BT Research Portfolio
Computation & Performance
Green Building Innovation
Text Andy van den Dobbelsteen, Mick Eekhout, Tillmann Klein, Ulrich Knaack, Rudi Stouffs
Layout Michiel Fremouw
Photos Department of Building Technology (Marcel Bilow, Michiel Fremouw and others)
Printed by Sieca on 280g colotech (cover) and 90g colotech
ISBN 978 90 5269 387 3
©2010 Department of Building Technology, Faculty of Architecture, Delft University of Technology
Publikatieburo Bouwkunde

cover: Seattle Art Museum, 2007 extension by Brad Coepfil of Allied Works Architecture
ARCHITECTURAL ENGINEERING
   Prof. Dr.-Ing. Patrick Teuffel
   Prof. Thijs Asselbergs

DESIGN of CONSTRUCTIONS
   Prof. Dr.-Ing Ulrich Knaack
   Dipl.-Ing Tillmann Klein

PRODUCT DEVELOPMENT
   Prof. dr. ir. Mick Eekhout
   Dr. ir. Arjan van Timmeren

CLIMATE DESIGN and SUSTAINABILITY
   Prof. dr. Andy van den Dobbelsteen

BUILDING SERVICES
   Prof. ir. Peter Luscuere

BUILDING PHYSICS
   Dr. Truus de Bruin-Hordijk

STRUCTURAL DESIGN
   Prof. ir Kees van Weeren
   Prof. ir. Rob Nijsse
   Prof. ir. Joop Paul

STRUCTURAL MECHANICS
   Prof. dr. ir. Jan Rots

DESIGN INFORMATICS
   Prof. dr. ir. Sevil Sariyildiz
   Dr. ir. Rudi Stouffs

HYPERBODY
   Prof. ir. Kas Oosterhuis
1. PREFACE

The Department of Building Technology is located within the Faculty of Architecture at TU Delft, representing the technical area of building design. The responsibility lies in the fields of structural, constructional, climatic and computational design, for which the department encompasses 11 professorships and approximately 100 staff members, providing education in the BSc and MSc tracks and two of a total of six research programmes of the faculty.

Building Technology strongly believes in technical development for a sustainable, efficient and human-centred architecture. With regards to this, there is intensive interest in technology-related research to provide strategies, tools and technologies for designers and users of architecture.

In the tradition of research within an architectural faculty, the department links its research activities to education - explicitly in the MSc track - and to architectural and architecture-related practice outside the university to guarantee interaction and relevance.

Research within Building Technology is divided into two programmes: Computation & Performance, a section oriented around the potentials of computation for architecture, and Green Building Innovation, which focuses on components and technologies for sustainable architecture and urbanism. Levels of activities take place in all planning scales, involving urban strategy and planning, architectural design, structures, construction and climate concepts all the way to details and materials.

Both programmes are executed by several chairs that share interest in the content and collaborate in research projects. Therefore, the staff of Building Technology is involved in research with 1/3 of its capacity, strongly supported by an growing amount of PhD students.

Prof. Dr.-Ing. Ulrich Knaack
Chair of the Building Technology department
CONTENT

1. PREFACE ................................................................. 4

2. PROGRAMME HISTORY ........................................ 6

3. COMPUTATION AND PERFORMANCE programme introduction .............................................. 8

4. GREEN BUILDING INNOVATION programme introduction ...................................................... 10

5. RESEARCH PORTFOLIO ........................................... 16
   How to read this chapter ................................................................................................. 16
   Computation and Performance (C&P) ............................................................................. 23
   • Events ....................................................................................................................... 25
   • PhD research ............................................................................................................ 39
   • Projects .................................................................................................................... 49
   • Publications ............................................................................................................ 79

   Green building Innovation (GBI) ...................................................................................... 103
   • Events .................................................................................................................... 105
   • PhD research ......................................................................................................... 113
   • Projects .................................................................................................................. 141
   • Publications .......................................................................................................... 199

   Department wide projects .......................................................................................... 209

6. DEPARTMENT STAFF ................................................... 214

7. CONTACT ................................................................. 224
2. PROGRAMME HISTORY

The history of the program during the last assessment period is turbulent. Almost every year new arrangements were made, while the programs were expanding. Now the growth has come to a stop and the current international recession which also threatens the research funding, has to be met with an adequate answer. The origin of the programme is the Blob/ICT research programme that received a good assessment in 2004 over the previous period of 1997-2002:

- Quality 4
- Productivity 4
- Relevance 4
- Viability 4

The results can be read here: http://www.qanu.nl/comasy/uploadedfiles/Architecture.website.pdf

As such the programme blobs/ICT had the highest marks of Architecture TU Delft.

The Assessment period was full of changes. The Chair of Informatics decided to follow an independent path and separated in 2004. In the chair of Product Development a new sub-programme was launched in September 2004 'Concept House', mainly on 3rd flow income from SME industries. The newly appointed professor of Design of Constructions, prof.dr.Ulrich Knaack introduced a sub-programme of Façades after his assignment in April 2005. In 2008 the order was given by the dean to subdivide the department of Building Technology into 3 in stead of 5 programmes (by a clustering of programmes), which meant a new subdivision. A second move was to widen the programme of Building Technology, called 'Building Innovation', to a faculty wide programme, also by order of the dean. This programming was able to expand its collaboration on 3TU level in order to get closer to the Dutch supplying industry.

Recent development

![Diagram of research programmes]  

*Development of the research programmes of Building Technology.*

However, after the 2nd internal assessment in 2008, the programs of ICT and Zappi were joined to form the program of 'Computation and Performance' and the two programs of 'Building Innovation' and 'Climate Design' were joined to 'Green Building Innovation'. In 2009 dr. Andy van den Dobbelsteen was appointed as the professor for Climate Design. He was appointed to be the new program research leader of GBI.
The future of the programs

Discussions to make the two programs of BT into one Building Technology program for sake of clarity in the programming in general are discussed, but frozen, as will the potential to widen the program of ‘Green Building Innovation’ to a 3TU program remains for the future. This widening could be of considerable interest for the Dutch supplying industry. In all of the past turbulent years the individual researchers did their work. To make larger sets of researchers gives the program more body, but it also helps to address the building industry in a more impressive way, as long as the quality of the research is kept at a high level and the accessibility of the researchers via a research portal is increased.

A major step to be taken up is to readdress the societal challenges in the research topics. For that aim prof. Mick Eekhout has analysed a new type of programming, ‘3TU Spearhead Building Research’ that unites the 3TU in a new programming where the joint energy of all 3TU researchers of the building faculties is united to initiate innovations for the Dutch Building industry and to aid the industry to escape from the current recession period.

The TU Delft Rector Magnificus has strongly recommended the dean of Architecture to target at marks 4 and 5 in Assessments. It is clear that researchers are caught between the goal to do fundamental research on a high scientific level and the addressing to the industry which is financing the research more and more. This leads to a splits in research: on the one hand the scientific quality has to be maintained or increased; on the other hand research effort is more directed towards societal problems, as the financing of PhD students will in future entirely come form external funds and the building industry.

The principle function of horizontal programmes is to answer societal problems and to obtain external funding (right); The main function of the section-wise research groups is to collect scientific and professional quality and to have it assessed regularly (left). This splits between science and industry is classical.

Mission of the programme of Green Building Innovation

The Research Programme of Green Building Innovation aims “to lead the international practice of building engineering design in sustainable experimentation with globally innovative and improved versions of material combinations of elements, components, systems through to constructional parts in the integrated architecture-oriented design as the integrated technical artefact consisting of constructions, load bearing structures and climate installations with a special focus on sustainability in its widest sense.”
3. COMPUTATION AND PERFORMANCE programme introduction

**VISION:** The developments of architecture and building design are driven by attempts to achieve step changes in performance; the most important way to attain this is to use innovative computational tools, techniques and methods in the design, manufacturing and construction process. Considering performance as a driver in the building design and planning process is a prerequisite to achieve buildings that better perform, function and operate, consume fewer resources in construction and operation, and offer a healthier and more comfortable environment to its occupants, while still being economically viable.

**MISSION:** The mission of the Computation & Performance research programme is to improve the performance of buildings and the built environment through scientific inquiry into novel ways of evaluating and influencing building performance using computational methods for measurement, prediction and simulation of buildings’ performances, form finding, design generation and analysis, information modelling, decision-making and design communication. Performance in this context refers to technical performance as well as qualitative performance—physical and psychological.

**OBJECTIVES:** Through a multi-disciplinary approach, we aim to meet four challenges:

- To define building performance and quality, and to develop the computational means to assess in design the many various aspects that constitute them.

- To apply the understanding of performance and quality to the computational design process, so as to plan, construct and operate buildings where the reality meets or exceeds the aspirations that motivated their production.

- To develop design, communication and decision-making practices, and their computational support, which enable stakeholders to effectively apply the understanding of building performance and quality in an informed and balanced way so as to achieve mutually acceptable outcomes.

- To continually re-examine the relations between performance/quality, function, materials, systems, society, and architectural form within an investigation of computationally enhanced holistic design strategies.
C&P: basic competences (vertical) and societal and scientific themes (horizontal)

C&P programme coordination
Dr. ir. Rudi Stouffs

Key players from chairs involved

<table>
<thead>
<tr>
<th>Research competence</th>
<th>Structural Design</th>
<th>Structural Mechanics</th>
<th>Design Informatics</th>
<th>Hyperbody</th>
<th>Architectural Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures</td>
<td>Prof.ir. Kees van Weeren</td>
<td>Prof.ir. Rob Nijsse</td>
<td>Prof.ir. Sevil Sariyildiz</td>
<td>Prof.ir. Kas Oosterhuis</td>
<td>Prof.Dr.-Ing. Patrick Teuffel</td>
</tr>
<tr>
<td>Informatics</td>
<td>Prof.ir. Joop Paul</td>
<td>Prof.dr.ir. Jan Rots</td>
<td>Dr. ir. Rudi Stouffs</td>
<td>Prof.ir. Kas Oosterhuis</td>
<td></td>
</tr>
</tbody>
</table>
4. GREEN BUILDING INNOVATION

programme introduction

The Green Building Innovation (GBI) research group is founded on the competence of the scientific areas (or Sections) of Climate Design (chairs of Building Physics, Building Services, and Climate Design & Sustainability) and Building Technological Design (chairs of Design of Construction, Product Development and Architectural Engineering).

As described by Prof. Mick Eekhout, Green Building Innovation has evolved over time from the programmes of Building Innovation and Climate Design (since 2003), as well as a considerable part of the Sustainability programme from 2008.

Many issues related to the GBI programme’s performance over the years 2003-2009 were presented and discussed in the report ‘Architecture and the Built Environment – Research in Context 2003-2009’. This text will briefly discuss the programme’s structure and basis, as an introduction to the research projects shown further on in this portfolio.

GBI PROGRAMME COORDINATION
Prof.dr.ir. Andy van den Dobbelsteen
Research assistant: Michiel Fremouw

KEY PLAYERS FROM CHAIRS INVOLVED

<table>
<thead>
<tr>
<th>Product Development</th>
<th>Architectural Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof.dr.ir. Mick Eekhout</td>
<td>Prof.Dr.-Ing. Patrick Teuffel</td>
</tr>
<tr>
<td>Dr.ir. Arjan van Timmeren</td>
<td>Prof.ir. Thijs Asselbergs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design of Constructions</th>
<th>Climate Design &amp; Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof.Dr.-Ing. Ulrich Knaack</td>
<td>Prof.dr.ir. Andy van den Dobbelsteen</td>
</tr>
<tr>
<td>Dipl.Ing. Tillmann Klein</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building Services</th>
<th>Building Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof.ir. Peter Luscuere</td>
<td>Dr. Truus de Bruin-Hordijk</td>
</tr>
<tr>
<td>Ir. Kees van der Linden</td>
<td>Ir. Kees van der Linden</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESEARCH COMPETENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials, Components &amp; Buildings</td>
</tr>
<tr>
<td>Building Envelopes</td>
</tr>
<tr>
<td>Energy Efficiency</td>
</tr>
<tr>
<td>Comfort</td>
</tr>
</tbody>
</table>
Vision

Sustainability of the built environment is an urgent necessity and it is the present generation of scientists, designers and builders who need to make the radical changes before irreversible effects take place to the climate and energy provision. Society needs to shift toward an economy based on renewable or recyclable resources and a built environment that can largely sustain itself. The greatest challenge lies in the alteration of existing areas: with 90% of the near future building stock already built, effective improvement can only be achieved by immediate action to improve entire regions, cities, districts, neighbourhoods, buildings and building elements. A separation of scale and competence is not the issue anymore: for a paradigm shift we need to think across boundaries and disciplines.

Next to this development as a principle is the quest for research unison, deeply embedded in our understanding of sensible research to develop the future.

This requires research that on the one hand has a scientific basis but on the other hand can translate this knowledge to novel technology and design interventions. The Department of Building Technology seems the right place to start this endeavour.

Mission

The mission of Green Building Innovation (GBI) is to be internationally leading in building engineering research and design with a special focus on sustainability in its widest sense. GBI is to become an excellent research group in the area of sustainable technology for the built environment, renowned in the world for its science-based technical innovation through various scales. For the building industry as well as research funding institutes, the GBI group should be considered the logical, leading partner for research on sustainability and innovation.

GBI intends to change the course of planning, design and technology, directing the building industry towards a sustainable future. The built environment needs a radical shift when boundary conditions for architectural design and urban planning will inevitably change. Building Technology will play an important role in this.

Together with the colleagues of the building faculties at Eindhoven and Twente consortiums are made with the building industry to come to a national sustainable building technical research plan in which GBI has the initiative and knows its position between all other national research related institutions (TNO, BNA, SBR, CUR etc).

Objectives

For the long-term intrinsic value of our scientific area GBI aims to continuously enhance their basic competence.

For the mid-term viability of research focus GBI concentrates on themes overlapping within and outside the building technology boundaries on socially urgent issues, such as sustainability. For short-term financial feasibility GBI responds to the day-by-day societal and commercial demand for research in fertile areas of building technology, as long as scientific challenge is involved.

The two latter terms will often co-emerge, as recent developments demonstrated.

GBI intends to proactively take the lead where interests meet opportunities.

In practical terms, GBI intends to grow even when financial circumstances at the university at present are – to say the least – restrictive. The area of technology for a sustainable built environment requires much more development than done so far. The expertise of this particular academic field is still out of balance compared to the immense and urgent societal need within the coming decades, so we foresee a great opportunity to expand as a research group.

GBI: basic competences (vertical) and societal and scientific themes (horizontal)
How to read this chapter

The research portfolio is a summary of completed and ongoing research at the Department of Building Technology within the programs Computation and Performance and Green Building Innovation.

