa but they are inevitably separated by the frame. Finally the frame determines the basics for both identities in a building.
When focusing on the lifecycle of buildings the outer identity can be approached on two radically different ways. On the one hand buildings can obtain a strong outer identity because of their ‘dearness’ to the public realm through time. On the other hand referring to the present means an identity which can be obtained through time and not on a particular moment hence the possibility of evolving.

When comparing these two different approaches we conclude that the outer identity designed for the total lifecycle of a building always limits the evolution of the inner identity. So the frame should be created in such a way that both identities allow each other to evolve. At the end all buildings are predictions and predictions are bound to be wrong, so also both identities are bound to be wrong. When we construct evolving architecture we can optimize an inner and outer identity through the buildings lifecycle. In this way a building will further grow its soul because of its possibility of evolving.

Usability
Yet, how will the ‘City of Tomorrow’ be used? Who are the owners and users of these so called evolving buildings?

The ‘City of Tomorrow’ allows multifunctional use in it’s evolving buildings hence the city becomes a dynamic environment where functions within areas can shift and change. Users can easily leave or change their way of use within the same building with the least effort. In this way the ‘City of Tomorrow’ becomes utter usable because of the close collaboration with it’s dynamic environment.

The investor decides about the outer identity and owns the permanent frame. The user is the owner of the temporary infill and rents the frame or the investor rents both the temporary infill and frame to the user. In some situations the investor and the user can be the same.

Feasibility
Using flexibility as foundation of sustainability means that material, energy and information flows reach a particular building for a certain price but simultaneously surpluses and waste can be linked to the life-web of the city so one can make money out of it. This way of approaching buildings needs a total different way of thinking. Focusing on lifecycle will finally translate itself in a higher exit yield throughout the buildings lifespan. In this way the ‘City of Tomorrow’ become close to nature because the nature always enriches itself and does never retrench. Sustainability decides the feasibility of these evolving buildings in terms of lifecycle.

An investor is used to divide the estimated first year rent by the activated investment costs. The result of this calculation is the so called Gross Initial Yield (GIY). The GIY for residential functions is often lower than for offices. This is caused by the different risk profiles. Buildings in the ‘City of Tomorrow’ are focused on a larger market because of their possibility of evolution. When aiming on a larger market the risk of vacancy becomes lower, so the GIY decreases. This means that the building can be optimized according to the rent and the investment costs. With a lower GIY and normal market rents there will be more investment fee for flexibility and sustainability. This additional fee above the general investment decides the feasibility of these evolving buildings in terms of short investment period.
‘When a cell in the human body become abnormal and starts dividing without control it firstly uses all the surrounding resources and then it affects the total body. In the biology we call this cancer, in the psychology it is called ego and in the construction industry we can call this phenomenon the conservative way of thinking.’

Sustainability becomes more and more the foundation of the construction industry. We have tried to create terms to define sustainability. People, Profit and Planet is currently the symbol for sustainability. These three pillars capture an expanded spectrum of values and criteria for measuring organizational and societal success: economic, ecological and social.

Albert Einstein mentioned: ‘you can’t solve problems in the same line of thinking you created them.’ These three pillars are created in a world which is led by people with a conservative way of thinking. In the current construction industry the projects are mostly driven by finance. Stakeholders are focused on short investment periods. But Profit can’t be separated from People and Planet hence we introduce the terms Home and Humanity. In the ‘City of Tomorrow’ Profit should be seen as the result of value creating evolving buildings.

HOME is our planet and the cities where our houses are a part of. We are not the first ones to build on this planet. What if we, at the moment of creation, could ask ourselves: How does nature solve this?

The world is a ‘series of interwoven systems. All living species are self-regulative systems, interconnected by networks, and thereby forming larger ecosystems. An ecosystem in nature connects individual flows of material, energy and information into a life-web among organisms hence no surpluses or waste arise. When constructing the ‘City of Tomorrow’ the biggest challenge would be to regulate flows of materials, energy and information compatible with similar flows inherent in a natural ecosystem. This can be achieved when the resource flows are interconnected to the life-web of the city among the different building-layers or in buildings mutually. From this point of view we build upon effectiveness. When we build effective these resource flows reach the building for a certain investment cost and leave the building for a certain revenue. This way of approaching cities and buildings create values which unavoidably result in profit.

‘We are now more than ever facing the biggest challenge of our century. We are a part of a brilliant planet, surrounded by geniuses. We need a way to remind our self’s those geniuses and to somehow meet them again. We should be in touch with this incredible models, this elders that have been on this planet far, far longer than we have and hopefully with their help we learn to live on this earth and on this Home that is ours but not ours alone’ (Benyus, 1997).

HUMANITY is where we build for. Constructing for human beings means thinking of buildings as spaces for living, working an so on.

Design doesn’t stop when buildings are completed. It’s routinely renewed during occupation and adaption. It should be easier to adapt buildings when potential benefits or shortcomings become apparent. Where opportunities exist for the builders to become artistically involved in their work, such buildings have a distinct soul even before they are occupied. The spirit of a place can develop because of, not in spite of, the building. It makes a lot of difference whether things are designed for people or together with them. Architects hope their buildings will last for several generations, but however much they design with occupants in mind, they’ll never meet all of their future requirements and wishes. Unless we design something nourishing to our soul, not just nice, dramatic, photogenic, novel, we can’t hardly expect it to be nourishing to Humanity. When we love our buildings again value is created which unavoidably result in profit.

‘Neither past nor future mean anything on their own. Future grows out of, is fed by, past; and past is always inspired by future. Development, whether buildings or any other aspect of place, if aligned with this continuum, will ‘fit’ timelessly in place and time. Non-aligned, imposed ones can’t. To be harmonious, the new needs to be an organic development of what is already there, not an imposed alien’ (Day, 2004).
Saman Mohammadi & Niel Slob are currently graduating for the double master course Architecture (Hybrid and Tall Buildings) and Real Estate & Housing (Design & Construction Management) at the faculty of Architecture in Delft.

For Real Estate & Housing they are researching lifecycle focus as a method of programming & designing. To prove the benefits of a lifecycle approach in terms of Home & Humanity, they use flexibility as a tool to achieve maximum sustainability throughout the building's lifespan. For Architecture they test their research results on a HighRise design.

Finally the results will be published in the strategic-manual, ‘Flexibility as Foundation of Sustainability’ in October 2010.

In order to shorten the distance between their findings and the practical way of developing they cooperate with project management office Draaijer+Partners. They also use the expertise of the following participants from practice: Claus & Kaan Architecten, Stadgenoot, LSI & the Municipality of Rotterdam.

References

- Meadows D. (2004) Limits to growth, the 30-year update
3D IMPRESSIONS
Elevation

Vertical Section

Horizontal Section

WEST FACADE ELEVATION AND SECTIONS

SOUTH FACADE ELEVATION AND SECTIONS
THE IMPACT OF TALL BUILDINGS
On the urban experience of Rotterdam. Case Study: Schiekadeblok, Hofplein
Introduction

Urban Context
- Fighting the Downtown Dullness
- Connecting the Centre
- Displacing the Centre
- Accelerated Evolution and WWII
- Perception of the Skyline

Building Block
- Building Block in Perspective
- Chopping the Weena
- Van Traa's Boulevard
- Face of the Weena
- Streetlife

HighRise
- HighRise Districts
- The Birth and Growth
- Merging with the City
- Composition of the HighRises
- Rotterdam HighRise Facts

Participants
Introduction to the report

What is the impact of high rise on the city? This analysis focuses on the specific impact of high rise on the city Rotterdam, the perception of the city and her functionality. To incorporate this analysis more in our design studio work, we limit ourselves to the factors that influence our design location (Schiekadeblok).

There are already several analysis and investigations done for this area. This analysis can be seen as a complementary document on the existing research. Therefore a summary of significant drawings from other documents is attached.

This analysis is built up in three scales. First the urban scale, from regional impact to an analysis of the city centre. Then the Plot scale, with the central district area as surroundings. And for last the building scale, where the specific features of high rise that determine the city as context are examined.

Why focus on high rise in Rotterdam?

Rotterdam wants to be known for its skyline. The marketing position of Rotterdam depends on its skyline. Why?
Positive effects
• Densification and diversification of the city centre
• Being modern
• Modern grid and big boulevards can accommodate high rise easily
• Spectacular views can be created over the river Maas and from the farmland upon the city, which provides unique selling points
• Metropolitan living and working in downtown Rotterdam

Negative effects
• One of the biggest challenges of high rise is to accommodate all ground floor related functions on a small plot. This means a big area of the façade on ground floor is used as entrance or exit for supplying the building of goods. Also the building structure demands more space than normal, which concludes in a quite closed façade on street level most of the times. This should be avoided for the continuity of program on street level, which makes city centers readable and exciting.
• High rise has a negative effect on city comfort. Where low rise functions as a windshield, high rise just increases inconvenience from wind. In wintertime the shadows caused by high rise can reach up to 1 km, for a building only 200m high.
• As positive counterpart the only advantage it gives to the urban dwellers, is a skyline (metropolitan allure). The upper floors of high rise buildings in Rotterdam are up to now barely accessible for public. Since the views are spectacular, it is almost antisocial to burden city dwellers with the negative effects of high rise in their direct environments without cashing in something of the high rise experience.
impact of tall buildings on the urban experience of Rotterdam. Case study Schiekadeblok, Hofplein
Heavy industry and living are a polemic combination. How to accommodate the two on a small area? Rotterdam had a strong ambition to house the biggest harbor in the world. But besides the harbor it should also be a home to all the workers.

