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Sustainable Tall Buildings – Some Introductory Remarks

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Biography

Werner Sobek studied architecture and structural engineering at the University of Stuttgart in Germany. In 1991 he became full-time professor at the University of Hanover in Germany. One year later he founded his own engineering consultancy in Stuttgart, Germany. In 1995 Werner Sobek took over the famous Institute for Lightweight Structures at the University of Stuttgart as successor to Frei Otto. In 2001 he also took over the chair of structural engineer Joerg Schlaich, fusing the two institutes into the new Institute for Lightweight Structures and Conceptual Design (ILEK).

While the ILEK specializes on the research into new materials and new concepts for lightweight and adaptive structures, Werner Sobek Ingenieure is one of the leading engineering consultancies in Europe. It excels through excellent engineering combined with first-rate design of constructional elements. A particular focus lies on special structures in steel, glass, titanium, concrete, textiles and wood. Werner Sobek Ingenieure has offices in Stuttgart/Germany, Frankfurt/Germany, and New York, NY.

The works of Werner Sobek have been awarded numerous awards and distinctions, e. g. the DuPont Benedictus Award, the Design Award of the Industrial Fabrics Association International, the European Gluelam Award, the Fritz Schumacher Award, the iF Design Award, the SEAOI Structural Engineering Award, AIA awards of the American Institute of Architecture, the Hugo Haering Award, the 'Building of the Year' Award of the Association of Architects and Engineers of Hamburg, the Fazlur Rahman Khan Medal as well as the UIA's Auguste Perret Prize.

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Abstract

This paper considers the basic requirements needed to achieve truly sustainable buildings. It discusses possible ways of modifying the cooperation between all project partners responsible for the implementation of a green design. It further identifies the concept of triple zero as a new approach towards vital ecological issues. The paper also proposes a new certification procedure offering a comprehensive assessment and classification of sustainable tall buildings.

Keywords: Triple Zero, Integrated Design, Certification

Introduction

Over the last five years the focus of building design has shifted from predominantly architectural and functional approaches to more exhaustive approaches putting a special emphasis on sustainability. Today investors, building developers, and project managers do specify certain demands for sustainability in the first stages of a project. But these demands are simply additional requirements leaving the conventional contract documents and planning process unchanged. Specialist consultants are as yet insufficiently involved in the first design phases, although their contribution is vital for a really ecological design. Moreover, sustainability is often merely used as an argument for architectural competitions and marketing purposes, the final result not matching the promises made at an earlier stage.

In order to develop and implement truly sustainable building concepts, an interdisciplinary planning process is indispensable. All planners involved in the project should participate at the earliest project phase possible. Moreover, coherent guidelines and assessments are necessary to ensure a coherent and sustainable design process in all phases of a project. Sustainability has to be the governing factor in the compilation of all specifications and contract documents. The present paper proposes an approach towards achieving this aim. This approach will hitherto be called integrated design.

Sustainability covers social, ecologic, and economic questions. The social aspect comprises cultural considerations, comfort, social integration, health, ergonomics, and functionality. It is generally taken care of by architects. The economic aspect is assessed by value-engineering and commercial departments. The ecological aspect, however, is often reduced to energy efficiency only. Ecology is thus taken into consideration but to a relatively limited degree. The present paper proposes a much more comprehensive target concept called triple zero – zero energy, zero emission, zero waste.

Last but not least a national certification procedure is presented offering an advanced tool for the classification of structures according to their sustainability. This classification system is about to become the governing factor for the assessment of buildings, especially for office, retail and residential buildings, in Germany and beyond.

This paper shows a way to successfully fulfil the demands for full sustainability by applying an integrated design process, the triple zero concept, and the new certification procedure proposed by the GeSBC.