Naturally, the content varies in terms of type, project size, research topic and others, but there is one poster dedicated for each venture. In order to provide a basic structure, the content is divided into four categories regardless of the different group competencies:

- Events
- PhD research
- Project
- Publications

The following index helps the reader to identify potentially interesting content. Further information e.g. the content, the involved team, research period and project volume, can then be found on the specified pages. Different colors on the pages indicate the responsible research team with a specific competence within the department.
COMPUTATION AND PERFORMANCE (C&P)

EVENTS
A Turkish store in NL (2004-2005) ............................................................... 22
Bridge Design in a Historical Setting (2008) .................................................. 23
Compositions (2008) .................................................................................. 24
Computational Intelligence for Design Applications (2007) ................. 25
Digital Manufacturing Workshop (2007) ..................................................... 26
DSD&BT Lecture & Workshop Series (2007-2008) ..................................... 27
Free Form Design (2007) ........................................................................... 28
Free Form Design Workshop (2007) .......................................................... 29
Game Set and Match (2006) ..................................................................... 30
International Colloquium Design Informatics (2009) ............................. 31
Open Platform (2009) ............................................................................... 32
SmartStructures (2006) ........................................................................... 33

PhD RESEARCH
Adaptable Geometry (2006-2011) ................................................................. 36
Adaptive daylighting systems (2010-2014) ................................................. 37
Beyond BIM (2006-2011) ......................................................................... 38
CLIP (2006-2010) .................................................................................... 39
Data Mining of Urban Features (unknown) ................................................. 40
Decision Support for Energy Efficient Redesign (2008-2012) ............ 41
Digital Design in a Homogeneous Environment (2006-2012) ............ 42
Structural Damage in Masonry (2006-2011) ........................................... 43
Urban Grammars (2007-2011) ................................................................. 44

PROJECTS
A Possibilistic Fuzzy-Neural Tree (2009-2010) ......................................... 46
Architectural Cardboard (unknown) .......................................................... 47
Architecture and Aerodynamics (2006-2008) ........................................... 48
Avenirs de Villes (2005) ........................................................................... 49
CLIP EPI-CREM (2009-2010) ................................................................ 50
Computational Intelligence for Sustainable Architectural Design (2010-2012) ................................................................. 51
Constructing Process Models from Distributed Design Activity (2001-2004) ................................................................. 52
Curved Surface Structures (unknown) ......................................................... 53
Digital Pavilion (2006) ............................................................................ 56
Faro 3D laser scanners (2009-2010) .......................................................... 57
FlexTool (2006-2007) .............................................................................. 58
Fragile though Ductile (2006-2010) ........................................................... 59
iLITE Transitions (2007) ................................. 60
InfoBase + KeySet (2002-2004) .......................... 61
Interactive Environments Minor (2010) .............. 62
Muscle NSA (2003) ......................................... 63
Performance oriented geometry (2009-present) .... 64
Representational Flexibility (2001-2005) .............. 65
Structural Design, Composite Structures (2009-2010) 66
The Emotive InteractiveWall (2009) ................. 67
The Strength of Glass (1995-present) ................. 68
The Vela Roof (2009-2010) ............................... 69
Virtual Operation Room (2002) ......................... 70
Visual Perception Computation (2005-2008) ....... 71
Web Protospace (2006-present) ......................... 72
Wind Farm Noordoostpolder (2009) .................... 73

PUBLICATIONS
Adaptive Corporate Environments (2007) ............. 76
Architectural Geometry (2007) .......................... 77
BCN Speed & Friction (2005) ............................. 78
Blurring the Lines (2006) .................................. 79
Challenging Glass (2008) ................................... 80
Collaborative Architectural Design (2008) ............ 81
Design Spaces (2006) ....................................... 82
E-Activities and Intelligent Support (2003) ........... 83
GameSetandMatch II (2006) ............................... 84
iA BookZine (2008-present) ............................... 85
Inception Support for Large Scale Construction Projects (2006) 86
Innovation in Architecture, Engineering and Construction (2005) 87
Intelligent Computing in Engineering (2003) ........ 88
Intelligent Design Objects (IDO) (2009) .............. 89
Modelling Collaborative Knowledge in Digital Free-Form Design (2006) 90
Multiplier Design Studio (2009) ......................... 91
ONL Hyperbody Logic (2006) ............................ 93
Safety concepts in Structural Glass Engineering (2009) 94
System Embedded Intelligence (2008) ................. 95
The Architectural Information Map (2009) .......... 96
Urban Design with Patterns and Shape Rules (2009) 97
Virtual Context (2005) ..................................... 98
GREEN BUILDING INNOVATION (GBI)

EVENTS
European Facade Network (2009-2014) ........................................................................... 102
Future Envelope Conference (2007-present) ................................................................. 103
Integrated Design Workshops (2006-2014) ................................................................. 104
Material Design (2005-present) .................................................................................... 105
MaterialZ (2006-2007) ................................................................................................. 106

PhD RESEARCH
Autonomy & Heteronomy (2002-2006) ............................................................................ 110
Breakthrough Building Innovation (2008-2012) ........................................................... 111
Climate adaptation and spatial planning (2008-2012) .................................................. 112
Climate-Responsive Design (2006-2011) .................................................................... 113
Daylight and Outside View (2006-2011) ...................................................................... 114
Designing the urban microclimate (2006-2011) ............................................................ 115
Free to Design (2007-2011) ........................................................................................... 116
GSRH-SDcities (2005-2010) .......................................................................................... 117
Holistic Energy Assessment Tool (2008-2012) ............................................................. 118
Indoor Climate in the Tropics (2008-2012) .................................................................. 119
Integrated Facade Components (2006-2011) ............................................................... 120
International Facades (2006-2011) .............................................................................. 121
Interrelating Essential Flows (2009-2013) .................................................................. 122
Livable Carbon Neutral Cities (2009-2014) .................................................................. 123
Living Envelopes (2006-2011) .................................................................................... 124
Making The Difference - Individual Thermal Comfort Demand Profiles for Dwellings (2008-2011) ................................................................. 125
Material design (2009-2014) ....................................................................................... 126
Rapid Prototyping in Architecture (2008-2012) ............................................................. 127
Re-Face (2005-2009) ................................................................................................... 128
Residential Building E-novation (2009-2013) ............................................................... 129
Smart Composites (2007-2011) ................................................................................... 130
SREX, Synergy of Regional Planning and Exergy (2008-2011) ..................................... 131
The Climate Adaptive Skin (2006-2010) ................................................................... 132
The Sustainable Office (2000-2004) .......................................................................... 133
Uncertainty Analysis(2007-2011) ................................................................................. 134
Vacuum Insulation Panels ABC (2005-2010) ............................................................... 137
## PROJECTS

<table>
<thead>
<tr>
<th>Project</th>
<th>Start/End</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built Environment &amp; E-Mobility</td>
<td>2009</td>
<td>140</td>
</tr>
<tr>
<td>Carbon Fiber Reinforced Composites</td>
<td>2010-2012</td>
<td>141</td>
</tr>
<tr>
<td>Ceramic dodecahedron sculpture</td>
<td>2009-2010</td>
<td>142</td>
</tr>
<tr>
<td>Comfort in BK-City</td>
<td>2008-2010</td>
<td>143</td>
</tr>
<tr>
<td>Concept House Prototype</td>
<td>2009-2010</td>
<td>144</td>
</tr>
<tr>
<td>Daylight and Outside View</td>
<td>2010</td>
<td>145</td>
</tr>
<tr>
<td>Deflateables</td>
<td>2006-2008</td>
<td>146</td>
</tr>
<tr>
<td>Development of Future Research Topics</td>
<td>2010</td>
<td>147</td>
</tr>
<tr>
<td>Dutch Blob Technology</td>
<td>2010-2012</td>
<td>148</td>
</tr>
<tr>
<td>Energy Saving Energy Supplier</td>
<td>2007</td>
<td>149</td>
</tr>
<tr>
<td>EOS-LT TRANSEP-DGO</td>
<td>2008-2012</td>
<td>150</td>
</tr>
<tr>
<td>EPM Almere</td>
<td>2007-2008</td>
<td>151</td>
</tr>
<tr>
<td>EPM De Groene Compagnie</td>
<td>2008-2009</td>
<td>152</td>
</tr>
<tr>
<td>Exergy Planning Heerlen</td>
<td>2009-2010</td>
<td>153</td>
</tr>
<tr>
<td>Exergy Planning Parkstad</td>
<td>2006-2009</td>
<td>154</td>
</tr>
<tr>
<td>Experimental Prototypes and Realizations for Blob Claddings</td>
<td>2003-2012</td>
<td>155</td>
</tr>
<tr>
<td>Experimental Prototypes and Realizations for Blob Structures</td>
<td>2003-2010</td>
<td>156</td>
</tr>
<tr>
<td>Experiments in Frameless Glazing</td>
<td>1988-2010</td>
<td>157</td>
</tr>
<tr>
<td>Free Form Technology from Delft</td>
<td>2003-2009</td>
<td>158</td>
</tr>
<tr>
<td>Free-D Facades Manufacturing</td>
<td>2005-2010</td>
<td>159</td>
</tr>
<tr>
<td>Free-D Glass</td>
<td>2007-2008</td>
<td>160</td>
</tr>
<tr>
<td>From Space Structures to Spatial Structures</td>
<td>1973-2010</td>
<td>161</td>
</tr>
<tr>
<td>Future Facade Principles</td>
<td>2006-2014</td>
<td>162</td>
</tr>
<tr>
<td>Future Markets for a System Provider</td>
<td>2007-2008</td>
<td>163</td>
</tr>
<tr>
<td>Grounds for Change</td>
<td>2005-2006</td>
<td>164</td>
</tr>
<tr>
<td>Heat Maps</td>
<td>2010</td>
<td>165</td>
</tr>
<tr>
<td>Innovating and Experimenting with Prototypes in Practice</td>
<td>1983-2010</td>
<td>166</td>
</tr>
<tr>
<td>IPC Cassette Façade</td>
<td>2009-2012</td>
<td>167</td>
</tr>
<tr>
<td>IPC The Living Skin</td>
<td>2009-2011</td>
<td>168</td>
</tr>
<tr>
<td>LeanConstruction &amp; aE (unknown-present)</td>
<td></td>
<td>169</td>
</tr>
<tr>
<td>Lord of the Wings</td>
<td>2002-2008</td>
<td>170</td>
</tr>
<tr>
<td>Methodology for Product Development</td>
<td>2006-2008</td>
<td>171</td>
</tr>
<tr>
<td>Modular Façades</td>
<td>2008-2009</td>
<td>172</td>
</tr>
<tr>
<td>Natural and hybrid ventilation</td>
<td>2010-present</td>
<td>173</td>
</tr>
<tr>
<td>Netherlands 2040</td>
<td>2009-2012</td>
<td>174</td>
</tr>
<tr>
<td>Next Active Facades</td>
<td>2009-2010</td>
<td>175</td>
</tr>
<tr>
<td>OSSB Sustainable Housing</td>
<td>2009</td>
<td>176</td>
</tr>
<tr>
<td>POP Energy Groningen</td>
<td>2007</td>
<td>177</td>
</tr>
<tr>
<td>Rapid Prototyping in Façades</td>
<td>2008-2010</td>
<td>178</td>
</tr>
<tr>
<td>Research in graduation work of the International Façade Design Master</td>
<td>2008-present</td>
<td>179</td>
</tr>
</tbody>
</table>
Robust Climate Design (unknown) ........................................................................................................ 180
Slimme Gevel - Metadecor (2009-2010) .......................................................................................... 181
Smart & Bioclimatic Design course (2005-present) ........................................................................ 182
Smart Material Housing-IN4M (2009-2010) .................................................................................. 183
Solarlux (2007-2008) ....................................................................................................................... 184
Sparkasse Ludwigshafen (2006-2007) .............................................................................................. 185
Stylos Pavillion (2005-2007) .............................................................................................................. 186
The 1.3 Meter Plan (2007-2009) .......................................................................................................... 188
The Slim-Slide backing system (2010-2012) ..................................................................................... 189
Tubular Structures in Architecture (2008-2010) ................................................................................ 190
University of Bielefeld (2007) ........................................................................................................... 191
Vacuum Insulation Panels ABC (2007) ............................................................................................ 192
Visual Comfort for Seniors (2008-present) ..................................................................................... 193

PUBLICATIONS
A New Indoor Climate (unknown) ....................................................................................................... 196
Adaptation to Climate Change, A Spatial Challenge (2009) .............................................................. 197
Book of chairs (2009) ......................................................................................................................... 198
Bridging the gap (2009) ....................................................................................................................... 199
imagine Book Series (2007-2014) ..................................................................................................... 200
MIA Bouw (2009-2010) ..................................................................................................................... 201
The Future Envelope Book Series (2007-2014) ................................................................................ 203

DEPARTMENT WIDE PROJECTS
Adaptive Building Systems (2008-present) ....................................................................................... 206
Solar Decathlon 2011-12 (2009-2012) ............................................................................................ 207
Computation & Performance
C&P: EVENTS
A Turkish store in NL
An international interdisciplinary design studio
TU Delft – Bilkent University

A collaborative work was initiated in Fall Semester 2004 between Technical University of Delft in the Netherlands, and Bilkent University, Ankara, Turkey. The work involved 21 architecture students from TUDelft Faculty of Architecture, and 16 interior architecture students from Bilkent University, Faculty of Art, Design and Architecture. Students were asked to form groups of four or five, comprising of architecture and interior architecture students. Each group worked on designing a Turkish store in the Netherlands.

One of the main aims of the study was to make the students from different disciplines to collaborate. This would almost be a rehearsal of the real life market encounter for both parties. However, student groups involved in the study were not only from two different disciplines, but two different cultures as well. The impact of two different cultures in such a collaborative project may not be much since the the academic education both camps are receiving are strictly tied with the principles of universal design. As such, students performed with the same set of values, beliefs, doctrines and ideologies. Yet, the project was consciously chosen to provoke and reflect the traces of both cultures as much as possible. Therefore, the chosen site was within the boundaries of one culture (Dutch), yet the function and customer profile belonged to the other one (Turkish). The reason for establishing such a framework for the project was to impose the conditions so that even the slightest cultural impact that would have affected the collaboration would be observed.

The collaboration platform used in the course was the Mediated Discourse platform of InfoBase.

The final product expected from the students was a movie, integrating a scenario and all the group work. Throughout the process of the collaborative work, students’ evaluations and observations about the process were studied with two extensive questionnaires. First questionnaire was administered at the beginning, specifying the students’ backgrounds and expectations from such a collaborative work. The second questionnaire was held after the project was completed, concentrating on the evaluation of the project from many aspects. Students were also encouraged to reflect their observations to their instructors during the course of the project.

Based on the findings of the questionnaires and the observations, the enablers and disablers of the work can be analyzed by looking at the following aspects:
- technical dimensions
- students’ computer background
- knowledge and motivation related dimensions
- guidance
- communication related issues

Both Universities gained valuable experience to be reflected on their curricula.

For a beneficial collaboration, achieving compatibility in terms of the following factors are necessary:
- Work discipline (meeting the deadlines, promptness in participation, prioritizing tasks)
- Vocabularies (using the same terminology)
- Job description and task distribution (sharing the responsibilities, criticizing mutual efforts towards achieving collective success, not for the sake of proving dominance over the other party)

RELATED PUBLICATIONS
Bridge Design in a Historical Setting
Performance, Geometry & Materials: Designer as Tool Builder
10-12 March 2008

A bridge has many meanings and symbols. But from whatever point of view we might look at it, a bridge always expresses the strong, audacious desire to “cross a boundary”, to overcome an obstacle. Building an imaginary or real bridge is always a challenge, an attempt to fill a gap, to encourage encounters.

In the world of design, there are two schools of thought regarding bridges: those who hold bridges to be infrastructure which are certainly noble but which must simply serve the purpose of solving traffic problems, and, on the other hand, those who believe them to be the outcome of creativeness and inspiration, objects whose shape is both essence and substance. In this workshop the aim is to build a “bridge” between those two perspectives. To reconcile aesthetics, functionality, inspiration and craft, while achieving a balance between bridge and its surrounding, in this case a historical setting.

Examples of bridges in a historic setting are the bridge design of Santiago Calatrava of the Fourth Canal Grande Bridge in Venice or the design competition for the new Academia Bridge also in Venice. Another example is the reconstruction of the historic old bridge in Mostar which was destroyed in the Balkan wars of the ninetieths. For all of these examples the bridge is more than just a piece of infrastructure, but also an object of identity and even of pride. This sensitivity and how to design a bridge in this context is the main topic of this workshop. The design task for the workshop was a new mobile footbridge for the Arsenal in Venice.

Tutors:
Enzo Siviero, Massimo Majowiecki and Tobia Zordan – IUAV Venice
Andrew Borgart, Axel Kilian, Paul de Ruiter, Bige Tunçer and Michela Turrin – Delft University of Technology

Models by Alper Alkan, Jose Beirao, Wei-Tsang Chang, André Chaszar, Ahu Sokmenoglu.
The theme of the symposium Compositions was about designing and building with composite materials. Goal of the symposium is to inspire parties from the whole building-chain (from Architect to project developer) and the supplying industry by sharing knowledge about composite material applications in the building industry. Influenced by welfare, social and economic developments the building industry will change dramatically the coming years. The buildings should become more durable, lighter, quicker to build, more economic and above all more tailored to current custom needs. Composites have these qualities and will accelerate this revolution. The morning session was dedicated to visions. Leading speakers from different disciplines in the building and composite industry gave their visions on the future of composites in Architecture. The afternoon session was dedicated to practice. Speakers with practical experience showed case studies on engineering, fabrication and recycling. Actual building projects with composites as an essential where shows.
Computational Intelligence for Design Applications

Performance, Geometry & Materials: Designer as Tool Builder
14-16 November 2007

This 3-day seminar included lectures and working sessions aimed at introducing advanced computational methods to the TU Delft Faculty of Architecture’s instructional staff, researchers, PhD candidates and advanced MSc students. The focus was on Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms, with tangential attention to optimization, fuzzy-neural decision support, generative systems and negotiating agent systems.