Separation of functions, as proclaimed by CIAM utopians worldwide, was fully embraced by town planners from Rotterdam. The new city centre was destined to be used for culture, commerce, recreation and work. Living was planned around it in extended suburbs.

Around the seventies planners wanted to get rid of this mono functionality. Separation of functions and low density did not lead to a lively and exciting downtown. Since this turning point densification projects where planned on strategic points within the old city centre, to accommodate more housing near the existing commercial, recreational and office buildings.

Besides these densification projects, also new districts are filled in with high rise. From 1985-1995 the Weena finally got it’s long waited street profile. And from 1995 up till now high rise for international offices are built on the Kop van Zuid. These projects are thought out as mixed and dense areas. The current situation though shows heavy plinths that accommodate few public functions and are not capable of interacting with the public space.

Program: zoning vs mixed, densifying and diversifying, connecting through program
The lack of a natural historical growth and evolution can be experienced in the lack of commitment to the city centre from its dwellers. The city has little capacity to maintain dwellers within her walls. Rotterdam is often referred to as urban landscape. In the current situation it is difficult to attract people to live in the centre.

Living in the incorporated municipalities or suburbs is much cheaper and they are excellently connected by public transport. densification by high rise is therefore a struggle between feasibility in costs and rivalry with low prices in the suburbs. This results in a majority of new housing projects for the high end class.
Our Plot is located on a very strategic point considering regional and even international transportation. Only a five minutes walk from the central station where a high speed train connection is an outcome for traveling through Europe. Also it is located on the beginning of a main access to the city centre, easily accessible by car.
DISPLACING THE CENTRE
Transport and structure: centre zones projected through time

"Onder de stedenbouwkundigen, bestuurders, ondernemers en architecten bestaat een voortdurende drang om het centrum radicaal te verbeteren om het bestaande los te laten en het nieuwe ruim baan te geven."
Pedestrian streams

The continuous displacement of the city centre from east to west has led to strong urban boulevards in north-south direction and weak urban boulevards in east-west direction. In this context an urban boulevard is defined by a boulevard which is a readable path connecting important secondary roads and functions for a city and is used by pedestrians as an orientating device. The main east-west boulevards (Weena in the north) and three north-south boulevards are marked in the sketches, from left to right: Westersingel, Coolsingel and Binnenrotte are badly connected for pedestrian streams.

The Coolsingel forms a connection between old and new centre and houses therefore some of the most important public buildings of Rotterdam. Such as its town hall, stock exchange and international warehouses. Coolsingel is marked by the Hofplein in the north. This square can be seen as the beginning of this urban boulevard and therefore a gate to the city centre. Our study location approaches Hofplein with one facade.

For the readability of a city it is important that the main gateway connects with main boulevards and main functions. In modern transportation systems, the main gateway of the city has become the train station. Considering this, it is not surprising that tourists often get lost downtown Rotterdam.

Rotterdam is redesigned based on modern thoughts influenced by functional segregation of functions. This segregation led to extended areas of pedestrian zones, which have great potential, un-
Envisioned developments that influence circulation around schiekadeblok and centre-north (based on Maxwan plan) and critique

less connected to the main urban boulevards. For the entrance of the city centre on Hofplein it is important to upgrade the Weena into a better east west connection from central station to Coolsein-gel and with that connecting the central station with the third expansion of the city centre on the edges of river Maas.

The proposed urban developments suggest a backbone structure north of Weena. This backbone crosses the Cool-singel in a higher level, connecting central district with living areas in the north and Blaak station in the south. The negative effect of this new urban boulevard is that it disconnects the east west stream from central station towards Coolsingel even more.

The fact that Coolsingel is the dominant urban boulevard is supported by the public transport system since one of the two metro lines crosses the city beneath this boulevard. Combining this information with the planned high rise zone gives a reasonable underground for sustainable densification of the city centre.

Envisioned developments that influence circulation around schiekadeblok and centre-north (based on Maxwan plan) and critique

- pedestrian boulevard
- planned pedestrian boulevard
- car/bike boulevard
- landmark
- designplot
- commercial program
- cultural program
- recreational program
- weak connections for pedestrian
- north south barriers
Rotterdam differs a lot from the traditional Dutch city. Until 1940, its city centre had a dense network of narrow canals where goods could be transported. Strongly focused on the waterfront, it can be compared with the water-structure of Venice, Italy. Rotterdam city centre was not suitable for modern ways of transport and many small working-class houses were not meeting the new standards for comfortable living. For city planners, the bombing of the city centre by the Germans in WWII besides destruction, brought opportunity for modernization and rethinking the city functionally.

Small private investors were scarce after the war. Projects were planned in the modern way with government and real estate developers in charge of big areas. The essence to provide as many square meters new floor area possible in a short time span, with a lacking context and with a tight budget. This resulted in individual buildings thought out rationally and functionally. These projects were thought out only by a few men, without many restrictions from context or compromise between different parties.

Image 1: Rotterdam before the war, showing dense canals and narrow streets.
Image 2: Rotterdam after the war, with modern buildings and open spaces.

ACCELERATED EVOLUTION AND WWII

Culture: morphology related to history and architectural thinking

1914 | 1918 | plan Witteveen
1940 | basisplan van Traa | 1946
1970 | 1985 | binnenstadplan
1995 | 2005 | 2009

- Weena 1947
- Weena ca 1965
- Hofplein ca 1965
- City Hall 1920
- Groothandelsgebouw 1951
- Cebeco Shell gebouw
- Hilton hotel 1964

- Accelerated evolution and WWII
- Optimistic and rational townplanning with collective character
- Rediscovering the importance of re-use and rehabilitation
- Commercialisation attracting international headquarters
- Connecting city to Maas & Manhattanisation
- Adapting historical centre to modern lifestyle
- Functional and rational townplanning
- Redevelopment phase (wederopbouw)
The scale of the new projects can be seen on pictures from the archive.

The new urban plan made by van Traa in 1946 contains a contradiction in terminis. It conserves the old city structure, with its disrupted sightlines and irrational structure, but filled up with new structures that are influenced by a rigid new monumentality and big scale. Though structures are maintained, the original streets where widened up as are some canals to improve circulation by modern traffic.

As can be seen in the morphology sketch, the destruction in WWII gave opportunity to change the plan from Witteveen to bend the Coolsingel eastwards to improve the connection from Oude Binnenweg to Willemsbrug, into a new plan to extending the coolsingel into a third connection crossing de river Maas which resulted in the Erasmusbrug. This new connection is now the backbone for the High Rise zone.

The urban plan of van Traa is designed as a two-dimensional plan where the third dimension (unlike Berlagas plan for the expansion of Amsterdam) is left to the architects and developers according to the tendencies of the day. This approach left all possibilities for the high rise building as the modern living machine open.

"De vaste vorm die bij Berlage later leven krijgen moest, heeft men verworpen voor een levend groeiproces en de vorm komt daarbij aan het slot."
How is the skyline perceived?

The following pictures show the results of an expedition to the city in search for the places where tall program on Schiekadeblok influences our perspective. This information is complementary to the existing documents. A skyline is never perceived from a theoretical south or north, a skyline is perceived from the road or from your window. To provide a more general overview of perceptions, points of view are picked out on busy traffic streams or special public spaces. With the Google earth streetview application, a first selection of viewpoints is made. Logical barriers and sightlines are extracted from geographical information. After this pre selection viewpoints are photographed in the real situation. A quick sketch of the future building envelope in these pictures helps to visualize the effects of a high rise on Schiekadeblok.

These pictures can help during the design process in making decision about image and form. The envelope projected on the site has a gross floor area of 365,000 m² and six height accents.

Two different scales are distinguished in this analysis. First the longer sightlines through the city, from these sightlines the skyline is part of our active view field. Then the street profiles where high rise is part of the building mass. From this distance you will have to actively look upwards to experience the high rise.
View on the Skyline

Viewpoints within a range of 3km.

1. Train arriving from The Hague/Schiphol/Amsterdam
2. Entrance to center from highway A13 arriving from The Hague/Schiphol/Amsterdam
3. Willemsbrug
4. Erasmusbrug south
5. Erasmusbrug north
6. View from Maas
7. Entrance to center from highway A16 arriving from Antwerp
8. Brienenoordbrug, Highway A16 arriving from Antwerp

<table>
<thead>
<tr>
<th>Highways</th>
<th>Site</th>
<th>High Rise Zone</th>
<th>Viewpoint</th>
<th>Barrier</th>
<th>Railway</th>
</tr>
</thead>
<tbody>
<tr>
<td>purple</td>
<td>red</td>
<td>pink</td>
<td>blue</td>
<td>green</td>
<td>gray</td>
</tr>
</tbody>
</table>
Experience of the Skyline

Viewpoints within a range of 1km.

1. Proveniersplein/north entrance central station
2. Schiekade, arriving from north by car/bike
3. Heer Bokelweg arriving from north-east by car/bike
4. Central station square
5. Weena
6. From pedestrian street ‘lijnbaan’
7. Coolsingel, approaching from south
8. Pompeburg, approaching from east
impact of tall buildings on the urban experience of Rotterdam. Case study Schiekadeblok, Hofplein
Building Block in Perspective
Morphology: Rotterdam vs. other HighRise city blocks

Grid and Block
From city perspective we arrive at the inner city buildingblock of Rotterdam. In the following section of the analysis we will compare the grid and building block size with other European cities, American cities, and Asian cities.