Representative life-time phases

The life-span of a structure can be divided into five periods, subdivided into several sub items:

1. Preliminary Phase
   - Definition of building task, data collection
   - Architectural and functional concept (possibly defined for a competition)
2. Realisation Phase
   - Schematic design
   - Detailed design
   - Construction design
   - Bidding and contract award
3. Construction
   - On-site activities
   - Re-design
4. Operation Phase
   - Utilisation
   - Conversion
5. Removal Phase
   - Deconstruction
   - Disposal of waste

Design Groups and Involved Parties

Depending on the extent and type of structure, various disciplines are required for the design process. The following list is a typical compilation of disciplines involved in a larger project.

Developer:

- Principal, Investor
- Project manager

- Project controlling and monitoring

General Design:
- Architect, design engineer

Construction:
- Structural consultant
- Geotechnical engineer
- Special structure consultants (light structures, special foundation, etc.)
- Wind engineer

Building Services/ Physics:
- MEP – Mechanical, Electrical, Plumbing
- Building Physics consultant incl. hygrothermy (heat and moist transfer)
- Special consultant on cooling and heating
- Thermal simulation, CFD engineer
- Façade consultant
- Daylighting consultant

Ergonomic and Interior Design:
- Interior architect
- Ergonomic consultants for workplaces, offices, apartments, hotels, wellness, retails
- Acoustic consultant
- Light planning consultant

Cost Assessment/ Economy:
- Value engineer
- Full life-cycle costs/ Environmental costs consultant

Traditional Linear Design Process

The traditional linear design process basically follows consecutive planning and design phases shown in *Figure 1*. Architects, engineers, and specialist consultants are successively included in this planning procedure. Often engineers and specialist consultants participate only to a limited extent in the early phases of a project. However, the first two phases of a project are of the highest importance, as here the effect of measures aiming at sustainability and cost-efficiency is strongest. The rare examples where specialist consultants are involved from the very beginning of a project demonstrate the validity of this argument [Morgan, 2001].

As a typical example, structural engineers, MEP, and lighting consultants often become involved in the schematic or detailed design. Therefore these experts are often acting only in a passive way, because the main design has already been determined before. In the later planning phases major changes or innovations are more difficult and less efficient. The frame in which the consultants search for solutions gets narrower the more advanced the design already is [Schuster, 2005]. Within the old-fashioned linear planning process, the active involvement of these specialist consultants in the preliminary design is more or less impossible.

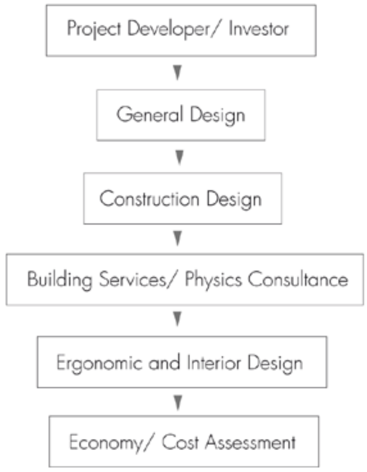

Figure 1. Traditional Linear Design Process

Sustainable Guidelines and Standards

The existing guidelines and standards, e.g. [DCLC, 2006], [BVBW, 2001] or [USGBC, 2005] on sustainable designs are focussing on the final performance of the building. These codes are measuring the sustainability of a building against various design categories (e.g. energy/CO_2, water, waste, health and well-being etc.). In [DCLC, 2006] and [USGBC, 2005] the rating is performed using a table of points awarded for a variety of criteria (e.g. in [USGBC, 2005] sustainable sites, water efficiency, atmosphere, material & resources, indoor environmental quality, innovation & design process), whereas the structure is considered as a whole package. Although very good checklists and references to special codes are given, e.g. in [BVBW, 2001], the design process itself is not mentioned in these guidelines.