The increasing size and complexity of design projects and design-related tasks is creating an increasing demand for more sophisticated ways of manipulating and reasoning about design information. This event brought together a group ranging from experts to novices in order to present, learn about, discuss and apply some of these advanced techniques, with the goal of disseminating knowledge and interest among a larger pool of educators and researchers who might find them applicable to their work.

The topics discussed also tied in with other lectures in the DSD 2007-8 BT series, including those of Charles Walker, Fabian Scheurer, Kristi Shea, Michael Weinstock, Hugh Whitehead, and Chris Williams.

In addition to organization and moderating by Bige Tuncer and Andre Chaszar, key personnel in the event included the following presenters:

- Michael Bittermann - TU Delft / TOI
- Luisa Caldas - U Lisbon / Fac. Arch.
- Ozer Ciftcioglu - TU Delft / TOI
- Sanja Durmisevic - TU Delft / TOI
- Patrick Janssen - U Melbourne / Fac. Arch.
- Catholijn Jonkers - TU Delft / EWI
- Pascal Wiggers - TU Delft / EWI

Outcomes of the event included continued examination and/or incorporation of some of these computational intelligence techniques in the work of BK/BT researchers Bittermann, Chaszar, Ciftcioglu, and Durmisevic. Further opportunities are sought to extend and consolidate the related knowledge and the network of interested parties.
Digital Manufacturing Workshop
Performance, Geometry & Materials: Designer as Tool Builder
12-14 September 2007

To what extent can digital manufacturing methods inform the creation of architecture? What is the effect of architectural systems inspired by nature to be translated and produced using computer controlled machines? To explore these possibilities is the basis for the Digital Modeling and Fabrication Workshop.

The workshop instructed participants on designing and manufacturing architectural surfaces, and the modeling and manipulation of nurbs surfaces for output to digital manufacturing devices. The workshop attempted to explore at various levels 'why', 'what', and 'how' issues of virtual and physical modeling. Various modeling and scripting techniques were used to produce a design object per participant: a light modulation sculpture that modulates light by translucent surfaces, perforation and curvature.

Tutors:
Oliver Tessmann – Bollinger + Grohmann and University of Kasssel
Edgar Stach – University of Tennessee
Bige Tunçer and Paul de Ruiter – Delft University of Technology


EVENT INFORMATION
Organizer: Bige Tunçer
Tutors: Oliver Tessmann, Edgar Stach, Paul de Ruiter
Period: 12-14 September 2007

RELATED PUBLICATIONS
• (NB: a planned publication of the event’s contents and results intended for publication in 2008-9 was disrupted by the loss of video recordings and all other materials due to the fire in May 2008)
DSD/BT Lecture & Workshop Series

Performance, Geometry & Materials: Designer as Tool Builder
September 2007-June 2008

The Delft School of Design in cooperation with Building Technology organized a lecture, seminar and workshop series centered on performance, form and materialization of buildings. The series involves world renowned academics and professionals each contributing viewpoints from their own disciplines to the theme. The focus of all the contributions is the emerging role of designers as tool builders – the tools being digital, conceptual, or procedural. This role of designers is placed in a local/global and a historical context as well.

The series consists of thematic public lectures followed by round-table discussions, and design workshops.

This series is set up not merely to let researchers and practitioners present their work, but more importantly, to provide for an engaged and open discussion on recent projects, research issues and design perspectives, with an eye for future research directions. The themes that characterize the contributions are complex geometry architecture, concerning buildings that could not have been realized (or arguably even conceptualized) with traditional means, and performance based architecture, concerning questions of performance in the design/realization of buildings. These two themes are interwoven.
Free Form Design
First International Colloquium of Free Form Design, 2006

Delft, 28-29 September 2006

Session 1: The human context
- culture, politics, economics, ethics, esthetics
- performative design
- relationship to existing material conditions
- historical and theoretical setting

Moderated by Arie Graafland, lectures by:
- Branko Kolarevic, Ball State University
- Axel Kilian, MIT
- Rivka Oxman, Technion University
- Larry Barrow, Mississippi University
- René Motro, Montpellier University
- Lars Hesselgren, KPF London
- Chiara Silvestri, Montpellier University
- Kas Oosterhuis ONL / TU Delft

Session 2: Technological opportunities
- design, engineering, manufacturing, construction
- process and organization management
- digital representation techniques
- ethics

Moderated by Deborah Hauptmann, lectures by:
- Mick Eekhout, Octatube / TU Delft
- Peter Brandon, University of Salford
- Hanif Kara, AKT London
- Sawako Kaijima, AKT London
- Larry Sass, MIT
- Manfred Grohmann, Bollinger+Grohmann
- Jürgen Ruth & Alexander Stahr, Bauhaus University
- Thorsten Helbig & Florian Scheible, Knippers Helbig
- Arno Pronk, TU Eindhoven
- Massimo Majowiecki, University of Venice

Session 3: Emerging knowledge
- research, education, practice
- collaborative knowledge organization
- competence in digital collaborative design

Moderated by Michael Weinstock, lectures by:
- Jaime Sanchez-Alvarez, MERO-TSK
- Matias del Campo & Oliver Bertram, Vienna
- Jalal El-Ali, Buro Happold London
- Fabian Scheurer, ETH Zurich
- Jeroen Coenders, Arup Amsterdam
- Robert Aish, Bentley Systems
- Harald Kloft, OSD / TU Kaiserslautern
- Andrew Kudless, Ohio State University
- Annette Bögle, TU Berlin
- Cristiano Ceccato, Gehry Technologies

Session 4: Debates
- three one-hour confrontations

Moderated by Michael Weinstock, debates between:
- Mick Eekhout – Branko Kolarevic
- Fabian Scheurer – Larry Barrow
- Hanif Kara – Cristiano Ceccato

EVENT INFORMATION
Organizers: Andrew Borgart, Bige Tunçer, Tuba Kocaturk and Martijn Veltkamp
Sponsors: Department of Building Technology and Delft School of Design

RELATED PUBLICATIONS
Free Form Design

International Workshop Pascalian Forms – Delft University of Technology, University of Montpellier (France), School of Architecture Montpellier (France)

The objectives of the Free Form workshop were to provide tools of generation and rationalization for designing free form buildings / structures which are described by complex geometries. The experimentation, mainly through the realization of a 1 to 1 prototype, was the educational concept. The theme of modularity of curved shapes with Pascalian forms was at the centre of the process, and was approached in various ways (theoretical and practical), with the purpose of creating connections between the idea, the concept, and the realization. The realization was achieved of a wood and cardboard prototype of approximately 10 by 4 meters and 3.5 meters high as a formwork for a glass fibre and resin composite prototype and for the basis of tests on visual perception of curvatures. Mixed groups of students from both countries were formed to produce a design for a double curved surface each from which one was chosen to be built. The aim was to formulate replies to two answers relating to the free form design:

A. How to ensure the greatest coherence in the design process which leads from first draft to the effective realization of doubly curved structures (means and methods)?

B. How do the users perceive curvature, and double curved surfaces?

EVENT INFORMATION

Tutors Delft: Andrew Borgart, Peter van de Rotten, Dominique Vosmaer

Tutors Montpellier: René Motro, Nicolas Pauli, Alain Marty, Birgitta Dresp-Langley, Marine Bagnéris, Chiara Silvestri

Period: October 2007

Funded by: Les Grands Ateliers, TU Delft
Game Set and Match

The GameSetandMatch International Conference series, an initiative of Prof Ir Kas Oosterhuis and Hyperbody

“Architecture is the masterly, correct and magnificent play of masses brought together in light” as Le Corbusier put it in his manifesto Towards A New Architecture. Everything has changed since then, and we are ready for a new paradigm: “Architecture is the programmable hyperbody played skilfully by its masters at the speed of light”.

Le Corbusier gave shape and meaning to architecture in the era of the Industrial Revolution. Let’s now programme hyperreality in our era of the Digital Revolution. Let’s face it: virtual reality is in all respects more real than what we take to be natural reality. Virtual reality including any software ever written for any platform is hyper-real. Simply because we know the stuff it is made of. We know every bit and byte. In the Digital Revolution reality is being rewritten from ground zero.

Architecture becomes a game being played by its users. And not only architecture will be subject to the forces of real-time calculation. Planning, construction, interior design and landscape design are also ready to be developed as real-time games. During the design process the game is designed by the architect and played by all parties involved. During the life cycle of the building and the build environment, the game is played by their users, by the visitors and by the built environment itself. Visitors become participants in the experience economy. By playing the game the participants set the parameters. Each actors triggers an array of sensors writing the new data into a database, from where the building picks up the new data and starts reconfiguring itself, in shape, in content, or in both shape and content. Then the new configuration is matched to the desired conditions. It is fair to say that the building will find itself in a state of continuous operation. The building elements consists of numerous cooperating programmable elements, behaving like a swarm. The building elements will show flocking behaviour, always keeping an eye on the neighbouring actor and always ready to act and react. Hence we propose a new motto for the discipline of architecture: “Game set and match”. To be played over and over again. Architecture is turning wild.
The International Colloquium Design Informatics was a platform for selected world renowned academic and practitioner experts to present their work in the field of design informatics in a setting of discussion. The field of design informatics in architecture and architectural engineering is characterized by the representation, perception, processing, computation, communication, modeling, storage, retrieval and reuse of information and knowledge in the context of an artifact’s lifecycle.

3 December 2009

Prof. Wytze Patijn, Dean of Faculty of Architecture
Welcome and opening

Prof. Sevil Sariyildiz, TU Delft, Chair of Design Informatics

Design Informatics at the Faculty of Architecture

Prof. Gerhard Schmitt, ETH Zurich, Chair for Information Architecture
Future Cities Laboratory

Prof. Ramesh Krishnamurti, Carnegie Mellon University, School of Architecture
Marching towards sustainable design patterns

Prof. Joop Paul, TU Delft, Chair of Structural Design and ARUP Amsterdam
Design strategies of buildings with complex geometries

Prof. Chimay Anumba, Penn State, Department of Architectural Engineering
Cyber-Physical Systems Integration in Design and Construction

Prof. Bauke de Vries, TU Eindhoven, Chair Design Systems
Design and Decision Support Systems research at the TU/e

Dr. Hielkje Zijlstra, TU Delft, Chair @ MIT
Data Based Research for Re-Architecture

Prof. Patrick Teuffel, TU Delft, Chair of Architectural Engineering and Teuffel Engineering Consultants
New challenges in design informatics: the evolution of adaptive systems

Prof. Wytze Patijn, Dean of Faculty of Architecture
Welcome and opening

Prof. Sevil Sariyildiz, TU Delft, Chair of Design Informatics

Design Informatics at the Faculty of Architecture

Prof. Gerhard Schmitt, ETH Zurich, Chair for Information Architecture
Future Cities Laboratory

Prof. Ramesh Krishnamurti, Carnegie Mellon University, School of Architecture
Marching towards sustainable design patterns

Prof. Joop Paul, TU Delft, Chair of Structural Design and ARUP Amsterdam
Design strategies of buildings with complex geometries
Open Platform
SmartGeometry International Workshop, 2009

The SmartGeometry Group organized jointly with the Computation & Performance research group of the Faculty of Architecture Open Platform, a 3-day Workshop at Delft University of Technology on the 27th-29th of November 2009. This event complements Smart Geometry's annual workshop and conference event, bringing many of Smart Geometry's experienced tutors to guide participants in exploring computational design through a variety of technologies.

The event ran in two parallel streams: one stream featured training in Generative Components (GC) and Grasshopper, while the second was a workshop where participants had the opportunity to propose and work on individual design projects using a variety of software platforms. Both streams offered participants close interaction with tutors from practices and universities known for their accomplishments in computational design and analysis, and complex geometry. Additionally, the stream featuring GC and Grasshopper featured tutors from the companies behind each platform, Bentley and McNeel. Those working on individual projects needed to be proficient in their chosen platform but could draw on tutor's skills in various technologies -- for instance Processing, C++/OpenGL, RhinoScript -- as well as tutors' expertise in complex problems of geometry, structure, algorithms, and analysis. Participants were able to change streams as it suited the development of their work. In the evenings, participants and public attended presentations demonstrating the latest projects and research in computational architecture and engineering.

Tutors
Hugh Whitehead (Foster + Partners)
Jeroen Coenders (Arup, TU Delft)
Janwillem Breider (Arup)
Rudi Stouffs (TU Delft)
Ben Doherty (Notion Parallax + Oxford Brookes)
Adam Davis (Foster + Partners)
Martha Tsigkari (Foster + Partners)

Robert Hart (SMART - Buro Happold)
Al Fisher (SMART - Buro Happold)
Sam Joyce (SMART - Buro Happold, Bath University)
Volker Mueller (Bentley Systems)
Lars Moth-Poulsen (Bentley Systems)
David Rutten (McNeel)
Giulio Piacentino (McNeel)
Rinus Roelofs (McNeel)
SmartStructures
International Design Studio – Delft University of Technology, University of Kassel (Germany), University of Tennessee (USA)

This collaborative studio implements the premise that tectonics is an integral part of architectural design and must be considered as such early on in the design process. Digital design and fabrication are changing architecture in fundamental ways. This has serious implications also for architectural education. Complex geometry architecture is successful when structure and manufacturing issues are integrated within the design process early on, and not treated as add-ons in a later phase. A powerful way to achieve this is to introduce physical and virtual modeling interchangeably in a design process at every stage.

The design project was a portable prefab pavilion that is representative of the three participating universities. The usable area should be around 100 m², the location is not fixed, but the pavilion can be placed in urban settings in different temperature zones. The program is also not fixed; it should contain multi purpose spaces. The only strict design requirement was that when disassembled, the pavilion should fit in one overseas container. Students worked in international teams of 3.

A major difference of this studio from other studios of its kind was that the students manufactured 1:1 or 1:5 scale components of their project. Hence, detail design and manufacturing played a highly important role, which is an important pedagogic consideration given the fact that students can design anything in 3D modeling environments, even if they do not have a clear idea on issues of buildability and possible structural solutions. An interesting result of the studio was the discovery of the design process that emerged. Students used many digital and analog design and fabrication media interchangeably throughout their design process, judging in an exploratory manner what medium would be beneficial to explore the design issue at hand. Design explorations were not limited by the studio instructors in terms of given tools and mediums. Students had access to digital modeling environments, FEM software, digital fabrication tools (laser cutter, 3 axes CNC milling machine, rapid prototyping), 3D scanner, digital presentation tools, and analog fabrication tools (vacuum molding, welding, casting, fiber/matrix molding). Design teams did not utilize the various design tools and media in a linear fashion; rather they alternated fluidly between methods throughout the design and fabrication process. Some projects show certain qualities that simply could not be achieved if not for such a fluent design process.

EVENT INFORMATION
Tutors Delft: Bige Tunçer, Andrew Borgart, Paul de Ruiter
Tutors Kassel: Manfred Grohmann, Oliver Tessmann, Gregor Zimmermann, Markus Schein
Tutors Knoxville: Edgar Stach
Period: August-November 2006
Funded by: TU Delft, University of Kassel, University of Tennessee

PRIZES
- SmartStructures studio won the 2008 AIA Education Honor Award
Adaptable Geometry

Digital design of reconfigurable structures for solar strategies

Michela Turrin (PhD candidate)

By focusing on passive solar large roofs, digital supports are investigated for early integrating performance evaluations in the design process, at different project scales. Geometry is explored based on parametric modeling and performance simulations toward optimal solutions and adaptable geometry is proposed to achieve multiple optimal solutions. Among various adaptable solutions, deployable structures are specifically investigated.