Rotterdam city blocks @ 1:5.000
When we look at building blocks between European cities we can see a layering of block arrangements that show us the expansion of the city within a relative short distance.

Like Amsterdam and London the blocks show a dense organic structure but Amsterdam becomes more gridlike towards the outside much like the city of Berlin. This grid structure which we also get with the city of Rotterdam is the result of master-planned Area’s.

This particular area of Rotterdam displayed on the right was not the original city centre it always had a grid-like structure. This grid structure has changed because of the master-plan of van Traa explained in “Accelerated evolution and other effects of WWII”. Because of the bombardment the plan of van Traa was realized, the difference is that this plan showed a larger grid setup.
American straight forward

American cities have very distinctive grid-structures within their city centers, this of course is not unsuspected as European cities are much older thus have grown in a different manner.

As we can see Rotterdam’s city centre grid shows a great comparison with these American city grids and blocks of New York and Chicago. Seeing as we are exploring Rotterdam in conjunction with highrise in this analysis, means that the grids of these American cities are also helpful in the 3rd dimension. It shows us that building high relates to a certain building block, clearly the Rotterdam building block has potential to build high when we look at this comparison of grids.
Asian Clutter

We have concluded that the Rotterdam city block has potential for building highrise but what about asian cities?

The grids of Tokyo and Hong Kong which are displayed here show a resemblance to the European cities in their small-scale building blocks. Yet despite these small blocks they still build highrise buildings, so why need a bigger block or grid?

The highrise type in these asian cities rarely have proper typology of a base and a tower. These towers are erected directly from the ground-level with a plinth which is not defined by building form but by representation of program.

This last is a point which Rotterdam wants to avoid; "geen prikkertjes" (no sticks) but a clearly defined and designed plinth to represent each individual function that can be found within the tower in this small are of the building on the ground floor.

Juxtaposed Asian city blocks @ 1:10.000
The Problem with Rotterdam is that during the restructuring the setup was to grand and large scaled. We've tried to show this with sections of the Weena.

Morphology: Mass study of buildings along the Weena.
The Future of the Weena

There are a lot of HighRise developments planned along or near the Weena. This longitudinal section shows the future developments with the conclusion that the current HighRises as the Delftse Poort will be overruled.
**VAN TRAA’S BOULEVARD**

Transport: Connections from Weena into the City

---

**Schiekadeblok as remedy**

In the master-plan of van Traa the Weena is a green boulevard which acts as a distributor between the central station and the city centre. Today this is still the case only the urban reality shows us that these connections aren’t all that inviting, which is a shame.

An important difference with the planning of van Traa is probably the reason why the Weena is the way it is now; In van Traa's plan the Weena was supposed to be a boulevard with trees and shops in stead of the row of buildings that are directly situated to the Weena (orange strip). These buildings have tried to compensate by making interior galleries as pedestrian traffic area’s which give you the feeling that you’re in a tunnel of never ending misery.

Coming to the second point, which is the entrance into the commercial centre (lijnbaan). Because of this extra row of buildings the openings to these very important access streets are limited and not focused on pedestrian traffic, especially the one closest to Hofplein. This last access point can be an interesting design problem which can be studied further for the Schiekadeblok design.
FACE OF THE WEENA
Program: Plinth of the Weena and its Program
Phenomenological analysis: Experience on eyeheight with the defining elements
Main streets and Alley’s

This street study shows the Weena and the parallel backstreets of the building-blocks situated on the Weena. As you can see the boulevard intended in the plan of van Traa has turned into a gallery which is much too dark and dull (2,3,11,13,14). This is due to limited height and the large-scaled columns which give the place an inhuman feeling. The open spaces do not get represented very well (4,5), they look just as dismal as the highway running through the Weena.

When we look at the backstreets things don’t look much better, for instance; the large columns reappear on the back of the Delftse-poort when clearly the street asks for a different approach (16,17,18), the closed walls that continue throughout this particular street tell us that these buildings don’t want to be part of that street (19,23,24). However when we look at the backstreet on the other side which leads to the lijnbaan (6/10), it is remarkably pleasant to walk through, especially the second half (8,9) when car access is no longer possible. What we see here then is that there is focus on the pedestrian in terms of design and program situation.
IMPACT OF TALL BUILDINGS ON THE URBAN EXPERIENCE OF ROTTERDAM. CASE STUDY
SCHIEKADEBLOK, HOFPLEIN

HIGHRISE
HighRise districts
In the Netherlands we have three HighRise locations namely: Amsterdam South-Axes, Rotterdam inner city / Wilhelminapier and The Hague inner city.

If we look at the realized HighRise projects in the last few years we can conclude that Rotterdam is on its way to become the biggest HighRise city in the Netherlands.

The realization of HighRise projects in Rotterdam inner city mainly became possible because of the destruction caused by WWII. And the realization of HighRise projects in Rotterdam Wilhelminapier became possible when the harbor lost / moved its main functions and the area became free for development.
At the moment there are a lot of High-Rise developments planned to be realised in Rotterdam.

Rotterdam has three High-Rise districts namely: Central station area, Wijnhaven and the Wilhelminapier.

The municipal vision is to link these three High-Rise zones by the Coolsingel. This main street will be a High-Rise zone in the near future. The Coolsingel will be transformed into a boulevard with High-Rises on both sides of the street.
The HighRise development in Rotterdam started in 1990 around the Central Station with the Weena Center, Wenenatoren & Delftse Poort. In the following 19 years they developed totally 13 New HighRises by the Central Station, the Stationskwartier and the Wilhelminapier. The last one is the Maastoren, which is just finished and also the Highest of the Netherlands with around 161 meters. For the coming years there are already a lot of new projects in progress.
Introduction

The HighRises in Rotterdam can be divided by different typologies with each their own consequences, advantages and disadvantages. The following typologies are developed in Rotterdam:
- Standing
- Lifted
- On a Block
- Interwoven

Standing

In this typology the tower is like a stick that penetrates the plot. The plot has the same dimensions as the tower. This kind of HighRises do not interact with their surroundings they rather stand on their own. Many theoreticians (Rem Koolhaas) say that these kinds of Highrises are the end of the street life.

In this kind of designs there are often problems with the entrance (for mix functions) / parking.
Lifted

In this typology the tower is lifted from the ground. Because of this phenomenon the tower is no more a barrier for the flows on the ground floor. The tower interacts with the plot by absorbing the flows on the ground floor.

In Rotterdam there are only two High Rises related to this typology, namely the Weenatoren & the World Port Center.
On a Block

In this typology the tower is lifted from the ground and installed above a larger plinth. The plinth interacts with its surrounding and it often represents the public functions. The tower stands on its own and one often doesn't even experience it when walking through the plinth.

The plinth is an important key element in these kind of designs to create a proper entrance (for mix functions) and arranging enough parking places.

This is a very popular one in Rotterdam, a lot of HighRises developed are based on this typology.
In this typology, the tower is merged with its plinth. In this kind of designs the LowRise interacts with its surroundings and absorbs the flows on the ground floor and brings them into the Mid/HighRise. The 'pyramid' can be seen as a good metaphor for the functioning of these designs.

It is very interesting to see that HighRises with this typology are not yet developed in Rotterdam but are planned to be realised in the near future.

Coolsingeltoren

De Rotterdam
In this typology the tower is lowered from the ground floor. Because of this phenomenon the tower can be reached from different levels namely: ground floor and the lowered basement levels. This gives the designer the possibility to create different functions in the building with each their own separated entries on different levels but still using the same core.

We think that this typology is not developed in Rotterdam because of two main reasons:
1. The water level in Rotterdam is very high.
2. It is very expensive to construct under the ground level because the construction should be realized with underwater concrete.
Introduction
Looking at the HighRises in Rotterdam it is clear that there are three different sorts referred to the functions, namely:
- Office HighRises
- Residential HighRises
- Mixuse HighRises

In this chapter a comparison will be made between these functions and the typologies of these HighRises.

Office HighRises
Office HighRises in Rotterdam are created by all the four different typologies of Rotterdam.

The Maastoren is an example of the "Standing" Typology. The World Port Center is based on "Lifted". The Delfse Poort is an example of the "On a Block" Typology, the Future Coolsingeltoren is based on "Interwoven".
Residential HighRises

Residential HighRises in Rotterdam are only created by two of the totally four different typologies of Rotterdam, namely: Standing & On a Block.

The Schielandtoren is an example of the Standing Typology which is totally filled with residential functions.

The Hoge Heren is based on the typology “On a Block” with in the block entrances and facilities related to the residential functions.
Mixuse HighRises

Mixuse HighRises in Rotterdam are created by all the four different typologies of Rotterdam.

The Millenniumtoren is an example of the "Standing" Typology which is filled with a hotel in the lowrise and offices in the rest of the tower.

The Coopvaert is based on the typology "Lifted" with a plinth related to the surrounding, above this public plinth offices and in the top apartments.

The Red Apple is an example of the "On a Block" Typology with in the block entrances, public functions and offices and in the tower apartments.

The Future De Rotterdam is based on the typology "Interwoven", where Offices, Hotels and Apartments are created in different towers which will be interwoven with Public Functions in the Block.
Typologies & Program
Looking at the different typologies in relation with their program it is interesting to see that only two typologies are used by a full residential function, namely Standing & On a Block.