There is a number of recent buildings in Europe showing a good sustainable performance such as the Post Tower/Bonn (see *Figure 2*), EnergyBase/Vienna, R&D centre of Festo/Esslingen, headquarter Telefónica/Madrid, the headquarter of Merck Serono/Geneva (see *Figure 3*), Kolumbus-Centre/Vienna or BMW-World/Munich. In all these buildings, various techniques were taken into consideration (and later on implemented) at a very early stage of the design. These techniques include intelligent double facades, solar-powered cooling, geothermal energy systems, absorption cooling, thermal storages, PCM, plasters with microcapsule including paraffin or silicate gel, photovoltaic, thermally activated structural members and air-conditioning based on heat exchangers. Future projects may use even more advanced techniques currently being prepared for maturity phase [Sobek, Haase, 2005].

Integrated Design Process focussed on Sustainable Buildings

Figure 2. Post Tower/Bonn (Copyright: H.G. Esch, Hennef)

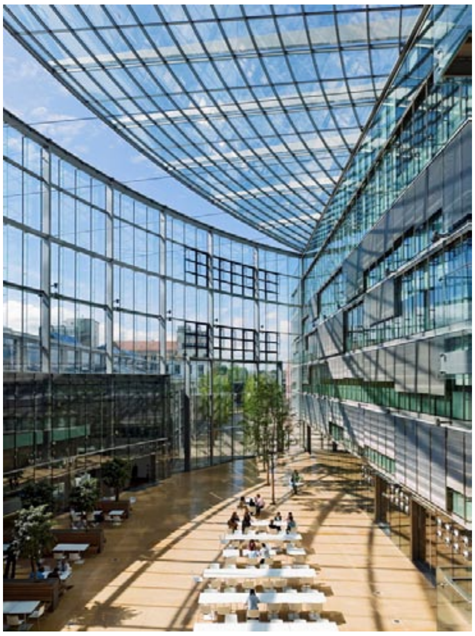

Figure 3. Merck Serono Headquarter/Geneva (Copyright: Rainer Viertlböck, Gauting)

Sustainable design requires a holistic approach, where the specialist consultants from various disciplines are included from the very beginning of a project. These specialist consultants have to be able to understand the needs and intentions of the other disciplines. This process is herein after called integrated design.

Within the integrated design process all parties involved are considered throughout the representative life-time phases according to 2.1 and 2.2. *Figure 4* gives an illustration and a matrix of the integrated design process. The relevant experts are involved from the first outline of the project until the removal phase. Therefore they acquire a better understanding of the various demands and performances of the various disciplines. Finally the building set-up is a common development.

Architectural, formwork, and reinforcement drawings are commonplace. The authors of the present article propose to create "member drawings" as well. Every structural and finishing member shall get a special barcode as an identification number. The members shall be marked with this barcode on site or already in the prefabrication plants. The member drawings shall include a list of members and be linked to a member databank. This databank shall contain detailed information on average life-span and costs as well as instructions on deconstruction and disposal of waste.

The whole integrated design process has to be focussed on sustainability. The key elements of design and construction have to be assessed with regard to their social, ecologic and economic impact on the building. Improvements and innovations shall be supported, negative impacts excluded.

The basic objective underlying integrated design is the triple zero concept described in the following chapter.

Life-time phases		Design Groups					
		Developer	General Design	Construction	Building Services/ Physics	Ergonomic and Interior Design	Cost Assessment/ Economy
Preliminary Phase	Definition task	X	X				
	Architectural Concept	X	X	X	X	X	X
Realisation	Schematic Design	X	X	X	X	X	X
	Detailed Design	X	X	X	X	X	X
	Construction Design	X	X	X	X	X	X
	Bidding and Contract Award	X	X				X
Construction	On-Site Activities	X	X	(X)	(X)	(X)	(X)
	Re-design	X	X	X	X	X	X
Operation	Utilisation	X					
	Conversion	X	X	X	X	X	X
Removal	Deconstruction	X					X
	Disposal of Waste	X					X

Figure 4. Matrix of design groups and life-time phases for an Integrated Design Process