Engaging in the design of large roof structures has become common for architects and engineers. This requires to confront not only the structural and functional aspects, but also the current increased emphasis on energy-related issues. This implies attention to the use of renewable energy resources, based on both on active and passive systems. By focusing on these latter, the research develops digital processes for performance-oriented design, aiming at integrating performance evaluations in the early stages of the design. The potential of parametric modeling is investigated as design support in combination with performance evaluation software and genetic algorithm-based methods to address the generation of the design solutions.

When dealing with passive solar strategies, performances confront a context that changes based both on daily and seasonal conditions. The definition of well performing geometrical solutions can therefore be addressed to multiple configurations. Adaptable geometry is explored in order to satisfy such a need for adaptiveness and reconfigurable structures are investigated. Specific attention is given to deployable structures, for which a taxonomy has been developed in order to extract parameters to support the digital design process. Integration of deployable modules is considered in the context of passive solar roofs based on their capacity in switching between close and open configurations.
Adaptive daylighting systems

Research to develop new material-systems which make better use of daylight in long-span roof structures.

The PhD research investigates the sufficient use of daylight in long-span roof structures and proposes its own design method for adaptive daylighting systems by combining and evaluating various design approaches ranging from parametric, to parametric-kinetic and to smart materials. The performance of the outcomes is one of the driving design parameters, which is assessed by different software simulation tools.

Long-span roof structures are employed for certain building typologies like airports, train stations, sports facilities, etc. Naturally those are frequented by a wider public. This implies that a designer has to take the programmatic requirements and comfort of many more people into consideration while ideally the energy use should stay low. Apart from climatic comfort sufficient lighting of those facilities is an issue for orientation, well being and security.

The daylight situation is constantly changing during the day and season while indoor spaces have various requirements in lighting quantities, qualities and kinds of light situations. These requirements can not be met in the most optimal way by employing a static system. Therefore an adaptive system has to be thought of which is able to readjust itself and mediates between current daylight condition and interior lighting requirement.

Design method
Parametric design deals with the generation of various designs and its geometrical variations based on input parameters. In this case mainly daylight to meet the required performances. The amount of data linked to drive these variations can not be handled manually anymore. Therefore parametric design tools are employed to enable the designer to handle this complexity. Parametric-kinetic designs deal with the change of orientation, location and dimensions of building components on a macro scale. So far this is often done by mechanical systems which are due to moving parts prone to failure. Current material researches however lead to the development of smart materials which offer new insights and solutions. It is possible to alter the material properties on the micro scale which have an effect on the macro scale in real time. A close connection between parametric design and software simulation tools ensures, that the intended performance criteria are meet. The combination of those four closely linked design issues should lead to new adaptive daylighting systems.
Beyond BIM

Parallel Model Derivation Processes in the Digital Representation of Architectural Works

Andre Chaszar (PhD candidate)

The research project concerns studying the ways in which architects, engineers and builders create, exchange, interpret and manipulate three-dimensional digital models of buildings, and proposing methods to improve these processes.

Observing that different (parallel) models are needed for various tasks and phases of building projects, and that currently such models are not used as effectively as they might - due partly to problems with tags and other conventions for organizing information - techniques proposed herein emphasize the introduction of user-guided geometric-content-based search, sort, classification and derivation methods that can replace or complement conventional attribute-based ones.

The methods are presented as algorithms, some of which are implemented for testing purposes as tools with application to design of architecture as well as:

- structure
- energy
- lighting
- acoustics
- and others.

PROJECT INFORMATION
PhD research
Supervisor: Prof. Sevil Sariyildiz
Co-supervisor: Rudi Stouffs
Period: December 2006 – March 2011
Funded by: TU Delft

RELATED PUBLICATIONS

- Chaszar, A.; Searching and Classification in Digital Media: Research and Applications; ICERI, Madrid, 2008
- Chaszar, A.; Beyond BIM – Reflections and Research on Design Communication via Digital Models; Yale Univ. Symposium, New Haven, 2010
- Chaszar, A.; Beyond BIM – Negotiating Complex Models; SIGraDI, Bogota, 2010
CLIP

Computational support for Lifecycle Integral Performance assessment

Ipek Gursel (PhD candidate)

This research develops a computational model, CLIP, in support of the existing lifecycle performance assessment processes. CLIP provides extensible representational and algorithmic solutions for the capturing, transformation, integration, and visualization of lifecycle performance information. CLIP was adapted for and tested by two real LBPA contexts, EPI-CREM and Carnegie Mellon University Facility Management Services (CMU FMS).

Lifecycle building performance assessment (LBPA) ensures that buildings perform as intended during building lifecycle. LBPA activities are multi-phase, multi-disciplinary and context-dependent, and generate large amounts of information that need efficient management. During the lifecycle of a building, multiple assessment methods are employed semi-concurrently, with a great deal of information overlap. Usage of disconnected tools for each method results in information fragmentation and redundancy, posing problems for well-informed decision making.

The objective of this research is to develop a computational reference model, CLIP (Computational support for Lifecycle Integral Performance assessment), that aims to improve the efficiency and quality of existing performance assessment practices. CLIP addresses basic LBPA functions of knowledge codification, data specification and data acquisition, while allowing other functions (such as data analysis) to be developed as an extension to CLIP that takes into consideration the context-specific functions, information content and knowledge. Moreover, CLIP decouples the contextual domain knowledge from the model and captures it in external ontologies.

To evaluate CLIP, it was extended into two prototype applications for two LBPA contexts: EPI-CREM and CMU FMS. EPI-CREM is a publicly funded project that aims to embed energy efficiency into the decision-making processes of corporate real estate management within EU. CMU FMS provides daily maintenance services to the university and manages the outsourced LBPA activities. CLIP was tested in these contexts with real building data during the assessment activities. The results support the CLIP model’s ability to successfully deal with the local volatility and variation in the processes and information content that is being managed.
Data Mining of Urban Features
Exploring the Patterns and Relationships of Urban Attributes by Data Mining
Ahu Sokmenoglu (PhD candidate)

This research applies data mining as a methodology of knowledge discovery in urban feature analysis with a particular interest in exploring the patterns and relationships of micro-scale urban data in Beyoglu (a historical neighborhood of Istanbul). The methodology consists of the application of data mining into a GIS based urban database built upon official data, gathered from urban analysis maps of the 2008 Master Plan of Preservation of Beyoglu.

In urban analysis, there is a need to advance from traditional one dimensional description and classification of urban forms (e.g. land-use maps, density maps) to the consideration of the simultaneous multi-dimensionality of urban systems. To address the multi-dimensional and relational complexity of urban environments requires simultaneous consideration of a great number of independent and dependent spatial, social, economic, cultural, morphological, environmental, political etc. features of urban entities, which is almost impossible to operate manually. Hence there is a need for an automated analysis and discovery method which can handle micro-scale data. With the capacity of incorporating various variables without restricting the analyst to a few ones and offering various approaches of automated analysis, data mining seems to be a promising methodology for knowledge discovery in urban feature analysis.

This research aims to apply data mining as a methodology of knowledge discovery in urban feature analysis with a particular interest in exploring the patterns and relationships of micro-scale data in Beyoglu. To meet this aim, a methodology is developed for formulation, analysis and evaluation of an urban database. Methodology consists of the application of data mining into a GIS based urban database built upon official data of Beyoglu, provided by Istanbul Metropolitan Municipality.

This is a data-driven approach not relying on specific theories but only relying on the data itself. There are no a priori assumptions about the system in investigation but this is an attempt to discover previously unknown hidden patterns and relationships within a specific urban database. Hence, this approach also suggests a context-specific analysis.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Urban Entity Level</th>
<th>Urban Entity</th>
<th>Value Type</th>
<th>Value</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID.8489</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_G</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_1</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_2</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_3</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_4</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_5</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_6</td>
</tr>
<tr>
<td>ID.8537</td>
<td>ID.8527</td>
<td>ID.8577</td>
<td>Residential, Business, Shopping, Social Infrastructure, Technical Infrastructure, Accommodation, Open Space, Empty, Other</td>
<td>nominal (8 categories)</td>
<td>LNDUSE_7</td>
</tr>
<tr>
<td>Density</td>
<td>Persons/ha</td>
<td>BuildingBlock</td>
<td>100, 100-200, 200-300, 300-500, 500-750, 750-1000, 1000-1500, 1500-2000, 2000+, non-person living</td>
<td>nominal (10 categories)</td>
<td>PNCH</td>
</tr>
</tbody>
</table>

RELATED PUBLICATIONS
Decision Support for Energy Efficient Redesign

Knowledge modeling (KM) for improving the indoor climate in existing housing

Irem Erbas (PhD candidate)

Reduction in energy consumption and quality of indoor climate are equally important issues in the energy-efficient redesign process of buildings. The energy issue is related to the efficiency of the buildings in terms of environmental and economic concerns while the quality of the indoor climate is related to the health and comfort of the occupants.

This research aims to contribute to energy efficient redesign processes of the existing housing stock within the context of sustainability. The main objective is to present an approach to provide integrity to deal with the growing amount of information and processing of this information in energy efficiency and indoor climate relationship during a redesign process of existing housing. The focus of this practical problem of energy efficiency is to ensure good indoor climate on several energy levels. It is intended to develop a decision support tool for architects which is based on knowledge modeling.

This is the level where design knowledge is elucidated from information at hand.

PROJECT INFORMATION
PhD research
Supervisors: Prof. Sevil Sariyildiz, Prof. Anke van Hal
Co-supervisor: Rudi Stouffs
Period: March 2008 – June 2012

RELATED PUBLICATIONS
Digital Design in a Homogeneous Environment

Digital manufacturing of independent and exchangeable building components for sustainable flexibility in architectural design

Paul de Ruiter (PhD candidate)

The traditional design environment has an inherent inflexibility to change, caused by the dependency on experienced-based knowledge distribution in a conventionalized framework. Integrating new design, building and manufacturing techniques and methods in the design process can create a conflict with the traditional design environment. With the increased consciousness of the massive ecological impact the building industry has on our planet, new design concepts are developed based on a pre-rationalization of the design for digitally manufactured component assembly and disassembly. The role of the actors changes with this development as building changes into assembly. The pre-rationalization and rationalization of the design for digital manufacturing necessitates the transition to a design environment supporting highly integrated and accurately defined designs. An environment which differs radically from the traditional design environment. Creating flexible knowledge integration in a multi-actor virtual collaborative design environment based on the direct access of 3D and non-3D design data in a web based environment. Moving the design data extraction and insertion from local to a web-based environment making it possible to create a bridge between architectural design and e-manufacturing.
Structural damage in masonry
Developing a diagnostic decision support

Ilse de Vent (PhD candidate)

The assessment of a building with damage can be compared to the approach to a patient in health care. In both professions, the most important, but at the same time most difficult phase is the diagnosis. Insight into the cause of a defect is indispensable for the selection of an adequate treatment, or an optimal conservation strategy. However, in building pathology the relation between the signs of a structural defect and its cause has not been defined unambiguously yet. This research project aims to overcome this obstacle.

This PhD research aims to enhance the diagnosis of structural damage in masonry, by providing a well-organised overview of damage mechanisms and how they can be distinguished. It has been triggered by the idea that the symptoms and context of damage give, in principle, sufficient clues to be able to deduce the cause of structural damage; however, that an objective guideline for the interpretation of these signs is still missing.

Hence, this study systematically investigates how the symptoms of structural damage can be related to specific damage processes. Also, the influence of contextual aspects regarding material, geometry, and environment, on the initiation and propagation of these damage processes is being examined. The resulting damage mechanisms give insight into how damage processes function, and will thus help surveyors to better distinguish between causes.

This project will result in an overview of unambiguous relations that link the characteristics of symptoms and context of damage to its cause. It intends to include clear guidelines and simple tests that can be used for investigating the cause of structural damage. Although the study is focused on masonry buildings in the Netherlands, the use of this guideline is expected to be profitable for a wider field, both as a learning tool for novice surveyors, and as a support for experts.

The results of this research can be implemented in an instrument for diagnosis and assessment of structural failure, for both curative and preventive use in restoration practice.
Urban Grammars
José Nuno Beirão (PhD candidate)

Grammar based design patterns for urban design:
A generative urban design tool is defined by developing grammar based design patterns encoding typical urban design moves recurrently used by urban designers into generic grammars. These individual design instructions are called urban induction patterns. A specific composition of urban induction patterns constitutes an urban grammar. A specific design is obtained by applying specific values to the rule parameters.

This research is part of the City Induction research project which aims at developing an urban design tool composed of three interrelated modules: (1) the formulation module which formulates context dependent urban programs, (2) the generation module, which generates design solutions for the urban program and (3) the evaluation module, which evaluates the evolving design solutions against the program. Donald Schön stated that designs evolve through a series of see-move-see cycles. It is a reflective process that is performed continuously along the design process by the designer before reaching a final solution. Design rules are the result of such a process. Generic grammars are very simple, customizable, and context independent shape grammars that correspond to generic design moves. Design moves are defined as design patterns, using a short generic grammar that can generate such specific design moves. Specific designs are the result of composing arrangements of such design moves and setting specific values for the rule parameters. So, a specific urban grammar is the result of making a specific arrangement of generic grammars and constraining their parameters to the values that encode the designer’s own design language. The design patterns encoding design moves are called Urban Induction Patterns and they constitute the generative feature of the generation module of the City Induction design tool. An Urban Grammar is a specific arrangement of Urban Induction Patterns. In order to introduce higher semantic response the shape grammars are augmented with description grammars to provide a description of the design goals to be achieved. Heuristics provide the search mechanisms to search for the best rules to apply in each design iteration.

PROJECT INFORMATION
PhD research: José Beirão
Supervisors: Prof. Sevil Sariyildiz and Prof. Henco Bekkering
Co-supervisor: Rudi Stouffs
Overall project: City Induction
Project leader: José Pinto Duarte (IST/TU Lisbon)
Period: October 2007 – September 2011
Budget: € 153,710
Funded by: FCT (Science and Technology Foundation)

RELATED PUBLICATIONS
A novel fuzzy-neural tree (FNT) is described. The FNT is quite similar to a feed-forward neural network in the sense that it has a feed-forward structure with nodes and weights and a single or multiple outputs. However it is built not layer by layer but node by node so that it has more free dimensions compared to a strictly defined feed-forward type neural network. Each node uses a Gaussian as a possibility distribution and the likelihood underlies the application of the possibility theory to the model.

The axioms of possibility measure $\pi(A_i)$:

\[
\forall A_i, i \in I, \quad \pi\left( \bigcup_{i=1}^{n} A_i \right) = \max_{i=1}^{n} \left( \pi(A_i) \right)
\]

\[
\forall A_i, i \in I, \quad \pi\left( \bigcap_{i=1}^{n} A_i \right) = \min_{i=1}^{n} \left( \pi(A_i) \right)
\]

The project leader is Ozer Ciftcioglu, his research is funded by TU Delft.

Period: January 2009 – May 2010

**PROJECT INFORMATION**

Project leader: Ozer Ciftcioglu

Period: January 2009 – May 2010

Funded by: TU Delft

**RELATED PUBLICATIONS**


**Conclusion**

- Possibility theory is central to the working of the fuzzy neural-tree concept
- Likelihood underlies the application of the possibility theory to neural-tree modeling
- Node inputs are processed as to their prior logical AND or logical OR definition in the model
Structures

Architectural Cardboard

Cardboard Interior Wall System

The Taco Wall, which will soon be commercially available, is a cardboard based inner wall system, developed in cooperation with the TU Delft, Paper and Cardboard Industry and the Kennis Centrum Papier en Karton. A single panel of the Taco Wall is built up from two cardboard outer plates, which are joined by a type of honeycomb cardboard. The major advantage of such a system, compared to traditional building materials, is the relative low price, the ability to recycle and its light weight. The typical building applications for cardboard wall systems are temporary constructions. Every building element should satisfy or surpass minimal technical properties or specifications.