The Blocks are mostly used as a connection with the city and for different facilities related to the functions in the tower.

Mixuse
On the basis of our analyses we have come to the conclusion that mixuse HighRise Towers are very rare in Rotterdam. Towers are mostly created for one specific function.

One structure principle for many functions (which means a tower that can be mixuse) can in our opinion be very interesting for the city of Rotterdam.

In times of economical crisis, changing markets and changing wishes of client, mixuse towers can offer a good solution for lowering the risks when developing a HighRise.

Mixuse Towers are mostly interpreted difficult because of the different basic plans of offices and residential functions.
Program
On the basis of our analyses of the HighRises in Rotterdam in relation with their program we have come to the conclusion that in most HighRises the functions are separated on the following way:

1. Program in the Plinth: Entrances of the Tower, Facilities, and Public functions like; restaurants, cafés, disco’s, clubs, parking, leisure and retail.

2. Program in the Tower: Living and working like; dwellings, apartments, offices and hotels.

Transportation
On the basis of our analyses of the HighRises in Rotterdam in relation with their transport we have come to the conclusion that the most HighRises are based on the following transportation principle:

The public program in the plinth of the Highrise is mostly accessed by stairs, escalators, small elevators and slopes. (Horizontal transportation).

The program in the tower of the Highrise is mostly accessed by elevator units (Vertical transportation).

It is very important for Rotterdam that the plinth interacts with his surrounding and that the tower can act on itself.
## Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Student ID</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mike van de Vliet</td>
<td>1368184</td>
<td><a href="mailto:m.v.vandevliet@student.tudelft.nl">m.v.vandevliet@student.tudelft.nl</a></td>
</tr>
<tr>
<td>Wendy Verweij</td>
<td>1182765</td>
<td><a href="mailto:w.verweij@student.tudelft.nl">w.verweij@student.tudelft.nl</a></td>
</tr>
<tr>
<td>Saman Mohammadi</td>
<td>1240046</td>
<td><a href="mailto:s.mohammadi@student.tudelft.nl">s.mohammadi@student.tudelft.nl</a></td>
</tr>
<tr>
<td>Niel Slob</td>
<td>1212001</td>
<td><a href="mailto:c.slob@student.tudelft.nl">c.slob@student.tudelft.nl</a></td>
</tr>
</tbody>
</table>

## Mentor

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>ir. J.A. Westrik</td>
<td><a href="mailto:j.a.westrik@tudelft.nl">j.a.westrik@tudelft.nl</a></td>
</tr>
</tbody>
</table>
THE IDENTITY OF A HIGHRISE
A Thesis about the way we experience Highrise

Thesis Architectural History
Faculty of Architecture, TU Delft
S. Mohammadi b1246046 & C. Slob b1212001
Preface 5
Journey to the land of giants 6
Form vs. Function 16
The Identity 26
Literature 36

Contents
“Perfection means something is complete and stands still and what stands still doesn’t change or evolve and is automatically dead. Everything in this universe changes, evolution implies that the creation is not complete hence the possibility of evolving”.

“The clarification of the Urban and Rural is an urgent task, standing against the further destruction of the natural landscape. So Hybrid buildings are undeniably fruits of modernity, being inherently connected to the development of the elevator, steel frame and concrete construction techniques. Hence a hybrid building is the combination of multiple functions within a single structure.”

In the last decades we have seen a large development in HighRises. The main reason is because of the fast growing population and ground prices. Because the plots are small and expensive, HighRise is often the most obvious solution. HighRise can be seen as a vertical city with mixed functions which also gives a lot of public space back to the city. A repetition of these vertical cities changes the city as we have known it before. Koolhaas is going one step further with his definition of the future city in the so called Generic City.

“The Generic City is the city liberated from the captivity center from the straitjacket of identity. The generic City breaks with this destructive cycle of dependency: it is nothing but a reflection of present need and present ability. It is the city without history. It is big enough for everybody. It is easy. It does not need maintenance. If it gets too small it just expends. If it gets old it just self-destructs and renews. It is equally exciting or unexciting everywhere. It is ‘superficial’ like a Hollywood studio-lot, it can produce a new identity every Monday morning. The Generic City is not only multiracial but also multicultural. The Generic City is on its way from horizontality to verticality. The skyscraper looks as if it will be the final, definitive typology. It has swallowed everything else.”

According to Koolhaas it seems that people think that convergence is only possible at the price of shedding identity. That is usually seen as a loss. But how can we define identity?

“The collective aspect of characteristics by which a thing is definitively recognizable or known.”

The form and function create together the collective aspects of characteristics of a HighRise. The main question remains:

**How does form & function relate to the identity of a HighRise?**

In this thesis we try to answer this question through revealing the possible interaction between form, functioning and the identity of HighRises from the beginning of HighRise buildings until now. Which results in recommendations for the design and construction of the places within these HighRises which nourish us as residence and workers.
Define HighRise


JOURNEY TO THE LAND OF GIANTS

“The essence of a skyscraper is to be grand and tall.”

In everyday usage, the term HighRise commonly designates any tall building. The height at which a building is considered tall is, of course, relative and has undergone many changes at different times and places throughout all epochs of building history.

“A building is characterized as a HighRise when it is considerably higher than the surrounding structures and explodes their scale.”

For example, if buildings in an urban setting have an average height of two to three stories, a 5-story building that soars above them may be considered a HighRise. However, matters become more complicated if a building’s neighbors are five to six stories high: now a building exceeding their height by a mere two to three stories will barely be perceived as a dominant structure. The town planner definition of a HighRise as a building that rises above the skyline offers a relative but not absolute measure. Obviously it will scarily serve as a basis for an unequivocal definition of a HighRise.

In Germany, consensus has been reached for the purposes of building supervision to define a HighRise in accordance with certain safety criteria. The dictates of fire protection and above all the effective use of fire escapes, have produced the following term:

“HighRises are buildings in which the floor of at least one occupied room is more than 22 m above the natural or a prescribed ground level.”

Other countries also have building laws that define buildings exceeding specified heights (which can vary between 13 m and 50 m) as HighRises. This limit may even vary within a single country. It is therefore difficult to generalize about how HighRises are defined in international legislation. In their comparative surveys of surveys of HighRise buildings, international databases such as skyscrapers.com have chosen a building height of 35 m or 12 stories as a benchmark. From the standpoint of building typology, the category of height alone, whether for fire safety or for database considerations, is not satisfactory for determining whether or a building should be classified as a HighRise.

To conclude, the definition of HighRise is time and culture related. It’s not a static definition that can be given but a dynamic typology that grows time by time.
The HighRise as a specific type of structure originated in the booming city of Chicago toward the end of the 19th century. Its development was decisively influenced by the great inventions of the age. The technological preconditions were created with the development of safe elevators and the skeleton steel structure made of rolled iron sections, two of the most important parameters and with the development of service systems, such as communication systems. Their combined impact led to the development of large office blocks and expensive floor areas stacked on top of one another.

Despite the use of skeleton structures of cast and wrought iron the first big office blocks in Chicago do not seem to strive for the heavens; the horizontal structure of their brick and natural stone facades lend them a certain heaviness reminiscent of the Italian Renaissance palazzo. The first one was the Home Insurance Building in 1884, designed by William Le Barron Jenney.

However the development of light and powerful steel skeleton structures soon emancipated architecture form its classical appearance. Vertical structural elements were accentuated to emphasis their lightweight character and to create the impression of soaring facades. Furthermore facades were increasingly reduced to lightweight shields mounted on a load-bearing structure separating the load-bearing and boundary functions. Incidentally the first building to receive the epithet ‘the worlds tallest building’ was the Masonic Temple in 1892 by Burnham & Root. It had a public viewing platform almost 100 m above the ground. Thematizing the capital and exploiting the buildings view as a popular attraction were quite novel approaches at the time. What are the characteristics of these new soaring office buildings?

Sullivan may be considered as the first theoretician of HighRise aesthetics. Between 1880 and 1895, when the first tall office blocks were all the rage in Chicago, Sullivan and John Wellborn Root, formulated the principles of an architecture in which form follows function. The new style which became known around the world as the Chicago School helped pave the way for the Modern Movement. The structure became a form giving element and was clearly identifiable from the outside. Sullivan was the first to define the rules for designing HighRises. To render the scale of the tall buildings legible, he subdivided the building into base, shaft and capital. This tripartite division is barely perceptible in the high block structures built in Chicago. Later, however, it was sometimes transferred dogmatically onto the outer form and can be considered typological of HighRise buildings in all epochs of their construction.

---

The Beginning

Chicago

This chapter ‘Journey to the land of giants’ is a summary formed on the basis of a literature study. The following books are mainly used:


A law passed in 1893 drastically limiting permissible height to 40 m, temporarily halted any further development of the HighRise in Chicago. As a consequence, Chicago was compelled to surrender its leading role in HighRise construction and development to New York. HighRise was not yet accepted. The great upheaval that it raised in the city, a striking symbol of the economic anarchy which have rise to it, aroused criticism, even counter attacks. Also in New York from the beginning of the century architects, critics, and local politicians rebelled against the transformation of streets into deep and somber canyons.

**New York**

In New York, the evolution of the HighRise was determined by two factors: the development of the idea of the tower and the influence of eclecticism. Speculators demands for maximum exploitation of the land sent buildings constructed on small plots soaring to new heights. We now see the transition from the tall office block to the office tower. An attempt was made to create the HighRise building as a homogeneous whole in historicist style. Gothic, Romanesque and Beaux Arts were employed as metaphors to link the new with the old. One of the first HighRises in New York was the remarkable triangular Flatiron Building in 1902, designed by Burnham.