The Triple Zero Concept

Triple Zero is a comprehensive approach covering all ecological aspects of sustainability:

a) Zero Energy

- reduction of the energy consumption in the operation of a building (lighting, heating/cooling, ventilation)
- avoidance of fossil fuels
- use of renewable energy sources

b) Zero Emission

- reduction of emissions (energy use emissions, particulate matter, plasticizer, scent etc.) throughout the life-cycle of a building (design, construction, operation, reuse, demolition)
- design of flexible and reusable buildings
- use of ecological and local materials to avoid sick-building-syndrome and high energy use for long transport

c) Zero Waste

- recycling of all materials used in a building
- avoidance of composite materials which cannot be separated at the end of their life-cycle
- easily demountable constructions
- registration of all building components in a data bank specifying the materials used, the manufacturer, particular information regarding dismantling and recycling etc.

The Triple Zero concept is to be used as the central guideline underlying the whole integrated design process.

Existing Certification Systems

Various countries have already implemented a certification system for sustainable designs, e.g.:

- USA:
  U.S. Green Building Council
  LEED – Certification System
- France:
  Association HQE
  HQE – Certification System
- Great Britain:
  Building Research Establishment
  BREEAM – Certification System
- Japan:
  Japan Sustainable Building Consortium
  CASBEE – Certification System

All these certification activities are coordinated and supported by national Green Buildings Councils (GBC). The umbrella organization is the World Green Building Council describing its activities as 'the peak global not-for-profit organisation working to transform the property industry towards sustainability through its members national GBC's'.

In several European countries an 'energy passport' for buildings will be introduced soon. For example, in 2007 the Energy Performance Certificates will be introduced in Great Britain under the Energy Performance of Building Directive (EPBD). The EPBD requires that all new, sold or released homes have an Energy Performance Certificate. The key information in this certificate is energy efficiency measured as carbon performance using the same calculation method as the Code for Sustainable Homes [DCLC, 2006].

Proposal for a Certification System of the German Sustainable Building Council

The German Sustainable Building Council (GeSBC) has recently been established. The mission of the GeSBC is to promote and support a fully sustainable design, realisation, usage and disposal of buildings. The aims pursued by the GeSBC are:

- Protection of resources
- Preservation of natural environment
- Health, comfort and well-being of habitants
- Protection of environment and public goods
- Preservation of values

The main objective of the GeSBC is the configuration of a national certification system making the above-mentioned aims "protection targets" for the assessment. Contrary to other certification procedures such as [USGBC, 2005], the GeSBC Certification clearly specifies the main objectives and not individual measures. Specific means are deliberately left undefined so as to allow for an open and innovation-friendly sustainable design process.

The GeSBC certificate defines a number of aspects necessary for full sustainability, e.g. thermal insulation, comfort, impact on environment, social aspects etc. Only for some of these aspects numeric indicators can be used, e.g. for carbon performance, total primary energy supply etc.

Therefore expert groups will work out a procedure how the assessment can be performed using these new comprehensive indicators.

In order to achieve maximum acceptance, a certification system has to be highly transparent and coherent. It also has to be adapted to the national culture of each country taking into consideration national building traditions, codifications, and social aspects.

As a result of its current deliberations, the GeSBC will introduce in the near future a certification system with five stars and gold as well as silver rating. The assessment starts with the individual target definition and accompanies the design process until the final award. A five star classification is an exclusive distinction which will only be given to truly outstanding projects.

Conclusion

The conventional and traditional way of linear planning is not compatible with the demands of a sustainable building design process. The stepwise involvement of specialist consultants at a relatively late stage of the project hinders a mutual understanding of the various disciplines and prevents true sustainability.

A tripartite approach is proposed to overcome this difficulty. Firstly, an integrated design process allows involving engineers and other specialist consultants already at a very early stage of a project. This allows for an optimum of innovation and cost-efficiency. Secondly, the triple zero concept covers all ecological aspects of sustainability. Thirdly, the certification procedure proposed by the GeSBC permits a holistic assessment of a building, measured by the achievement of five clearly specified targets.

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