Mechanics
Impact tests proved that this cardboard system can be used safely as an inner wall. However, a large problem, in the mechanical sense, is the glued connection between different elements of cardboard. Bending tests show that final failure occurs after delaminating of the internal wall elements.

Acoustics
Acoustic tests showed that the acoustic performance of cardboard is poor, however, the wall may be used in office buildings.

Fire resistance
It was impossible to ignite the impregnated specimens for 5 minutes, while the untreated specimens burn immediately. Solid board has a natural flame resistance due to the burning process. During burning, a layer of carbon is formed, protecting the underlying material from burning. Flame resistance of both solid board and honeycomb board, finished with vinyl can be categorized as moderate.

PROJECT INFORMATION
Project leader: Kees van Kranenburg

RELATED PUBLICATIONS
Architecture and Aerodynamics
Strategies for the design of wind optimized buildings

FIRST RESULTS A & A

Symposium Wind and Buildings / Architecture and Aerodynamics in April 2007

Analysis of a “Rotterdam” Design Proposal by Karel Vollers,
Huib Plomp / Lourens Aanen / Fabien van Mook

- Analysis of wind comfort
- Analysis of wind loading
- Analysis of façade and ventilation

R&D APPROACH

1. Aerodynamic analysis of Complex Geometries

Prediction of wind flows and wind pressures around complex building shapes/geometries in the built environment using CFD software.

Two types of buildings will be studied. The first type will be buildings with complex geometries. Especially the wind climate around this type of buildings is of interest. Due to the complex shape, high wind speeds can occur at unexpected locations. The influence of the angle of the twist might be one of the parameters that will be studied.

The second type of buildings that will get special attention are highrisers or sky-cities. For this type of buildings, wind load is the first aspect that is important. Reducing the wind load by making small changes to the geometry leads to considerable reduction of the construction costs of the building.

2. Design approach for wind optimized buildings

The analysis should lead to developing an integral (loads, ventilation and energy) design approach for wind optimized buildings.

PROJECT INFORMATION
Project leader: Huib Plomp
Executed by: Huib Plomp / Lourens Aanen / Fabien van Mook / Bas de Bont
Period: 2006-2008
Budget: € 0
Funded by:

RELATED PUBLICATIONS
• Plomp & Aanen; Wind energie en Hoogbouw, TVVL Magazine 6/2007
Avenirs de Villes
Interactive multiuser interface

"Avenirs de Ville/Future for Cities, Exposition d’Architecture" exhibition in Nancy, France. This complementary exhibition to The Urban Spirit, takes a look at two modern variants in urbanism: that of the town planners of the second half of the 20th C and the automobile town of tomorrow generated by necessity and chance.

The theme of the exhibition is the artist's and architect's view of the city of the year 3000. For some, towns will be determined by a population explosion as for Mexico City, Bombay and Cairo. For others, a more mysterious process is at work: the town is regenerating itself under the same laws as gave birth to the industrial town. However, none of us can with any certainty predict what our towns and life-styles will be like in a thousand years. Artists, architects and film directors from several different countries and generations have been invited to give their ideas on the town of tomorrow in a spectacular, playful productions: our wildest imaginings today could become tomorrow's reality.

ONL's will exhibit its 'Car City' in physical and digital form, and an interactive multi-player game developed with the Hyperbody Research Group will be open to the public.

PROJECT INFORMATION
Project leader: Kas Oosterhuis,
Executed by: Kas Oosterhuis, Chris Kievid, Dieter Vandoren, Tomasz Jaskiewicz
Period: 2005
CLIP EPI-CREM
A computational tool for Energy Performance Integration for Corporate public Real Estate Management

EPI-CREM is a publicly funded project that aims to develop methods and tools to improve energy efficiency across the public building stock in Europe by embedding energy issues into the existing corporate public real estate management (CREM) processes. This research project adapts an existing computational model, CLIP, to the EPI-CREM context to develop a software tool in support of the functions of EPI-CREM.

The European Council identified energy efficiency as an essential part of its strategy on climate change, aiming to reduce the EU energy consumption by 20% by 2020. Therefore, all CREM organizations need to take energy performance into account in their inspection, decision-making and executive tasks. Energy efficiency relates to the interests of CREM functions at various organizational levels, ranging from strategic to operational, that have different performance indicators. In this approach, both technical concerns related to building elements and high-level concerns related to building safety, health, environment, energy and quality are considered. EPI-CREM aims to bridge the gap between these dimensions by combining the top-down and bottom-up decision-making processes to achieve integral energy-oriented building maintenance.

CLIP EPI-CREM is the core tool within the EPI-CREM project and facilitates the key functions of lifecycle performance data acquisition and analysis for CREM:

- The capture of building related information that represents the as-is conditions
- Theoretical calculation of maintenance and energy performance of building elements
- Performance data acquisition through inspections
- Risk assessment
- Scenario analysis

CLIP EPI-CREM is currently being used during the real EPI-CREM work processes by the partner countries, Netherlands, France and Austria. Both the EPI-CREM project and CLIP EPI-CREM software tool led to other projects that extend the scope of lifecycle performance evaluation, such as RgdBOEI, building commissioning etc.

http://www.epi-crem.org
Computational Intelligence for Sustainable Architectural Design

Sustainability is a topical concern in building design for various reasons, spanning from ecological to monetary value concerns. This entails that the sustainability concept is not merely a matter of computing the energy consumption of a building, but it also concerns factors like comfort, functionality, ease of maintenance and recyclability. That is, sustainability is a complex and vague concept. Treatment of these issues requires advanced computational means. In this work bio-inspired information processing systems that are based on methods from the paradigm known as computational intelligence are employed for this purpose. The results are computation of sustainability performance with precision, and ensuring with certainty maximal sustainability of solutions.

One example of an application of this approach is determining the sustainability value of buildings and neighborhoods using a neuro-fuzzy modeling approach as shown in figure 1a and 1b. Another example is using multi-objective evolutionary algorithm (MOEA) to generate solutions with maximal sustainability performance, while the amount of possible solutions is excessively large. This is shown in figures 2a and 2b.

**Fig 1a. A Neuro-fuzzy model to compute sustainability performance of buildings**

**Fig 1b. An urban design subject to sustainability analysis**

**Fig 2a. Multi-objective evolutionary algorithm (MOEA) based layout design**

**Fig 2b. Adaptive Pareto front formation in MOEA**

**RELATED PUBLICATIONS**


Constructing Process Models from Distributed Design Activity

Collaborative design is a complex cognitive and social activity that requires coordination of both processes and products between its participants. Information required for this coordinative activity are descriptions of the various tasks and products found within a design project, and of the current state of these entities. State descriptions can arise from technical analysis, perhaps employing automated, machine-based methods, or can arise from a social process of consensual, collaborative assessment that results in design team members applying informal linguistic descriptions to processes. In the event that no automated process exists for state determination, then members of the design team must work together and find a mutually agreeable assessment of state. With this information designers are better able to determine the progress and status of a design process, and to assess their roles and responsibilities within a design team. This research describes the design and implementation of a design support tool that enables distributed teams to collaboratively determine the state of design entities, such as tasks and products. The tool is role-based, and enables users to communicate simple looped state-transition models that they feel suitably describe the possible states and transitions that a design entity could experience. These state models can describe the degree of completion, degree of acceptance within a team, or progress with respect to a series of milestones. By attaching entities to simple state-transition loops, users make input based on simple questions about the state of individual entities, rather than complex ones arising from the interaction of entities. Complex branching process structures can be created by composing entities. The tool automatically handles state assessment of complex, linked compositions of entities, while users handle assessment of simple, non-linked entities. It provides users with information regarding design state and structure, and supports a form of bottom-up design coordination that requires no centralized policies or inputs, prior to deployment.


Curved Surface Structures

The parametric relationship between geometric and mechanical properties of shell structures

The purpose of this research is to be able analyze the structural behaviour of shell structures by studying the way (applied) loads flow through the shell’s surface to the supports and how this relates to the shell’s geometry. To unlock this secret will give a fundamental understanding of the behaviour of shell structures and thus the means to design shells with efficiently of performance and elegance of form.

Shells have geometrical and structural properties, which have a close relationship, and determine its performance. These fundamental shell properties concerns the load path, the force network, the stress function and the curvatures. An unified approach of the fundamental shell properties will form the basis for new computational methods for form finding and optimizing shell structures.

PROJECT INFORMATION

Project leader: Andrew Borgart
Structural Morphology Group (SMG) of the International Association for Shell and Spatial Structures
Design Analysis by a Theory of Visual Perception

Visual perception is a phenomenon that plays an important role in the experience of architecture, as it provides information for evaluating relevant performance aspects, such as aesthetic value, way-finding, and privacy. In order to have precision information on perception, computational models of the phenomenon are required. In this work a novel, effective modeling approach is developed that is based on probability theoretic considerations. In this approach the perception is expressed via a probability, quantifying the degree of visual awareness an unbiased observer has for an object. The probabilistic approach permits dealing with the ample complexity characterizing the human vision system.

Plan view of the basic geometric situation of perception (left); perspective view with visual attention given by the pdf $f_x(x)$ (right)

An urban scene subject to perception analysis

A retail space subject to perception analysis

Perceptions along a trajectory through the space shown below for eight objects of the scene

The probability density $f_x(x)$ (top left) expresses visual attention in $x$-direction. The integral of $f_x(x)$ over an object's spatial extent in this direction, yields the perception of the object as a probability. Two examples of perception analysis in architectural design are shown below.

RELATED PUBLICATIONS
Design of Structural Grids for Domes and Free-Forms

The design of the structural grid affects the load transfer as well as the architectural design. Due to their irregular forms, Free-Forms are hard to classify. Most Free-Forms look like transformed spherical domes. In the same way, elliptical domes can be considered as stretched spherical domes. For ellipsoids the variety of form is almost infinite too, but these domes can be classified well. This research focuses on the analysis of grids for these domes. Several grids, for example zeppelin, schwedler, parallel and geodesic grids, are analysed concerning form, elements, joints, load transfer, production and construction, for the development of design tools.

PROJECT INFORMATION
Project leader: Wim Kamerling
Period: November 2008 – December 2009

RELATED PUBLICATIONS
• Kamerling M.W., Comparing Structural Systems for Free-Forms, AISS2009.
Navigating the interior feels like walking in the interior of a living installation. You are inside technology: ubiquitous computing at its full potential. Installations interact with the public, but also with other installations. The output of one installation provides relevant data which are used as inputs for other installations. The visitors are individually identified [using RFID tracking] and they build up their unique profiles while navigating through the floors of the pavilion with the interactive and interacting installations. Each visit will be an unique experience, the installation would never repeat its exact shape and content, always being adjusted in real-time by the movements of the public and by the streaming content [using WiBro/WiMax technology].
Faro 3D laser scanners
Research about 3D laser scanning technology and their further implementation within the building & planning industries

3D laser scanning technology enables architects and engineers to obtain exact 3D data from any given environment. The possibilities are ranging from landscapes, to urban situations, to buildings exteriors and interiors or smaller objects as such. The possibilities for employing such a technology are manifold. It can support processes i.e. building heritage documentation, site management and building execution or real estate management.

The main focus for the research is the Photon Laser scanner, a mobile device set on a tripod which is able to capture the 3-D data from the outside and inside of any given building. Here it is important to identify architecture and engineering practices which could be interested in terms of their projects’ relevance but also in terms of capacity to be able to make use of the 3-D point cloud data derived from the laser scanning process. We want to understand the workflow of the planning processes in order to be able to define requirements and to make use of the tool in the most effective way. Together Faro and TU Delft, the faculty of Architectural Engineering developed a questionnaire to gain the required information.

The outcome of the questionnaire showed certain tendencies in how planning, design and building execution is handled amongst the various practices. Based on that categorization and the detailed evaluation of the questionnaire steps in further researches are initiated. These are ranging from documentation and further evaluation of the application of the Photon laser scanner in the daily building practice until the specification of a possible new product.

PROJECT INFORMATION
Project leader: Patrick Teuffel
Executed by: Florian Heinzelmann
Period: September 2009- March 2010
Budget: undisclosed
Funded by: Faro Europe GmbH & Co. KG

RELATED PUBLICATIONS
- Phase 1 research report, Delft 2010
The transformation value of nursing homes is influenced by many factors. Therefore, the concept of transformation value was developed for the Project Toekomst Verzorgingstehuizen (future of nursing homes) of the Netherlands Board for Healthcare Institutions (Bouwcollege). A knowledge model was built to determine this transformation value.

**FlexTool**

**A knowledge model for the assessment of a building’s transformation**

The transformation value of nursing homes is influenced by many factors. Therefore, the concept of transformation value was developed for the Project Toekomst Verzorgingstehuizen (future of nursing homes) of the Netherlands Board for Healthcare Institutions (Bouwcollege). A knowledge model was built to determine this transformation value.

**Spatial Transformation**
- Dimensioning
  - minimal dimensions on a building level
  - load-bearing structure: depth and grid system
  - load-bearing structure: floor-to-ceiling height and floor thickness
  - load-bearing structure: dimensioning and cooling system
  - corridor width
  - facade openings/dimensions/room depth

**Technical Transformation**
- Positioning
  - corridor width and position of load bearing construction
  - corridor width and position of installations
  - position of vertical installations
  - direction of vertical installations (parallel or perpendicular)
  - clustering of vertical elements (installations/load-bearing construction)

**Spatial Transformation**
- Disassembly
  - main installation network
  - distribution network
  - connection principles of non-structural walls

**Technical Transformation**
- Capacity
  - capacity of installation ducts
  - capacity of load-bearing construction in relation to making an opening
  - capacity of the load-bearing construction in relation to change of corridor width
  - extension of a building
  - capacity of vertical communication/elevators

**Transformation Value**
- Spatial Transformation
- Technical Transformation
- Disassembly
- Capacity

**Related Publications**
Fragile though Ductile
Structural Aspects of Reinforced Glass Beams

This ‘reinforced glass beam’ research focuses on the application of glass as a structural building material and embodies the development of a novel safety concept for structural glass beams. This safety concept, which resembles reinforced concrete, aims for highly redundant structural glass beams by bonding a reinforcement section at the tensile edge of the glass. Several structural aspects are investigated in an experimental, analytical and computational manner. More information: Christian Louter, p.c.louter@tudelft.nl

1. Introduction.

PART I: Theory
2. Application of glass as a structural material.
3. The theory behind the reinforced glass beam concept.
4. Material properties of the three components.

PART II: Experimental research & analysis
5. The effect of temperature level, thermal cycling, load duration and humidity on the structural response.
6. The effect of beam size and reinforcement percentage on the structural response.
7. The possibilities of embedded glass fibre reinforcement.
8. Analytical and Computational predictions of the structural response.
9. Integrated discussion of all experimental, analytical and computational results.

PART III: Structural design

PART IV: Retrospect & Prospect
12. Future developments.
iLITE Transitions
Lights on the move

An event about exploring new directions, connecting people and sharing visions. Seven containers will be travelling through Europe and abroad, with exhibits from several leading architects and lighting designers, who have taken light as the raw material for their creations.

One iLITE configuration is standing on the floor, one is cantilevering from the wall and one is hanging from the ceiling of the container. ONL creates an endless universe of light, which fades out after three or four reflections. The public will get the feeling to float in an universe of slowly shifting light lines and swarming dots.

The always changing play of straight white lines and distributed coloured dots is created by an algorithm specifically written for iLITE. The movements of people in the space of the container change the patterns and the density of the light. The more people there are in the space or the faster they move, more LED’s will be triggered and the patterns will be brighter. The public will feel that their presence matters. When the people have left or come to a stand still, the lights will fade out to leave only a few twinkling dots.

PROJECT INFORMATION
Project leader: Kas Oosterhuis
Executed by: Chris Kievid, Dieter van Dooren
Period: 2007
Funded by: Philips
InfoBase + KeySet
A multimedia learning environment to support group work and discourse + metadata as a means to improve the quality of design

The aim of this project is to teach students how to deal with metadata for the exchange of knowledge and information within a professional community or network of students, educators and researchers. Metadata are, simply said, data about data. In practice, metadata consist of a structured collection of descriptive elements that describe an information object.