In 1908, Flagg designed a new tower for the existing 14-story Singer building. In its form the top of the Singer Tower imitated the corner towers of the Louvre in Paris. Its tower like extensions made it the most famous building in America and the tallest office tower in the world. Thousands traveled to New York to visit the viewing platform. Its design cites historicist forms in an endeavor to soften the futurist image of the HighRise. The soaring vertical elements of Gothic proved particularly suitable for creating a stylized mask to clad the HighRise. Soon the HighRise buildings of this epoch, such as the Woolworth Building in 1913, were to become the Cathedrals of Commerce. Attention was given in particular to accentuating the forms of their pinnacles turning them into symbolic advertisements for the building, their clients and architects, and indeed the entire city. The term skyscraper was coined. The public acceptance of the skyscraper architectural language grew reaching its zenith in the Golden Twenties.

**1916 Zoning Laws**

It was only when building clients and architects began pushing the exploitation of plots to extreme lengths that the enthusiast response skyscrapers had met with in New York declined. Consequently there was a shift away from the slender tower form in favor of the more compact tall block structure. The great bone of contention was the Equitable Building in 1915 by Graham. Following public protest, limits were imposed on such developments, which threatened to destroy the cityscape and jeopardized neighbor laws. As a result, new legislation was passed. The 1916 zoning laws. These laws prescribed the construction of the so called setback building, which meant that the more a building was set back towards the top the higher it was allowed to rise. This legislation instructed architects which form their buildings were assume.
The Downtown Athletic Club in 1930 by Starret & van Vleck is an example of how the zoning laws were implemented. Buildings thus constructed may be classified as HighRise structures with three distinct zones and greatly extended pinnacles. This style created by setting back buildings in distinct levels is often referred to as the Wedding Cake Style. Many American cities adopted regulations inspired by those of New York, including Chicago in 1923.

The race to achieve ever-greater heights continued despite the zoning laws. For if the floor area were reduced to a quarter of the ground floor area by introducing setbacks, a building could be made to rise indefinitely. In the early 1930s probably the most famous skyscrapers in the world were constructed: the Chrysler Building designed in theatrical Art Deco Style by William van Alen and the Empire State Building by Schreve, Lamb & Harmon, the archetype of the American Skyscraper, finally reached the limits of the proven steel skeleton structure. At 381 m, the Empire State Building remained the world tallest building for more than forty years: from 1931 to 1972. The economic crisis combined with the radical change in the spirit and style embodied in Modernism brought to an end the era of the Golden Twenties and that of the skyscraper too.

In 1922, radical new goals were formulated in what was probably the most famous international HighRise competition: The competition for the Chicago Tribune Tower in Chicago. A new generation of European Architects such as Gropius and the three Dutchmen Bijvoet, Duiker and Zandvoort, entered the competition, submitting designs with new radical goals. Even though their designs had little chance of winning, they nevertheless revealed a definite commitment to technology, functionality and clear lines. Modernist architects had entered the arena.

In 1937, Walter Gropius was offered a chair at Harvard; that same year, Laslo Moholy-Nagy founded the new Bauhaus in Chicago and in 1938, Mies van der Rohe became director of the Illinois Institute of Technology. In the distributing years between the War and the economic crisis two buildings were erected under the sign of Modernism: the PSFS Building in Philadelphia in 1932, designed by Howe and Lescaze and the RCA Building of the Rockefeller Center, designed by Hood & Foulhoux, Hofmeister, Corbett, Harrison & Mac Murray, which was erected in New York in 1940.

The PSFS Building was one of the first unmistakable attempts to apply the principles of the International Style of the Modern Movement to the American Skyscraper. However, it was only in 1947, short after the Second World War that Ludwig Mies van der Rohe initiated an entirely new generation of HighRise buildings of which Lake Shore Drive Apartments in Chicago, with their curtain wall facades were an early example. Between 1948 and 1969 Mies van der Rohe designed fourteen HighRises in Chicago which gave him an opportunity to develop and perfect an archetype.
His HighRise buildings look very similar to one another, for Mies van der Rohe was fundamentally opposed to the notion that each one had to have a distinct character. His buildings are based on a simple cubic form and display great attention in detail. The Seagram Building of 1958 planned in cooperation with Johnson, became the prototype of the modern office tower. Subsequently office towers were built in Mies van der Rohe style all over the world.

Later on he also designed some residential towers like the Lake Point Tower in 1968. However, the replicas did not attain the quality of the originals. The word skyscraper had more or less fallen into disuse; from a certain height upwards the buildings were simply referred to as tall building, HighRises or IGH (Immeubles de Grande Hauteur). Later on this way of thinking was further developed in the John Hancock Center in 1969 & The World Trade Center in 1973.

1961 Zoning Laws
The Seagram Building in 1958 was also innovatory with respect to urban planning. It was set back from the property line to create a large plaza in front. This mode of construction influenced New York's new building legislation the 2nd zoning laws of 1961, which now permitted greater concentration in return for public space on the site. Where the top had once been the most significant element of skyscrapers, this new type of HighRise building focused attention on the base as the public zone. The greater floor-space index that was now allowed for a building with a plaza triggered a building boom. A problem arose, however, when several of these buildings are placed alongside one another they create a rather unsatisfactory urban setting. The plazas pass into one another without interruption, dissolving the property line completely.

Postmodernism
In the 1970s and 1980s people began searching for alternatives to the stereotypical buildings of the Modern Movement. Clearly defined forms were distorted to create huge sculptural forms. Instead of being treated as purely functional components, technical elements were exaggerated to create decorative details or else concealed behind historicists facades. The AT&T Building in 1984 conspicuously drawn on historicism. It is designed as a skyscraper in a classical sheath with a crown that New York Times critic Paul Goldberger referred to as a vastly exaggerated version of a Chippendale pediment. The striking tripartite division of the building plays an important role in Postmodernist HighRise architecture. It represents an attempt to use a striking base zone in connection with a tall building and a conventional street development. This new awareness of the significance of the street space and scale led to another change in New York's legislation in 1981. The new law stipulated that the base of the building was not to be set back by more than three meters on certain streets in order to preserve the property line. At the same time appropriate measures had to be taken with new buildings to extend public access routes. This law aimed to ensure that public street space also extended into the building. In the Humana Building in 1986, for instance, this is achieved by means of a large frond hall lined with tall pylons.
The tall Buildings designed by Graves are characterized by their independent base which is pushed up against the street edge. The HighRise above is set back from the base, which in turn, integrates the public zone a feature typical of this type of building. The HighRise as a structure defined by public uses communications areas with atriums, conservatories for relaxing, shopping zones and other attractions had become the theme of a whole new generation of buildings. The tower and the base receive distinct uses as two separate zones.

In addition to this HighRise family there are other types in which the top of the building is given conspicuous thematic treatment. The skyline and prestigious appearance play a very important role here. Since the 1970s it has become possible to consider the typology of HighRises as a chronological evolution as styles have developed parallel to one another. Nor is it possible to focus on the USA alone, because Europe (since the 1950s and 1960s) and Asia (since the 1980s and 1990s) have played an increasingly significant part in the development of the HighRise.

In the early 20th century HighRise planning was discussed as a purely theoretical level in Europe. Not bound by the constraints of practical implementation, urban planning and architectural theories on the new type of building were able to develop more freely.

The model for a concentrated ensemble of HighRises in the city center, as implemented in the new American cities that were evolving on grid plans, was out of the question for Europe. The structure of the historically evolved city with a medieval city center and dominant historical structures called for a variety of approaches to HighRise planning. And these were formulated in diverse ways in different European Countries.

In Germany the positioning of isolated HighRise buildings at major intersections was proposed as a model compatible with the city. HighRises located at a suitable distance from the historical center were supposed to provide points of orientation in an expanding city. Even though this subsequence proved to be a useful model, the capital needed to implement this idea was still lacking in the early days.

The same is true of the rather different approaches adopted by the architect Ludwig Hilbersheimer, who published his designs for metropolitan architecture in 1924. A novel modern cityscape arose that was based on the notion of horizontal traffic layers and HighRise buildings.

In France they developed approaches for new HighRises to create completely new city structures using broken rows of buildings. Auguste Perret and Le Corbusier were the leading advocates of concept. There HighRises were designed as elements of urban development projects and were placed at sufficient distance from one another to create space for large traffic axes and green strips in
In Russia the ideas inspiring HighRise buildings were quite idiosyncratic. The development of HighRise began with the idea of creating the symbolic representation of a new society. Although they were never built. The First World War, the economic crisis and the Second World War were fundamental elements for the delay of HighRise developments in Europe. It started after the Second World War.

*After World War II*

Lacking the necessary economic power, Europe had yet to demonstrate whether the implementation of ideas that had, in some cases, been radically committed to Modernism were socially compatible. Before the Second World War, HighRise buildings were few and far between and remained well below the 100 m limit. It was only when work began on reconstructing the destroyed towns and cities and capital flowed in from abroad that HighRise planning received a new boost. In Western Europe (Paris, London, Frankfurt) projects followed the US Model; Eastern Europe (Moscow), in contrast consciously pursued a different course expressing its opposed ideological position. In both East and West, HighRise buildings served to symbolize the power administrative and economic of the towns and countries where they were erected. The rapid reconstruction carried out during the post-war period to accommodate the expanded demand for office and residential space, as well as the search for new, modern urban models, favored the choice of HighRise buildings as an appropriate form both the inner-city and the outlying areas. Even then, HighRises tended to be isolated phenomena because planners sought to show consideration towards the historical structures that dominated the old towns and cities.