We distinguish four aspects within this aim:
- [research wise] we consider a scientific approach for dealing with information and communication by means of the application of metadata;
- [didactically] corresponding to this approach, we developed a method for adding, using and managing metadata and implement this method in a learning path with increasing responsibility for the student;
- [technically] we developed a digital environment, named InfoBase, to support this learning path and to support students to store, exchange and manage the information they collect and generate by means of metadata, both individually and in group, and independently;
- [strategically] we encourage students through this system to learn from one another and to collaborate as young professionals by offering them the possibility to directly compare their work and designs; at the same time, we introduce the student to the paradox that a database loses information quality when it is cleaned up into a tidy database.

KeySet is a universally applicable metadata system that provides each design product with a unique key. KeySet defines four quality dimensions according to which metadata is associated to the design product. Metadata serve as the means to lay claims to the design product.

PROJECT INFORMATION
Project leader: Rudi Stouffs
Executed by: Design Informatics, Library TU Delft, Faculty TBM (WIT-Lab, EDUTEC)
Period: August 2002 – December 2004
Budget: € 546.000
Funded by: Central Educational Funds, TU Delft

RELATED PUBLICATIONS
Interactive Environments Minor

Interactive Environments Minor has been a full-time, semester-long project at TU Delft

Throughout the course, three interdisciplinary groups of students supported by TU Delft researchers and guest teachers have designed and built three interactive lounge pavilions. The pavilions attract people to enter, facilitate relaxation and provide a refuge from daily chores.

The Interactive environments at Delft Science Centre

Interactive Environments Minor has been a full-time, semester-long project at TU Delft organized by the Faculty of Architecture - hyperBODY and Industrial Design and Engineering - ID-StudioLab, hosted by the Delft Science Centre. Throughout the course, three interdisciplinary groups of students supported by TU Delft researchers and guest teachers have designed and built three interactive lounge pavilions. The pavilions attract people to enter, facilitate relaxation and provide a refuge from daily chores. Each of these structures is a dynamic system, which communicates with its visitors across different modalities. The installations not only actively adapt to their users’ actions, but autonomously develop a will and behaviour of their own. In this way interactive architectural environments come to life, engaging their occupants in an unprecedented experience of a continuous dialogue with the occupied space.

PROJECT INFORMATION
Project leader: Thomas Jaskiewicz
Executed by: students
Period: 2010
Funded by: TU Delft
Muscle NSA
The programmable modes of Trans-ports: muscle mode

The most important feature of the programmable Trans-ports pavilion is that architecture for the first time in history is no longer doomed to remain static after a dynamic design process. This notion formed the basis for a true paradigm shift in architecture at the millenium shift. Due to the programmability of both form and information content the construct becomes a lean and flexible vehicle for a variety of usage.

For the exhibition Non-Standard Architecture ONL and HRG realized a working prototype of the Trans-ports project, called the MUSCLE. Programmable buildings can reconfigure themselves mentally and physically, probably without considering to completely displace themselves like the Walking City as posposed by Archigram in 1964.

Programmable buildings change shape by contracting and relaxing industrial muscles. The MUSCLE programmable building is a pressurized soft volume wrapped in a mesh of tensile muscles, which change length, height and width by varying the pressure pumped into the muscle. Visitors of the Architectures Non Standard exhibition play a collective game to explore the different states of the MUSCLE. The public interacts with the MUSCLE by entering the interactivated sensorial space surrounding the prototype. This invisible component of the installation is implemented as a sensor field created by a collection of sensors. The sensors create a set of distinct shapes in space that, although invisible to the human eye, can be monitored and can yield information to the building body. The body senses the activities of the people and interacts with the players in a multimodal way. The public discovers within minutes how the MUSCLE behaves on their actions, and soon after they start finding a goal in the play. The outcome of this interaction however is unpredictable, since the MUSCLE is programmed to have a will of its own. It is pro-active rather then responsive and obedient. The programmable body is played by its users. A constant play of conjointly effectuating (re)actions, of attraction and repulsion between all players involved. This game truly is a multi-player game.

Centre Pompidou Paris, NSA exhibition
Performance oriented geometry
Parametric geometry for performance oriented design of passive solar roofs

Geometry has relevant direct impact on the performances of large roof structures; early integrating performance evaluations is a key design aspect. Parametric modeling is proposed as a support in generating design alternatives; genetic algorithms are used to address the generation of the alternatives toward performance oriented solutions.

Historical cities bear testimony to the importance of semi outdoor space; due to the increased demand for representative structures and for space utilization independent of the weather conditions, contemporary cities increasingly integrate such structures. Engaging in the design of large roof structures has become more common for architects and engineers. For large roof designs, aesthetics, structural performance and economics tend to dominate the design process. However, the current increased emphasis on energy-related aspects generates new challenges. Particularly, the use of renewable energy resources, including both active and passive systems, needs to be confronted in the design.

Performance-oriented design proposes to integrate performance evaluations in the early stages of the design process and the potential of parametric modeling is investigated as design support. Based on a set of chosen independent parameters, such digital techniques allow the automatic generation of design alternatives. The instances of the parametric model can be explored with respect to a given set of design criteria, based on the specific performances used as key drivers for the design. However, due to the breadth of the solution space, its exhaustive exploration is not possible when left to the intuition of the designer. This becomes even more problematic when dealing with interdisciplinary aspects. Directly looping the parametric generation of design alternatives with performance evaluation tools and orienting such generation toward the desired performance is the key principle of the proposed investigations.

PROJECT INFORMATION
Project leader: Michela Turrin
In collaboration with:
Peter von Buelow (Michigan University)
Axel Kilian (Princeton University)

RELATED PUBLICATIONS
Representational Flexibility
Dynamic Digital Design Representations

Development of a framework for representational flexibility that supports an exploration of alternative design representations, a comparison of design representations with respect to scope and coverage, and a mapping of design information between representations.

There is a strong need for computational representations for design that are both flexible and dynamic. Flexible representations can offer multiple design views of a same building or product, in support of a variety of partners and disciplines. Dynamic representations can adapt themselves to suit different tasks or phases in the design process, even for a same designer. Hereto, a framework for representational flexibility is developed that supports an exploration of alternative design representations, a comparison of design representations with respect to scope and coverage, and a mapping of design information between representations. This theory of sorts offers a description of representational structures using formal compositional relationships over primitive data types. This formalism additionally allows for dynamic information entities, enabling creative design by supporting re-interpretations of existing design descriptions through emergent forms, and considers a methodology for dealing with such creative dynamism within a design application. Together, these offer strong support for creative design by liberating the designer from a representational straitjacket.

Related Publications

Structural Design, Composite Structures

The efforts to save energy, needed to produce building materials, will rise in the following decades. In the past composite structures were developed to save materials and cost. Halfway the XXth century Jaques Coëlle developed ceramique infills for curved concrete roofs to save cement: the Fusee Ceramique’s. Using this system many domes and vaults were built. The structural analysis of composite structures of ceramics, mortar and steel shows the advantages and hazards of composites and will be useful to develop new composite elements.

PROJECT INFORMATION
Project leader: Wim Kamerling
Period: May 2009 – July 2010

RELATED PUBLICATIONS
• Paper: Arends G.J., Kamerling M.W., Rise and Decline of the Fusee Ceramique Vaults, 8th International Masonry Conference 2010, Dresden;
• Paper: Kamerling M.W., Structural aspects of vaults composed of ceramic elements, mortar and steel, 8th International Masonry Conference 2010, Dresden.
The Emotive InteractiveWall

Hyperbody, Festo and Burkhardt Leitner constructive as part of the Festo Bionic Learning Network.

As a prototype for an emotive wall, the InteractiveWall is an important step towards the development of an emotive architecture that is no longer a static backdrop for its users but a key component in a dynamic customizable environment.

An emotive wall is a wall that responds to the user, a wall that has a character, a wall that can move because it wants to. The emotive InteractiveWall is composed of 7 separate wall pieces (herein referred to as nodes) that display real time behavior by swinging its body back and forth, displaying patterns of light on its skin, and projecting localized sound.

The overall behavioral pattern of the InteractiveWall is inspired by the phenomenon of emergent synchrony as described in the book, Sync: the emerging science of spontaneous order (2003, New York: Interactiveion) by Steven Strogatz. Strogatz asserts that this synchronous behavior is the result of a simple, and inherent behavioral pattern that emerges as complex social behavior, which he illustrates in the behavior of the firefly. Complex patterns emerge out of the simple localized behavior of their flashing tails, because of their tendency to synchronize whenever they are near each other, even when they are swarming by the thousands.

As architecture becomes emotive, responsive, and interactive users can influence its behavior. In that sense architecture follows a general development in society towards individualization, personalization and customization, which follows the evolution of contemporary mundane technologies. Now it is architecture’s turn to become emotive, responsive and customizable. Therefore it is through projects such as the InteractiveWall prototype that we can explore the possibilities of emotive architecture. It is through projects such as the InteractiveWall prototype that architecture will come alive.

PROJECT INFORMATION

Project leader: MarkDavid Hosale, Chris Kievid
Executed by: Hyperbody, Faculty of Architecture, Delft University of Technology
Period: 2009
Funded by: Festo
The Strength of Glass

An integrated physicochemical/mechanical approach to the strength of glass.

Although glass is widely used as an engineering material in reality little is known about its mechanical behaviour, specifically the long term strength. In addition it is not clear what fracture parameter should be used for glass and how this should be statistically treated. The research is intended to provide fundamental insights into the mechanical behaviour of glass with the objective of determining reliable engineering “strength” values.

PROJECT INFORMATION
Project leader: Fred Veer
Research partner: Dr. Y.M. Rodichev, head of department of brittle materials, Pisarenko institute of strength, Kiev
Period: 1995 – Now

RELATED PUBLICATIONS
• The strength of glass, a non-transparent value; F.A. Veer; Heron, vol 52, 2007
• The strength of annealed, heat strengthened and fully tempered glass, F.A. Veer, F.P. Bos, P.C. Louter; Journal of fatigue and fracture of engineering materials and structures, 2009
• The mechanical strength of glass: hidden damage; F.A. Veer, Y.N. Rodichev; Journal of strength of materials, 2010
The Vela Roof
Performance oriented parametric design for passive reduction of summer overheating

Passive strategies for thermal comfort allow reducing the need for imported energies. Principles belonging to different disciplines are used, from the design of the overall geometry to its materialization. The Vela roof case study is an interdisciplinary design process based on integrated early performance evaluations, using parametric modeling as support.

Passive strategies for thermal comfort are based on the use of on-site energy. Taking advantage of periodic climatic changes enables one to store the solar thermal energy needed for heating or to disperse excessive heat. When focusing on large roofs, such strategies involve systems for heat gain reduction and passive cooling, relying on controlling airflow, controlling direct solar radiation and the mean radial temperature of the roof, and using thermal mass; furthermore, adiabatic cooling is to be taken into consideration when focusing on passive cooling. Such a large set of factors involves different disciplines, by increasing the complexity of the process. Integrating them in a performance oriented design process is a key aspect from the very early phase of the design.

The case study (Vela roof in Bologna, Italy) focused on passive strategies for reducing the summer overheating of the spaces underneath the roof. Investigations were done for increasing the airflow, reducing the direct solar exposure of the covered spaces, reducing the long wave radiations from the roof, and reducing the maximum temperatures using adiabatic cooling. The thermal comfort was estimated and compared for various design alternatives, including geometry and material properties. Parametric modeling supported the generation of design alternatives, based on meaningful parameters able of bridging different disciplines.

RELATED PUBLICATIONS
Virtual Operation Room
A time-based architecture for the augmented body

In order to study and practice e-motive architecture we build parametric environments and interactive interfaces to communicate with active worlds. Actual architectural concepts like e-motive architecture, time-based architecture, programmable architecture, free form styling, swarm behaviour and genetic algorithms come together in a game for the Technology Museum in Delft [Virtual Operation Room].

The VOR features a responsive geometry, responsive to actions of the players of the VOR game. In the BODYPORT [Christian Friedrich] the player navigates through its avatar into the entrance space, a kneadable vertex swarm which reacts to the movements of the player. From the BODYPORT you can choose three different worlds to get in to, using a joystick as the input device: the BRAIN [Sven Blokker], the PURIFICATOR [Chris Kievid] and the FLOW [Michael Bittermann].

In each of these highly responsive and pro-active worlds the player learns about the bodily system by acting, by pointing at sweet spots, by shooting cells, by killing cancerous growth. After having gained insight in the dynamics of the complex adaptive system of the human bodily system by collecting points, you can transfer yourself to one of the other worlds. The VOR claims to be a future [2010 and beyond] self-diagnosis tool and a concept for an auto-curing health game. The player experiences the self as an augmented body.
Visual Perception Computation

A theoretical framework for visual perception computation in science and Architecture

Perception is an important concept in science and architecture. Although perception concept is commonly well known, its treatment in a mathematical formalism is not common. In this work, the visual perception is defined as the probability of visual awareness of an object subtended by a visual angle. This definition already points out the intimate relation between perception and cognition. The perception is computed via visual attention which is the perception per unit vision angle at the infinitesimally small angle at the vision angle $\theta$. 

For uniform vision probability density $f_u(v)$:

$$f_u(v) = \frac{k}{\pi \sqrt{v^2 + k^2}} \quad v = \tan(\theta)$$

For non-uniform vision probability density $f_n(v)$:

$$f_n(v) = \frac{k}{\pi} \frac{1}{1 + (k^2 - 1)\cos(\theta)^2}$$

For uniform vision probability density $f_u(\theta)$:

$$f_u(\theta) = \frac{k}{\pi} \frac{1}{1 + (k^2 - 1)\cos(\theta)^2}$$

Uniform (k=1) and non-uniform vision probability densities

$$P = \int_0^\pi f_u(\theta)d\theta = \int_0^\pi A ds$$

$P \rightarrow$ perception; $\theta \rightarrow$ vision angle

$f_o \rightarrow$ visual probability density

Conclusions

• For uniform vision probability density the magnitude of attention is computed as

$$|A| = \sqrt{A_x^2 + A_y^2} = \frac{1}{\pi l}$$

• Attention along x and along y directions explains the reason why in the far end of figure 2 the objects on the right and left walls are not to perceive clearly, while the person in the far end can still be clearly perceived.

• Perception is computed via attention which is a function of vision angle, in general.

RELATED PUBLICATIONS


iWeb-Protospace

Protospace is a real-time collaborative design and engineering platform developed by Hyperbody.

The Protospace project aims at developing a digitally augmented group design and decision environment where advanced CAD methods meet immersive virtual reality visualization and multimodal user-interface technology.

ProtoSpace thus offers modes of interaction which current design environments, do not provide. Acting as a unified, intelligent transaction space for a team of experts from different disciplines, Protospace presents design projects on an active 360 degree panoramic screen (Fig.03). Multiple users are physically connected to this projected world via sensors, actuators and tangible interface devices which in-form Protospace’s computational systems. Changes in a design proposed by any player/expert can be calculated and evaluated in real time. Design alternatives can thus be efficiently explored in accordance with the player’s own disciplinary interest very quickly, while immediately informing the other players as regards the validity of the proposed alternatives. The players are given the most natural ways to communicate with such a design environment: wireless controllers, speech recognition, hand movements or simply moving around in the sensor field.

Such a parametric design process is not confined to the design itself. The adaptation of interfaces, representations, behaviours, validation and game play become a central and transparent part of the design team’s activity. ProtoSpace pro-actively supports this process, by having an open software architecture (Fig.04), by being open to re-interpretations, by developing a process-mind of its own. To the design-team, ProtoSpace is not just a handy tool for evolving initial sketches to a working prototype. ProtoSpace fluidly provides them with various perspectives of the design process and offers new approaches to the development of the design prototype. It becomes a partner in the design process. The Protospace environment enhances the sensitivity of the players/experts to each other’s points of view.

The Protospace environment in action at the I Web, TU Delft
Wind Farm Noordoostpolder
Analysis of the visualizations of the wind farm at Noordoostpolder

The objective of Koepel Windenergie Noordoostpolder (KWN) is to present stakeholders with a realistic image representation of the wind farm under development at Noordoostpolder. We were asked to serve as an independent party to act and to investigate whether the visualizations offer an accurate picture of the Noordoostpolder after realization of the wind farm.

Analysis of the visualizations of the wind farm at Noordoostpolder

The visualization of the images supplied were examined and evaluated on a number of aspects:
- Height of the windmills in relation to the position in the landscape based on the technical specifications.
- The position of the windmills relative to characteristic features in the landscape, based on topographic data from the Topographical Service TU Delft, together with the camera angles provided by KWN.
- The position of the windmills in relation to the camera position from where the picture was taken.
- The display size of the blades in relation to the windmill on the basis of technical specifications.
- The distance between the turbines, taking into account the perspective effect in the visualizations.

In addition, the software used for visualization, EMD International Windpro, was analyzed on the basis of perspective calculations and incorporating the wind farm into the landscape. It can be concluded that the software generates an accurate picture. The software is recognized internationally as the standard in the design and planning of wind farms. In addition, the software is accepted by all major manufacturers of wind turbines, local authorities and engineering firms.

After analysis, we concluded that the visualization of the wind farm under development at Noordoostpolder forms a realistic representation. In this, we specifically considered the scale of the windmills relative to the environment.

PROJECT INFORMATION
Project leader: Rudi Stouffs
Executed by: Ernst Janssen Groesbeek, Sander Mulders
Period: June – October 2009
Budget: € 3,800
Funded by: Koepel Windenergie Noordoostpolder
Adaptive Corporate Environments
Nimish Biloria (PhD)

Creating real-time interactive spatial systems for corporate offices incorporating computation techniques.

The inter-disciplinary research-driven design initiative focuses upon developing a real-time interactive architectural (spatial and informational) solution for contemporary corporate offices. Rather than creating conventional inert structural shells, which typically neglect the appropriation of their ambient, spatial and informational compositions to rightfully address dynamic nature of tasks being performed within them, the development of a meta-system, or in other words creating a 'soft' computationally enriched open systemic framework (informational) which interfaces with the 'hard', material component and the users of the corporate space formulates the core agenda of the research work. This soft space/meta system serves as a platform for providing the users with a democratic framework, within which they can manifest their own programmatic (activity oriented) combinations in order to create self designed spatial alternatives. The otherwise static/inert hard architectural counterpart, enhanced with contemporary technology thus becomes a physical interface prone to real-time spatial/structural and ambient augmentation to optimally serve its users.

A synergistic merger of the expertise offered through the fields of Rule based computation, Modular programming and Swarm behavior for data processing, structuring/re-structuring, information storage and retrieval, Control systems for developing sensing, actuating properties and for implementing space allocation sequences (Java based) and Kinetic systems for developing a dynamic skeletal framework, is henceforth adopted as a combinatorial approach towards achieving intelligent structural control of the architectural body and developing a real time updating data base which will be useful for maintaining and monitoring the body. A fully customizable, performance driven interactive architectural solution is thus envisioned.

Translation of point cloud simulation based derived heights via Java code to Local control agents (CPX controller, Festo) and subsequently the actuating agents, resulting in precision oriented spatial configuration generation.
Architectural Geometry
Helmut Pottmann, Andreas Asperl, Michael Hofer, Axel Kilian

Geometry lies at the core of the architectural design process. It is omnipresent, from the initial form-finding stages to the actual construction. Modern constructive geometry provides a variety of tools for the efficient design, analysis, and manufacture of complex shapes. This results in new challenges for architecture. However, the architectural application also poses new problems to geometry. Architectural geometry is therefore an entire research area, currently emerging at the border between applied geometry and architecture.

This book has been written as a textbook for students of architecture or industrial design. It comprises material at all levels, from the basics of geometric modeling to the cutting edge of research. During the architectural journey through geometry, topics typically reserved for a mathematically well-trained audience are addressed in an easily understandable way. These include central concepts on freeform curves and surfaces, differential geometry, kinematic geometry, mesh processing, digital reconstruction, and optimization of shapes.

This book is also intended as a geometry consultant for architects, construction engineers, and industrial designers and as a source of inspiration for scientists interested in applications of geometry processing in architecture and art.

PUBLICATION INFORMATION
Title: Architectural Geometry
Authors: Helmut Pottmann, Andreas Asperl, Michael Hofer, Axel Kilian
Publisher: Bentley Institute Press; 1st edition (October 1, 2007)
Hardcover: 744 pages
Language: English
ISBN: 978-1934493045
In BCN: Speed & Friction, Dutch architect Kas Oosterhuis, working with architects, designers, educators, and students, heads a distinguished team of professionals concerned with building, urbanism, and environment in a 7-day, non-stop design workshop at the University of Catalunya’s School of Architecture in Barcelona, Spain.

BCN—the acronym for Barcelona—is the profusely illustrated, bilingual (English and Spanish) document produced by Oosterhuis’s workshop. BCN considers what new forces in design, architecture, and urbanism might emerge from considering speed as part of the near-future city. BCN also questions how those forces may be intelligently contemplated.

Oosterhuis’s brief for the workshop was the imagining and design of a city conceived on the basis of speed and friction derived from an event such as a Formula I race. Typically, such one-day events briefly transform a city by closing streets, creating new urban patterns, attracting viewers from other locations, and focusing on the spectacle of speed. But Oosterhuis asked: what if such an ephemeral event became the permanent basis for a city? What new urban and architectural forms, imagined along the parameters of speed and friction, might result, and how they might become an innovative model for urban form?
Blurring the Lines
Computer-Aided Design and Manufacturing in Contemporary Architecture
André Chaszar (editor)

In architecture the interface between CAD (computer-aided design) and CAM (computer-aided manufacturing) is a hot topic. For architects, it offers the opportunity to work in a new way and regain greater control of the construction and manufacture of their buildings or - as the situation may demand - to collaborate more effectively with various experts.

The first few years of the 21st century have seen a revolution in the ways that we think about designing and making buildings. In no other area is this more apparent than in the interface of computer-aided design (CAD) and computer-aided manufacture (CAM). The potential blurring or assimilation of these two systems holds the still elusive but golden promise of a direct, smooth transference of design data into large-scale production facilities in which components are directly cut, modeled and molded. How far off are we from seeing the widespread adoption of this technology? What is the potential for CAD/CAM beyond tailor-made forms? In the future, what is the possibility of complex, large-scale modeling being produced as mass-customized buildings?

Addressing these and other critical questions, Blurring the Lines draws together the expertise of architects and engineers at the fore in this field, with contributions from Mark Burry, André Chaszar, Tim Eliassen, Doug Garofalo, James Glymph, Lars Hesselgren, Niels Jonkhans, Harald Kloft, Andrew Maher, Volker Muller, Kristina Shea, Tensho Takeomega and Neil Woodger of firms and institutions including Arup, Buro Happold, Atelier Ten, EPFL, KPF, NBBJ, RMIT-SIAL, TransSolar and SHoP Architects. In addition to essays on key topics that cover CAD, CAM and their intersection, case studies of projects bring into focus the use of pioneering technologies. These include among others: Gehry’s DZ Bank Conference Hall; Nox Architects’ Son-O-House; Piano’s Paul Klee Museum; Cook and Fournier’s Kunsthaus Graz; and Massie’s various digital housing projects.

Some of the conclusions drawn regarding gaps in the flow of information via digital model use and sharing have led to the research project “Beyond BIM” which studies and proposes improvements to the ways which architects, engineers, builders and others use to create, exchange, interpret and manipulate digital models.
Challenging Glass
Conference On Architectural And Structural Applications Of Glass, 2008
Freek Bos, Christian Louter, Fred Veer (editors)

‘Challenging Glass’ accompanies the first Conference on Architectural and Structural Applications of Glass, which is organized at TU Delft, 22-23 May 2008.

It provides the reader with nearly seventy papers, written by authors with backgrounds varying from practicing architects, structural and facade engineers through contractors to researchers in material science, building physics, lighting, and building and civil engineering. Just about every challenge that glass poses for architectural and structural applications is being dealt with. The topics that are covered in this edition range from glass joints, fixings and adhesives to architectural designs to the strength, stability and safety of glass. Other important issues are laminates and composite designs, glass lighting, the curving and bending of glass and the many facades of glass. ‘Challenging Glass’ contains a gathering of PhD researchers from around Europe and the world and truly accepts every facet of transparency and brittleness; those features that make glass so challenging.

‘Challenging Glass’ contains 65 paper contributions from 12 different countries organized into eight categories:

- keynotes
- projects and case studies
- joint, fixings and adhesives
- strength, stability and safety
- laminates and composite designs
- curved and bended glass
- architectural design and lighting
- glass in façades

Four specialists with an outstanding track record in different fields of glass design and engineering offer keynote contributions: Luke Lowings, Niccolò Baldassini, James O’Callaghan and Tanguy Rouxel.

PUBLICATION INFORMATION
Title: Challenging Glass
Editors: Freek Bos, Christian Louter, Fred Veer
Publisher: IOS Press (May 15, 2008)
Hardcover: 676 pages
Language: English
ISBN: 978-1586038663
Collaborative Architectural Design In Virtual Reality

Hans Hubers (PhD)

In this PhD research a method and software prototype has been developed for collaborative architectural design in virtual reality. 'Collaborative design’ stands for multidisciplinary working together from the very first beginning of a project. 'Virtual reality’ stands for a simulation in 3D computer software in real-time. ‘Real-time’ means that it is not an animation, which is developed before, but direct manipulation of virtual cameras in a virtual environment on the Internet.

The reasons for application of collaborative design are as follows:
- The big influence of decisions in the beginning of the design process on the cost/quality ratio.
- The potential contribution through knowledge and experience of all stakeholders at this beginning.
- The growing complexity of building projects, e.g. because of complex geometry, difficult locations in cities, underground building, building on water, the use of new materials and new building methods.
- The demand of guaranties of clients and the claims that different parties get because of building failures lead to the wish of these parties to have an influence on the design.
- There is a waste of time and money in the actual design process where the advice of experts often comes too late because other developments changed the design already.

Out of practical considerations this research is limited to a case where the design team consisted of an architect, a structural advisor, an installation advisor and a cost advisor who together developed the conceptual building design. The iteratively attained final design version thus involves the team members collaborative working in real-time. A software application prototype to enable a multi-disciplinary design team to collaborate in a virtual 3d environment in real-time over the Internet was developed as a part of this research agenda. The PhD research via its collaborative design initiative encourages the development of faster and much efficient architectural concepts. A collaborative design process from the initial stages of design is initiated via this research. Collaboration via real-time data exchange from a common database over the Internet is also a special feature of the research initiative.

The collaborative design methodology and software interface as an output of the PhD research
Rob Woodbury and Andrew Burrow set the stage in their paper “Whither design space?” The exploration of design spaces is a long-standing focus in computational design research. Design space exploration is the idea that computers can be used to help designers by representing many designs, organizing them in a network structure that forms the space, and by assisting designers to explore this space: that is, to make new designs and to move among previously discovered designs in the network.

They specifically focus on computational access to the design space and the implications of having a design space representation in reference to the premise that exploration is a good model for designer action. Possible structures for a design space are conditioned by models of exploration behavior, by choices of strategies for amplifying designer action, and by the limits imposed by both computation itself and our knowledge of it. Formalisms for design space exploration must simultaneously accord with designer action, implement a useful amplification strategy, and be both formalizable and computationally tractable.

Woodbury and Burrow raise, and answer, a number of questions, for example, what defines a good representation? Are design rules or, instead, design operators, the appropriate encoding mechanism for design moves in the design space? What is the role of the explicit design space, that is, the part of the design space the designer has previously visited, and what is the role of trajectories of design moves in design exploration? These questions, and others, form the basis for a discussion that can serve as a stepping stone for future research into design spaces.

In “The Whittled Design Space,” Ömer Akın examines Woodbury and Burrow’s paper according to four criteria: completeness, discrimination, alternative approaches, and combining exploration in different problem domains. In “Yes, and by the Way . . . ,” Ulrich Flemming picks up on the issue raised by Woodbury and Burrow of taking the specific domain representation too seriously, in particular, confusing the knowledge level with the underlying symbol level.

In “Explicit Design Space?” Ramesh Krishnamurti examines the need for an explicit representation of the design space, along with an explicit representation of a particular search strategy.

In “Quo Vadis, Design Space Explorer?” Gabriela Goldschmidt broadens the notion of exploration and bases it on a more cognition-oriented footing. Pieter van Langen and Frances Brazier argue in “Design Space Exploration Revisited” that design space exploration involves exploration in three related spaces. Gerald Penn offers in “Design Space and Typed Feature Logic” some insights into the logic of typed feature structures, including some of its weaknesses, recounting how Woodbury, Burrow, and colleagues have adapted it to design space navigation.

Sambit Datta, in “Mixed Initiative in Design Space Exploration,” addresses human–computer interaction over typed feature structures in the context of design space exploration.

In “A Typology of Design Space Explorers,” Woodbury and Burrow map the various responses, and their own work, according to two axes: the spectrum of strengths and needs that stretches from the machine to the human, and the time scale of events in design.
E-Activities and Intelligent Support

9th EuropIA International Conference on Advances in Design Sciences & Technology, 2003

Bige Tunçer, Şaban Suat Özsarıyıldız, Sevil Sarıyıldız (editors)

9th EuropIA International Conference on E-activities and Intelligent Support in Design and the Built Environment is organized in Istanbul, Turkey, 8-10 October 2003

The most significant impact and added value that ICT developments have brought to the building sector are probably the improved ease, effectiveness and efficiency of interaction and cooperation between various scientific disciplines. In EuropIA conferences, and thus in the 9th EuropIA international conference, disciplines such as engineering, computer science, mathematics, physics, social sciences and arts come closer than ever before, all with their specific knowledge for contribution in a new scientific discipline: ICKT (Information, Communication and Knowledge Technology) in design and the built environment. The participation of a wide range of scientists and the scope of this conference confirms this. The conference presents a cross-platform event for the study and analysis of the application of information, communication and knowledge technologies to architecture, building engineering, civil engineering, urban design, urban planning and policy analysis. All papers in this book are from the 9th EuropIA international conference on E-Activities and Intelligent Support in Design and The Built Environment, held on 8-10 October 2003 in Istanbul, Turkey. These cross-platform papers represent state-of-the-art research and development in these fields. The papers illustrate activities in both theory and application.

Both volumes express both the breadth and depth of e-activities and intelligent support in design and the built environment and offers clues about the future.

The first volume is a collection of papers related to e-activities in building design and construction. The 22 papers are grouped under the following headings:

- Process modelling and business process reengineering
- Information and product modelling
- Knowledge modelling and soft computing

The second volume is a collection of papers related to e-activities in design and design education. The 24 papers are grouped under the following headings:

- Design education and information libraries
- Design environments and multimedia
- Design requirements and objectives, evaluation and generative design

RELATED PUBLICATIONS

GameSetandMatch II
Kas Oosterhuis, Lukas Feireiss (editors)

‘GameSetandMatch II’ accompanies the second Conference GameSetandMatch, which is organized at TU Delft, 29 March-1 April 2006.

With the new technical possibilities of worldwide electronic networking and the ubiquitous employment of new media and digital technology in various fields of research and practice, conventional disciplines are gradually dissolving as new transdisciplines develop. Contemporary architecture too resides in a state of transgression that gives rise to new architectural conceptions benefiting from a multitude of influences. This publication brings together the manifold, international and interdisciplinary contributions to the ‘GameSetandMatch II Conference - The Architecture Co-Laboratory,’ directed by Kas Oosterhuis, Professor at the Faculty of Architecture of the Delft University of Technology, the Netherlands. It addresses contemporary and future changes within and across the boundaries of digitally-driven architectural and design practices. The notion of architecture as a co-laboratory accentuates this strong devotion to experimentation and collaboration. In so doing the publication offers a kaleidoscopic view of rather than a defined perspective on current developments in the digital design domain.