It was only in 1980s that people began to identify more closely with HighRises. During this phase, the appearance of HighRises altered. The stereotyped forms of the Modernists gave way to the playful variations of the postmodernists. The desire to create significant forms and to humanize the world of work led to the design of new types of HighRise structures. Great importance was now attached to integrating them into existing urban contexts. A return to the traditional values of the European City with their dominant historical structures resulted in the demand to keep important visual axes free and locate HighRise buildings outside the city center.

But there were differences in interpretation in Western Europe. While it was possible to keep the historical center of Paris almost free from HighRise buildings these structures have been rising successively in the center of London right up to the present. So was La Defense in 1989 built on the outskirts of Paris, but the National West Bank Tower in 1980 was erected in the center of London. Frankfurt used HighRise in order to ensure a permanent place as a financial and commercial center so an extreme concentration of buildings in the inner-city area was permitted. The Commerzbank in 1997 is an example of this HighRises in the innercity.
The HighRises in Eastern Europe were erected during the Cold War in an endeavor to convey the image of a centrally run society. Moscow assumed the leading role within the Warsaw Pact and served as the model for member countries. It became a city crowned by HighRises with the Lomonossow University Building in 1953 as one of the first.

Many cities in Europe and the United States experienced their greatest periods in growth around the turn of the century during the transition to industrial society. Asia’s Cities, in contrast, have experienced explosive growth rates during the past few decades with the onset of economic growth. After the second world war the victorious powers wielded a powerful influence in Japan and in strategically important locations in East and Southeast Asia. It was considered important to build up military, political and economic strongholds with Asia to counter the influence of communist China. This goals was reaffirmed in 1954 with the founding of the South-East Asia Treaty Organization, which was dominated by the USA. Dissolved after the Vietnam War, the alliance nonetheless exerted a considerable influence on the region’s development.

The Japanese economy began to boom in the 1950s. Somewhat later than Tokyo, the city states of HongKong and Singapore, underwent powerful economic booms as they emerged as economic and financial centers in the 1960s. They were followed by South Korea and Taiwan. Elsewhere in Asia, the cities of Bangkok, Kuala Lumpur, Djakarta and Manila began to grow dramatically during the 1980s, Americanization, technical modernization and higher standard for living fundamentally changed the economic and social structures there. These processes triggered the development of the HighRise building and the related technical know-how in these prospering Asian countries. For all that, the infrastructures one might expect to find in powerful economies are still lacking. Furthermore, there has been rapid urbanization of formerly rural structures; cities are growing so fast that it has become impossible to create the planning instruments needed to cope with their growth.

On the opposite side in China, cities have been growing upwards since the 1980s. The economic reforms introduced by Deng Xiaoping led to the establishment of Special Economic Zones which permit capitalist investments in specific areas. Through these experimental zones, China, its communist system notwithstanding is opening up to the world economy, giving its stagnating economy a powerful boost with Shanghai as the center of economic activity.

HighRise buildings are a symbol of economic growth. In Asia, extreme heights are held to be a visible sign that a country has managed the leap into the first world. As a symbol announcing the beginning of urban development, television towers of conspicuous dimensions and form have been erected there, such as the Oriental Pear TV Tower. But also very tall residential towers were erected during the last decades like the Highcliff & The Summit in 1995.
The desire to erect the world’s highest building in Asia was finally realized in Kuala Lumpur in 1998 with the Petronas Towers. It is a part of the largest building complex. In the social context of European city a complex of this magnitude would not have had a chance; indeed, it would destroy any sense of proportion and ruin the city. In Asia, however, such projects are constructed despite the absence of infrastructure or compensatory space. And developments such as these not only cause entire transport systems to collapse at regular intervals, but also bring about a dramatic deterioration in climatic conditions.

**Nowadays**

Shanghai, Singapore, Kuala Lumpur, Chicago, New York, Dubai, etc.: the major metropolitan centers around the world are unimaginable without HighRises. It isn’t just that we have become accustomed to the skyline. The stacked area development in these megacities is inconceivable and would be impossible to organize in layers with only a few floor levels.

Warsaw and Moscow are two European examples of cities where the HighRise enjoys a positive image: residential density per square kilometer and urban density in terms of opportunities for working and leisure time go hand in hand and are appreciated.

In Western Europe, conversely, there is considerable resistance to the HighRise genre: the traditional, originally evolved European city is governed by urban planning directives that preclude an impartial treatment of this building form.

In recent years, however, HighRises have become more accepted. The city of Frankfurt am Main plays a leading role in bringing about this change in Europe: there are good reasons why it has been dubbed ‘Mainhattan’ in analogy to Manhattan.

Today new challenges in HighRises can be found on different aspects. First of all the competition of the world’s biggest HighRise is still remaining. Nowadays, the tallest HighRise of the world is the Burj Dubai in Dubai which is just finished and had a height of around 811 meters. But it can be assured that this will be overruled in the near future.

Another challenge can be found in today’s complex geometries. Because of the development of technology more complex geometries can be built. The Swiss Re Tower in London and the Turning Torso in Malmo are examples of these kind of HighRises.

The final and most important challenge is the challenge of sustainability in HighRises. HighRises are seen as the most unsustainable buildings in the construction industry. The near future will be searching for a really sustainable HighRise with maybe a taller and more complex structure.
When looking at functions within HighRises through time the conclusion can be drawn that the first generation of the HighRise buildings were mainly based on office functions. Later on (mainly after World War II) residential and mix-use HighRises appeared.

Focusing on the composition of the HighRise, it can be separated in three parts, namely: base, shaft and capital. In the shaft mostly the next two main functions can be found; residential and office functions. In the base and capital we mainly find public functions like restaurants, café’s, etc.

On the basis of their functions, HighRises can be categorized as followed: mono-functional & multi-functional HighRise buildings. The mono-functional HighRise building can be defined as mainly one function within a single structure. The combination of multiple functions within a single structure can be defined as multi-functional HighRise.

The combination of multiple functions within a single structure is a strategy which has been repeated throughout the history. The houses over the store, the apartments above the bridge and the Roman bath are all examples of the tradition of combining two or more functions within the walls of a single structure.

This multi-functional HighRises can be divided in two basic categories of program: the thematic program and the disparate program:

“Thematic combinations cultivate the dependence between parts and encourage the interaction of elements. The traditionally related building types are combined into one structure.”

“Disparate combinations allow pieces to exist in a mutual, if often uneasy alliance emphasizing the fragmented, almost schizophrenic aspect of society and of the period. This type tended to emphasize an economic advantage. It was often formed by the economics of constructing the largest volumetric packaged and then filling it with a combination of independent functions.”

FORM VS. FUNCTION

When looking at mono-functional office HighRises, we can start with the first HighRise ever build. The Home-Insurance Building was constructed in 1984 and is a good example of a mono-functional office building. The building had a rectangular shape with a central core in order to allow maximum daylight in the building. The form of this HighRise was defined by the dimensions of its plot. The office function was poured into this form. The Seagram Building is located in New York. The layout of this HighRise consist of a square in which the core is placed on the back side of the building. The plan is designed to allow maximum daylight entrance hence all the distances to the façade are minimized. It is made following the principles of ‘Form follows Function’.

“It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function. This is the law.”

To Sullivan, “function” didn’t mean merely “utility” or “pragmatic use.” Instead, it meant something like “life force.” His “form follows function” dictum expressed a kind of essentialist vitalism. The “essence” of a thing in nature (an eagle, a cloud, a river) is its life force. This life force results in the outward form of that thing. In Sullivan’s own words, “Unceasingly the essence of things is taking shape in the matter of things.” Form follows function is one of the long-standing slogans of modern architecture. Its use was pioneered by turn-of-the-century skyscraper architect Louis Sullivan, complemented by Adolf Loos’ 1908 assertion that ‘Ornament is crime’, adapted by Frank Lloyd Wright and adopted by Modernists and Bauhaus designers such as Mies van der Rohe (‘Less is more’), Walter Gropius etc. Originally meant to be defiantly honest (let the form of a building or product result from its function) and no more and anti-style, it eventually evolved into yet another set of un-interrogated conventions, and is now being both challenged and re-worked.

Petronas Towers is located in Kuala Lumpur. In comparison to Home Insurance Building and Seagram Building the floor plan of this HighRise is created through complex repetition of a basic figure which shows great respect for the Islamic culture. The two towers taper on their way up hence all the floor plans have different dimensions.

Concluding mono-functional office HighRises, at the beginning the plot defined the form and the function was poured into this form. Later on this changed tremendously introducing the Modernism into HighRise. Form follows function was the fundament of this typology. HighRise Buildings, as the Seagram building, were optimized according to the standards of that function in that particular period. Later on it could be different also by introducing challenging geometries. For example looking at the Petronas Towers a symbol for the Islamic culture was used to set up the basic plan. It seems that the office function could adept itself into this or any other form.
Figure 1
Home Insurance Building
Chicago, 1884
Le Baron Jenney
Optimized by Plot

Figure 2
Seagram Building
New York, 1958
van der Rohe & Johnson
Optimized by Function

Figure 3
Petronas Towers
Kuala Lumpur, 1997
Pelli & Associates
Optimized by Form
When looking at mono-functional residential HighRises, we can start with the Lake Shore Drive Apartments. This HighRise is a good example of a mono-functional residential building. The building has two identical towers with a rectangular shape. Eight apartments are situated around the central core. The grid shapes the apartment layouts with their own width and depth. The form within this HighRise is optimized according to the function.

The Lake Point Tower was also constructed in Chicago. In comparison to Lake Shore Drive this HighRise has an organic form but with less variety of apartment units. Nevertheless all the distances from the corridor to the façade are more or less the same. The clover-leaf shaped tower has a triangular central core. This shape allows a maximum daylight entrance with a minimal footprint. The function was optimized according to the clover-leaf shaped form.

Highcliff & The Summit is a residential tower in Hong Kong. In comparison with the Lake Point Tower this HighRise has also an organic form but with a high variety of apartment units. All the distances from the corridor to the façade differ. The layout of this HighRise consist of two ellipses that are shifted into each other. The function was optimized according to the ellipse shaped form.

So the same conclusion, as mentioned with mono-functional office HighRises can be drawn for the mono-functional residential HighRises. Both mono-functional residential and office HighRises are a combination of the form and function. Sometimes the form is optimized on the basis of the function and vice versa.
Figure 4
Lake Shore Drive
Chicago, 1951
van der Rohe
Optimized by Function

Figure 5
Lake Point Tower
Chicago, 1986
van der Rohe
Optimized by Form

Figure 6
Highcliff & The Summit
Hong Kong, 1995
Dennis Lau
Optimized by Form
When looking at multi-functional HighRises, we should start with Downtown Athletic Club. This HighRise is the apotheosis of the Art Deco skyscraper aesthetic, because each floor is devoted to a different function. The main idea was to make every floor represent a total new world. The buildings two major functions are the athletic club and hotel. The athletic club in the lower portion of the building is comprised of single and double height rooms containing billiard and card areas, squash and handball courts, a putting green, a bowling alley, a gymnasium, swimming pool and baths. The Hotel in the upper portion is organized around the perimeter of the building. The rooms vary in size as the tower floors diminish in area. Restaurants, kitchens and lounges, located in the intermediary zone of the building, are shared by both the club and the hotel. All these different functions require different floor plans. These different function with each their own requirements are made possible because of the buildings basic rectangular form with a irregularly placed setbacks, creating the impression of tree-rings. This is not to be measured in terms of the contemporary comparison with the classical tripartite division into base shaft and capital of Beaux-Art aesthetic. The setbacks create a diversity of floor plans which make different functions possible within the same building.

The John Hancock Centre is a multifunctional HighRise in Chicago. Because of its tapering shape it makes a kind of functions possible. Functions that need more square meters and less daylight are situated in the lower part of the HighRise and functions which require more daylight and less square meters are located in the higher part of the HighRise. Again we can notice that the form of the HighRise allows the different functions to exist as we have seen in the Downtown Athletic Club. The functions are optimized by the tapering iconic form. Turning Torso is a multifunctional HighRise in Malmo. In comparison to Downtown Athletic Club and John Hancock Center this HighRise has a organic form with only two functions namely: apartments and offices. The main difference between these and the other two multifunctional HighRises is the fact that Turning Torso integrates two total different function within the same floor plan. The functions are optimized according to the same form.

In multi-functional HighRises the form and ‘functioning’ (more functions) instead of function are optimized among each other. Sometimes the form is optimized on the basis of the functioning and vice versa. Finally the form can also express the different themes, this is called expression or repression of the program:

“Expression of the program can occur through the direct combination of established single function building types, thus creating a functional expression. Repression of the program renders the building as a ‘mock’ graft, thus creating a monolith expression.9”

The Downtown Athletic Club, the John Hancock Center and the Turning Torso are all examples with a repression of the program, as the most of the HighRise buildings are.

A thesis about the way we experience HighRise

Figure 7
Downtown Athletic Club
New York, 1930
Starret & van Vleck
Optimized by Function
Repression of the Program

Figure 8
John Hancock Center
Chicago, 1970
SOM
Optimized by Form
Repression of the Program

Figure 9
Turning Torso
Malmö, 2005
Calatrava
Optimized by Form
Repression of the Program
What can we conclude on the basis of the previous analysis in relation to the main question;

How does form & function relate to the identity of a HighRise?

Form & Function both relate to the identity of a HighRise. As seen in the analysis coming to a HighRise design is an interaction between form and function. Following strictly the function means a form which is optimized to that function and vice versa.

But how is this related to identity? As mentioned before identity is defined as followed:

“The collective aspect of characteristics by which a thing is definitively recognizable or known.”

Looking at the analyzed HighRises we need to make a distinction between two categories of identity, namely: outer and inner identity.

The outer identity is conceptual formed by the surrounding area of a HighRise. Functions can affect the public space but are not in direct relation to it. The outer identity can be seen as the face of the building towards the outside world as a part of the public realm.

The inner identity is conceptual formed by the function of a HighRise. The public space can affect the function but are not in direct relation to the inside. The inner identity can be seen as the way we experience spaces related to a particular function.

Designing means finding the optimum between these inner and outer identity.

• Focusing more on the outer identity, the more it imprisons the inner identity.
• Focusing more on the inner identity, the more it shapes the outer identity.

Finally the form determines the basics for both identities in a HighRise building. With the restrictions of the form an inner identity can be formed for a particular function and an outer identity can be formed towards the outside world.

But how can this form be defined for the total lifespan of a HighRise which can less more than 100 years?

“Thinking about users means thinking of buildings as spaces, their outsides as boundaries to spaces. Space is to live in. Objects are frozen thoughts.”

---


Figure 10
Designing the inner and outer identity
Focusing on the form related to the inner identity is focusing on functions. Functions are designed for a particular moment on the basis of requirements in that period of time. The function within a HighRise is not a static snapshot but changes throughout the lifespan of a HighRise. Everything changes, we are working and living different as we did 50 years ago and shall keep changing on our way in to the future. Functions should have the ability to evolve hence inner identity should have this possibility.

“Perfection means something is complete and stands still and what stands still doesn’t change or evolve and is automatically dead. Everything in this universe changes, evolution implies that the creation is not complete hence the possibility of evolving.”

A building should provide a shell for the total lifecycle of a building which will further grow its soul because of its possibility of evolving.

“The building serves merely as a framework for individual uses and no longer as a shell with a precise content. Architecture no longer has the task of developing scenarios, of manifesting values, planning can only limit life processes. Form is thus no longer the representation of a specific function, but is a direct translation of highly diverse, mixed functions.”

As mentioned before focusing on the form related to the outer identity is focusing on the public space. Christopher Day is referring to the history. HighRises obtained a strong identity because of their dearness to the public realm through time. The outer identity should be designed following this dearness.

“Soul-sustaining environment isn’t just eco-by-product. It’s vital for sustainability. Places of beauty, especially those we’ve taken part in making, we value. What we value, we maintain and protect. Value is the root of longevity. Building and place longevity give durable roots to our surroundings. These give society a stable framework.”

On the other hand Koolhaas is referring to the present referring to the outer identity. An identity can be obtained through time and not on a particular moment. So it is very difficult to design a outer identity for a buildings lifespan.

“Identity is like a mousetrap in which more and more mice have to share the original bait, and which, on closer inspection, may have been empty for centuries. The stronger identity, the more it imprisons, the more it resist expansion, interpretation, renewal, contradiction.”

An outer identity designed for the total lifespan of a HighRise always limits the evolution of the inner identity. So both identities should be created in such a way that they allow each other to evolve. All buildings are predictions and predictions are mostly bound to be wrong, so also both identities are bound to be wrong. With the possibility of evolving buildings can optimize an inner and outer identity through their total lifecycle.


THE IDENTITY

“...A set of hybrid buildings can form the Generic City. Is this contemporary city like the contemporary airport – ‘all the same’? Is it possible to theorize this convergence? And if so, to what ultimate configuration is it aspiring? Convergence is possible only at the price of shedding identity. That is usually seen as a loss. But at the scale at which it occurs, it must mean something. What are the disadvantages of identity, and conversely, what are the advantages of blankness? What if this seemingly accidental – and usually regretted – homogenization were an international process, a conscious movement away from difference toward similarity? What if we are witnessing a global liberation movement: ‘down with character!’ What is left after the identity is stripped? The Generic?”

‘The Generic City is the city liberated from the captivity center from the strait-jacket of identity. The generic City breaks with this destructive cycle of dependency: it is nothing but a reflection of present need and present ability. It is the city without history. It is big enough for everybody. It is easy. It does not need maintenance. If it gets too small it just expends. If it gets old it just self-destructs and renews. It is equally exciting or unexciting everywhere. It is “superficial” like a Hollywood studio-lot, it can produce a new identity every Monday morning. The Generic City is not only multiracial but also multicultural. The Generic City is on its way from horizontality to verticality. The HighRise looks as if it will be the final, definitive typology. It has swallowed everything else.’

HighRises, by their nature, are icons. Their form makes them icons which mainly is experienced from the scale of the city. We just see a giant facing us. Two-thirds of the world’s population now live in cities hence ‘Vertical Cities’ are the inevitable fruits of this phenomenon.

HighRise buildings continue to proliferate. Overglazed (so air-conditioned) and under-daylit (so fluorescent lit), full of synthetic materials and electromagnetic confusion, they’re unhealthy, disconnected from life (both living nature and surrounding society) and heavily energy dependent. Awareness of how buildings can connect us with life and function in harmony with nature’s forces is essential to reduce both health costs and energy (of which buildings use half). The fixed idea imposed as object: the individuality of place, the users and the stream of time through past to future are of no concern to such a building. These blinkers of imagination shape and are shaped by the speculative building industry and other vested-interest manipulators of wants, like industrial standardized mass-production.

When making these Hybrid HighRises we have to be careful with the places inside these buildings. The inner identity should be the reflection of individuality. A ‘place of the Soul’ which nourish us as residents and workers.

“Small rural buildings we may experience as objects in relationship with their surroundings, large urban ones more commonly only as the boundaries of space.”

---

Why Identity?


Inner vs. Outer Identity

Small vs. Tall Buildings

Architecture is but a part of the built environment. Inside a building, its parts become the whole environment; from outside it's only part of our surroundings. We rarely experience larger buildings as architectural objects, but where we do, it's usually because they're forceful and dominating. Such buildings impose their presence on us and – most particularly – are imposed upon their surroundings. They're crystallized monologues – nothing about meeting the needs of people or place. Lending themselves better to photography, they're also favorite subjects for architectural magazines.

Architecture as Space

Often our experience of buildings is not as free-standing objects but of boundaries of space. The quality of this boundary is a major ingredient of the quality the place will have. Thinking about users means thinking of buildings as spaces, their outsides as boundaries to spaces. Small rural buildings we may experience as objects in relationship with their surroundings, large urban ones more commonly only as the boundaries of space. Space is to live in. Objects are frozen thoughts. The one is life-enhancing; the other, if big enough, threatening, dominating, stealing sunlight with its huge shadows or tricking our sense of orientation with its reflections.

We as students spend much time we wasted drawing carefully composed elevations and how little we spent on sections, internal perspectives or views of relationships with surroundings. It should be the other way around! We should spend less interested in objects but in places.

Commitment

Design doesn't stop when buildings are completed. It's routinely renewed during occupation and adaptation. Likewise it's normal for design refinements to continue right through construction. Hand construction may sound unrealistically out of date, but makes it easier to adapt buildings when potential benefits or shortcomings become apparent. Hand construction also gives textural scale: bricks, slates and wood are hand-scaled, mechanically erected panels crane-scaled. Where opportunities exist for the builders to become artistically involved in their work, such buildings have a distinct soul even before they're occupied. The spirit of a place can develop because of, not in spite of, the building. Hence, quite apart from its appearance, method of construction and form of contract have a bearing on the spirit of a building.

“Neither past nor future mean anything on their own. Future grows out of; is fed by, past; and past is always inspired by future. Development, whether buildings or any other aspect of place, if aligned with this continuum, will ‘fit’ timelessly in place and time. Non-aligned, imposed ones can’t. To be harmonious, the new needs to be an organic development of what is already there, not an imposed alien."
Figure 13
Buildings as Spaces
It makes a lot of difference whether things are designed for people or together with them. Architects hope their buildings will last for several generations, so however much they design with occupants in mind, they’ll never meet all of them. But unless we can design something nourishing to our soul nourishing, not just nice, dramatic, photogenic, novel we can hardly expect it to be nourishing to anyone else.

“\textit{What makes the human being really human, however, is the ability to distinguish what would be the right or wrong way to act. Unlike animals we can transcend instinct, habit or behavior conditioned learning by using our thinking and moral and aesthetic sensitivities to consciously choose our actions. In our surroundings we also make distinctions as to what we like or dislike. We can be nourished by artistic qualities which go beyond mere psychological technique. To uplift the spirit, places must, in some way, be artistic.}\textsuperscript{19}”

The sequence of preparatory experiences we pass through to approach, enter and use a building do more than affect our experience of it. They change our inner state, which can both enhance our receptiveness to health-giving qualities in our surroundings and trigger transformative processes in our inmost being. All healing is founded on such inner transformations, albeit initiated by outer agents. Threshold, sequence and ‘oasis’ have, therefore, important health-giving functions. Our surroundings are potentially the most powerful art form we experience in our lives. Whether they will bring illness or healing depends upon all of us whose decisions and actions shape human environment.

“\textit{Art is the experience of something which leaves you never the same again. It has brought an inner step forward. Medical, psychological and spiritual healing involve processes by which something outer is brought to patients so that they can make an inner step. Just as healing is quite distinct from medical, psychiatric or ideological ‘treatment’, this is a process of enabling, not of manipulating.}\textsuperscript{20}”

In every seed there is, more or less, a pure plant, an archetype. As the plant grows, the individuality of its surroundings, soil, climate and so on causes it to modify this archetype. If you look closely, two adjacent clumps of grass are different. Trees can be so different that we recognize them as individualities. Even development in time is a metamorphic process: young and mature and early and late leaves have different shapes. When we build objects that don’t evolve, we deny this life process and this response to surroundings. We impose dead ideas, often ideas which aren’t even modified by materials (in the way that clouds often form the shape of a landscape, itself made up of a metamorphic series of forms).

“\textit{Like strong colours, repetition leaves us unfree. It’s hard not to give ourselves over to repetitive music. Rhythm brings the first transformative influence of life; adaptability carries it further.}\textsuperscript{21}”
Figure 14
Evolution as a dynamic ongoing never ending process

Figure 15
Architecture as Art
Once we think of the creation of places as a process, it is obvious that for places to develop in a healthy way, every stage needs not only to be healthy but to add something beneficial to whatever has gone before. While the purpose of architecture is to fulfill and harmonize people’s and places’ needs, this is a process. It doesn’t stop with design. Building construction, then occupancy and use, further develop this process. Each stage builds on the one before and opens itself to the one after. This process should be linear but a cycle with closing loops. Architecture is about bringing place and project, background context and the life of future users into relationship. If it can weave together what has come before (the environmental context) and what will come (the users) and through the process of designing and making raise the ingredients artistically, it can find in a new, conscious and relevant way the organic process on which the evolution of places depends.

“Soul can incarnate progressively into a building with each step from wish, through idea, planning, constructional design and building to occupation. Each stage develops, deepens and extends that which had come before. These stages don’t alternate from artistic to practical but, with these aspects inseparable throughout, make a continuous process of incarnation into substance until architects complete their task, leaving a shell for the life which will further grow its soul.”

Every building situation is unique. The building’s relationship to its surroundings is unique; its users, even if we don’t personally know them, are individuals. If designers live up to their responsibilities, they must listen to the unique requirements of each individual environment, each particular set of users. If not, we’ve seen enough mass housing repetitively and brutally imposed! Once we listen like this, it’s quite clear that no two sites, no two users are the same. They may share similar characteristics, but they’re not the same. No one design can fit in different surroundings; only in one can it be appropriate.

“We have come to take for granted that buildings are provided ready-finished by others. The less we are able to do ourselves, the more dependent we become. Dependency is a step towards social malaise. In this conventional building process, time costs money. Flexibility takes time and, by making rigid pricing difficult, financial risks are added. So everything has to be fixed and put on paper and, as a matter of course, we accept the disadvantages of these conservative way of working.
Figure 16
Everything in the universe is unique

Figure 17
Flexibility as the key to react on different requirements and needs
**Timelessness**

Proportion determines whether places are at rest or have a directional dynamic and the feeling that goes with it. Upward, forward or all-round horizontal emphasis can induce awe, expectation or soothing. Proportions at balance reflect balance in the human body, inducing a mood of balance in the soul. Proportions too high, too wide, too long, like lines that are too dynamic or spaces too strongly focal risk being too compelling. We should leave users free.

Perhaps the most essential quality is timelessness. A painting can be timeless, so can a building. Obviously the painting has to avoid anything that finds its resolution in time outside the moment like someone kicking a ball. The same with a building. This doesn’t only mean qualities at once traditional and modern; it also means resolving sculptural forces, energy and implied movement, gesture, gravity, structural and visual tension. Dead things are stable, immovable, but they’re left behind by time.

“The eternal lives in every moment.”

Most of us spend most of our time in, near or influenced by built surroundings. We spend our lives in what were once the thoughts of architects. Today’s thoughts make the world of tomorrow an awesome responsibility. Especially so as in barely half a lifespan architecture has destroyed so much cityscape and landscape the world over; so many communities, so much ecology, local and global.

While nature is shaped by self-balancing processes, townscape, not unnaturally, is shaped by material considerations. But why can’t built environment offer as wide a range of spirit nourishment as do healthy landscapes? But whatever our role, architect, builder, building owner or user we are all co-shapers of our environment. And we won’t support life unless we consciously choose that as a priority whatever the price.

---

Figure 18
Timelessness, the eternal lives in every moment

Figure 19
What we shape we use
LITERATURE


BIOGRAPHY

Saman Mohammadi & Niel Slob are currently graduating for the double master course Architecture (Hybrid and Tall Buildings) and Real Estate & Housing (Design & Construction Management) at the faculty of Architecture in Delft.

For Real Estate & Housing they are researching lifecycle focus as a method of programming & designing. To prove the benefits of a lifecycle approach in terms of People, Profit & Planet, they use flexibility as a tool to achieve maximum sustainability throughout the buildings lifespan. For Architecture they test their research results on a HighRise design.

For future practical use, these results will finally be published in a manual during the summer of 2010, named: ‘The Anatomy of the Hybrids’. A summary of this thesis will be added into the chapter Hybrids of the Manual. For more detail read the following article about their Manual.