The authors of the essays and papers included in this book come from very diverse backgrounds ranging from architecture and design to technology and engineering as well as computer sciences and humanities. An interlaced series of three thematic areas - Play, Geometry ++ and Open Source - will relate diverse sources of knowledge and enable the reader to cross-reference, ask questions, view contexts in a different light and even create new connections between the presented contents. This collection of writings serves the generally interested reader as well as the scientific reader and provides a source of discussion to draw inspiration and motivation from.
What is Interactive Architecture? First clarify what it is NOT. Interactive Architecture - from here on abbreviated as iA - is NOT simply architecture that is responsive or adaptive to changing circumstances. On the contrary, iA is based on the concept of bi-directional communication, which requires two active parties. Naturally, communication between two people is interactive; they both listen [input], think [process] and talk [output]. But iA is not about communication between people, it is first defined as the art of building relationships between built components and second, as building relations between people and built components.

iA is the art of building bi-directional relationships. The Centre for Interactive Architecture, regards all iA built components as, essentially, input-processing-output [IPO] devices. iA theory includes both passive and active IPO systems. Let me clarify this statement with a classic example: the door. The door in the building functions as a switch. It is either open or closed. When we add the lock to the door, it is either locked or unlocked. And the one who has the key is authorized to lock and unlock the door. The door functions in the building as a semi-permeable membrane for the two spaces A and B at either side. The door allows people or goods to go in or to go out, which s as output from room B and input from A. Input and output are clarified now, what about the processing? The door processes people, but also goods carried by the people, airflow, dust particles, smell etc. When the door is opened, the two systems find a new equilibrium: number of people, goods, light, temperature, and data. The door processes by counting what passes through the opening.

He iA bookazine series will consist of twelve issues bi-annually published over a period of six years. Each issue will have at least one scientific paper on a particular aspect of iA, one iA-driven MSc project, one iA-inspired case study from practice, one interview with a renowned researcher / practitioner, and one blog by Kas Oosterhuis.
Inception Support for Large Scale Construction Projects

A Knowledge Modelling Approach

Şaban Suat Özsarıyıldız (PhD)

This thesis presents the results of an investigation into the initial stage of Large Scale Construction (LSC) projects. This thesis focuses on early client and design processes as well as the decision processes covering the total life cycle of a project. The challenge targeted in this PhD study therefore was to investigate the applicability of Information Communication and Knowledge Technologies (ICKT) in the inception stage of complex Large Scale Construction projects.

The research question is: “Is it possible to develop a concept and tool that helps the client to formulate an optimal Client Brief that helps the project team to deal effectively with the severe information and knowledge processing challenges required to optimally fulfill client’s needs?” This research analyses existing and alternative approaches to improving inception stage support. The success of the various approaches and technologies seems to depend on their ability to improve dynamic processes for project knowledge developments and stimulate project innovations. Performance based approaches are valuable for projects in the public sector where government design/engineering departments are in control. ICT can play an important role during Inception of LSC projects in the future.

Conclusions derived from this investigation are
1) from the client point of view, at the start of the research in 1997, Inception Support Systems did not exist and no research on inception modelling had been reported. Individual companies should be able to store company knowledge in company-private knowledge stores and be able to apply that knowledge in different contexts and projects
2) from the contractor point of view, involvement in early inception and concept design stages of LSC projects helps the contractor to come up with the best technical solutions for his part of the project, provided innovation and value added is rewarded.
Innovation in Architecture, Engineering and Construction

3rd International Conference on Innovation in AEC
Sevil Sarıyıldız, Bige Tunçer (editors)

Rotterdam, The Netherlands, 15-17 June 2005

The need for innovative approaches to design and construction is now recognized by most sectors of the construction industry, all over the world. There is a considerable body of ongoing research that is geared towards innovation in design and construction processes in the building sector. The scope of these projects encompasses the use of innovative materials, innovative design concepts, innovative construction methods, novel procurement methods, innovative deployment of ICT tools, etc. The aim of this conference is to act as a focal point for the dissemination of results from ongoing studies, applications and demonstration projects, both from scientific institutions, universities and the building industry, throughout the world. It is intended that the conference brings together both practitioners and researchers interested in innovative approaches to design and construction in the building sector.

The first volume is a collection of papers related to innovation in design, engineering and construction. The 45 papers are grouped under the following headings:
- Innovation in architectural, structural and urban design
- Digital design and manufacturing
- Innovative approaches to collaborative working
- Innovative materials, design & construction technologies
- E-learning and education
- Organizational and theoretical aspects of innovation

The second volume is a collection of papers related to innovation in technology and management in AEC. The 48 papers are grouped under the following headings:
- Soft computing and knowledge modeling
- Innovative information and knowledge management
- Technological innovation in design and construction
- Innovations in construction and facility management
- Innovations in health, safety and sustainability in AEC
- Lessons from practice: industrial innovations

RELATED PUBLICATIONS
Intelligent Computing in Engineering

Özer Çiftçoğlu, Edwin Dado (editors)

EG-ICE is the acronym for the European Group for Intelligent Computing in Engineering. The focus of EG-ICE is to promote research and applications of advanced informatics to all aspects of engineering. The primary goals of the group are to promote advanced informatics research across Europe by improving contact between researchers, fostering research collaboration and enhancing awareness of the latest developments. With this latter aim in mind, the group maintains active contact with similar groups in countries outside Europe and encourages membership by non-Europeans. The group has a further aim to increase the awareness of industry of advanced informatics as well as the economic benefits that can be gained by implementation. To achieve its aims, the group runs a yearly workshop and is active in the promotion, dissemination and exchange of ideas in order to provide effective links between research, industry and teaching.

Intelligent computing is the application of advanced computing methods to improve performance in areas such as complex representations that are clear to users and easily modifiable; exploration and search in exponentially complex search spaces; visualization tools and flexible engineer-computer interfaces that empower rather than hinder; active control for learning, self diagnosis and repair; and computer supported collaborative work for higher quality communication. The goal is to make decision making more reliable, spontaneous and creative.
Intelligent Design Objects (IDO)

A cognitive approach for performance-based design

Michael S. Bittermann (PhD)

A novel computational system for architectural design is presented. It generates designs that satisfy multiple, vague criteria put forward by decision makers, such as architects.

Design is complex. This is because it involves conflicting goals that are often vague. Also, prior to the design it is generally not clear how important goals are relative to each other. And finally the amount of possible solutions is large in general. These bottlenecks are addressed in this thesis.

A novel approach for design is proposed, where computation is used to reach most suitable solutions. The approach is based on a novel concept of the objects forming a design. This concept is termed intelligent design objects (IDO). Such objects exhibit intelligent behavior in the sense that they approach most desirable solutions for conflicting, vague goals put forward by a designer. That is, the objects know ‘themselves’ what to do to satisfy a designer’s goals. This is accomplished using methods from the domain of computational intelligence, as these are uniquely able to deal with the complexity of design mentioned above.

The result from the approach is that designers and decision makers have great certainty about the satisfaction of their goals and are able to concentrate on second order aspects they were not aware of prior to the execution. The approach is implemented for two applications from the domain of architecture demonstrating its effectiveness.

The thesis addresses to students, researchers and executives in the field of architecture, and other areas of design. It may be also interesting for researchers in the domain of computational intelligence, as it provides a formalism of intelligent design, and it exemplifies the use of these modern technologies in the design domain. Due to its generic nature, this formalism may have some significance in the development of the science of design.
Modelling Collaborative Knowledge in Digital Free-Form Design

Tuba Kocatürk (PhD)

This research focuses on the emerging domain of digital free-form design, and attempts to explicate its knowledge content and characteristics through a systematic inquiry of the free-form design practice. It is claimed that the free-form design cannot simply be characterized by their formal complexities, but should rather be understood in its totality with its unique methodological, technological and theoretical content, which is representative of a larger scale of impact of the digital technologies on architectural design and production.

The emerging knowledge content of the new domain is characterized with the extensive use of digital tools and technologies, formal and procedural complexities, pluralistic design methodologies, and the unique forms of interactions it requires across multiple disciplines. Studying a new and evolutionary design domain is a challenging task which requires the selection of a critical strategy with an awareness of the possible contradictions between the past understandings and emerging characteristics about design. There is a critical balance between to what extent to allow the established preconceptions to influence our inquiry, and to what extent to be open to the emergent concepts that will challenge the established understandings about design and design knowledge. This has been an initial motivation for this research which has led to our research questions:

1. How can such a model accommodate change, incorporate different design experiences and new information?
2. How can it evolve by the actual creators of the knowledge themselves, thus contributing to a collective and collaborative creation of knowledge?
3. How can this facilitate knowledge transfer between designers within and across disciplines?

The following are the applicable outputs of this research and can be utilized as described below:

1. A taxonomy (a representational, hierarchically organized vocabulary of free-form design): By capturing the knowledge that designers use to accomplish their tasks in an explicit manner, we can study these methods and possibly improve upon them.
2. A Knowledge Framework (formal and theoretical representation of the domain semantics): The representation of knowledge forms a transferable, teachable body of knowledge, thus contributing to the education of new generations of architects.
3. A prototype (a web-based environment to support collaborative knowledge construction, sharing and reuse): Modelling knowledge in a form comprehensible to computers, forms the basis for developing design support tools which could respond to the specific knowledge content and the knowledge needs of the designers.
The 798 district needs to grow further. It needs new spaces for new functions and for new people. It needs to become one of the main focal points in the cityscape of Beijing. Nevertheless it would be a mistake to assume that one, to-down design can provide an answer to fulfill all the needs of the growing 798 community. The expansion has to be flexible, diverse and unconstrained and it has to become a landmark icon for this amazing site.

As an answer to this demand professor Kas Oosterhuis together with Hyperbody came up with the idea of making a distributed design for the eastern part of the 798 district - the 751 factory. The concept was to create a large scale, multifunctional, three dimensional urban structure, which would be conceived as a result of a bottom-up and distributed design process. The bottom-up nature of the development can be achieved by dividing the area into smaller, interdependent projects, assigned to autonomous but at the same time closely cooperating designers. On one hand all of them should have all the design freedom they may need, but on the other hand their design as a group should be a game in which they follow the same, clear set of rules.
New Instruments for Dynamic Building-Construction

Computer as partner in construction

Reinout van Rees (PhD)

For dynamic processes to become possible in Building-Construction, ICT support is needed. Data access and data exchange needs to be ubiquitous. Existing research often only targets elaborate international standards (that don't really get off the ground because of international differences) or it targets big, elaborate, expensive systems (that are only available to the top 1% of the companies).

This thesis proposes an open source Building-Construction Ontology Web (bcoWeb) coupled with the so-called REST style of web services. Open source to maximise the possibility of participation and to limit the dependency on organisations or individual companies. Simple REST web interaction to keep the complexity low without sacrificing functionality. An ontology web consisting of multiple independent (national) ontologies to facilitate meaningful information exchange without first needing to build The One Big Ontology (that will never be completed).
ONL Hyperbody Logic
Part of the AADCU

Hyperbody Logic gives an extensive overview of the recent works of Kas Oosterhuis and Ilona Lénárd of ONL with a special emphasis on interactive projects.

The book series "A Global Survey on Digital/Multi-media/Net Based Arch Design" is designated to introducing contemporary digital, multi-media and net information based architecture design into China with a global perspective, in order to provide a valuable reference for professional architecture design practice and education development in China and furnish Chinese architecture students and professionals with rich information on the world's new architecture culture experience.

From France to Italy, from U.S to Spain, Netherlands, Germany, Finland... all the architects are carefully selected with extensive consulting from experts in both U.S. and Chinese architectural education institutes and have gone through rigorous examinations of our advisors.

PUBLICATION INFORMATION
English and Chinese published
AADCU, 2006
254 pages, Hardcover,
ISBN: 7-5453-6164-1
Safety concepts in Structural Glass Engineering

Towards an integrated approach

Freek Bos (PhD)

There are two things everybody knows about glass: it is transparent ... and it breaks! And it is these two qualities (transparency and fragility) that provide it its unique position in the building industry. Transparency is the prime architectural driving force, and fragility a key property making engineers hesitant to apply it quite to the extent architects would like, i.e. as a load bearing material. In spite of several decades of development, there is still no comprehensive method to assess the safety of a structural glass element, that agrees with its specific failure behaviour. Therefore, this dissertation proposes the Integrated Approach to Structural Glass Safety, based on four clearly defined element safety properties, damage sensitivity, relative resistance, redundancy, and fracture mode. The Element Safety Diagram (ESD) is introduced to provide an easy-to-read graphical representation of these properties. The safety performance of a large number of glass beam designs has been compared through experimental testing based on the proposed approach. The effects of a wide range of safety enhancing design measures on each element safety property is extensively discussed. Elastic strain energy release is identified as a, hitherto underexposed, parameter with major influence on redundancy – the most important safety property. Finally, the Integrated Approach is applied to re-evaluate the safety of two full-scale case-study projects which started this study.
System-embedded Intelligence in Architecture

Henriette Bier (PhD)

This research focuses on critical assessment of computer-based systems in architecture with respect to their incorporated aspects of intelligence, classifying digitally-driven architectural design and architecture through procedural- and object-oriented studies. It, furthermore, introduces methodologies of digital design, which incorporate intelligent computer-based systems proposing development of prototypical tools to support the design process.

The research, attempts to answer questions regarding how aspects of intelligence are incorporated in design systems and how these influence the design process and the design: Generative Design, for instance, has been focus of current design research and practice largely due to the phenomenon of emergence explored within self-organizing systems, generative grammars and evolutionary techniques. In this context, system-embedded intelligence has often been reduced to the mechanics of working with these systems. This research, in response, not only critically reveals what these techniques offer architectural design, but also addresses challenges in their application and development. Its relevance as reference for developing an understanding for computer-based systems in relation to their incorporated aspects of intelligence has been meanwhile confirmed in projects implemented internationally. Furthermore, intelligent software-prototypes developed within this research have been tested in practice and in design studios and will be further developed in prospective design and research projects undertaken at TU Delft. Methodologically seen, observations, assumptions and theories have been verified in practical experiments implemented in international workshops, whereas, software-prototypes have been mostly developed and tested at TU Delft. Aspects of intelligence incorporated in computer-based tools and processes and their influence on architectural design have been explored within this research with emphasis - not on representation but - on capabilities to compute complexity, i.e. complex systems, in architecture, whereas complexity has been defined as arising from the multiplicity of interactions within architectural sub-systems such as physical, environmental and socio-technical systems.
The Architectural Information Map
Semantic modeling in conceptual architectural design
Bige Tunçer (PhD)

This research focuses on the acquisition, representation, sharing and reuse of design information and knowledge in the conceptual phase of architectural design, and targets the creation of situated digital environments where communities of architectural practice communicate and collaborate using this information and knowledge. The utilizable outputs of the research are the ArcIMap method and model, and the four prototype applications embedded in education and practice.

Four prototype applications of ArcIMap have been developed, situated, and evaluated in different architectural education and practice contexts. These applications and their evaluation have provided valuable feedback to the theory forming and to the iterative definition of ArcIMap.

The first application is an analysis presentation tool that uses three Ottoman mosques as its case study, researches and validates the unified representational framework and evaluates the notions of interaction and associative browsing in an application of ArcIMap. The second application, Blob Inventory Project (BLIP), is a precedent library designed for modeling knowledge that has emerged from digital design, engineering and production processes of free-form geometry buildings and has been used in the 3rd semester of the MSc. architecture education. BLIP researches and evaluates user interface and interaction aspects of ArcIMap. The third application, Design Analysis Network (DAN), is an information system implemented as an educational architectural analysis environment used in the undergraduate 2nd year design studio. DAN researches and evaluates all components of ArcIMap, but especially the embedding in a context. The fourth application, DesignMap, is a flexible and extensible content management system intended to be used at the early stages of design, is targeted towards small and medium-sized architectural offices, and has been used and evaluated at the architectural office Mecanoo in Delft. DesignMap researches, implements and evaluates ArcIMap within the context of architectural practice.

ArcIMap is both a method and a model. The method defines social and information processes in order to create complex information structures underlying complex adaptive systems. The model acts as a structure for the design of complex information structures. The techniques and technologies encapsulated in the model enable the implementation of applications of ArcIMap in various educational and practical contexts. An application of ArcIMap must be rooted in its use context, therefore, a study of the social and work processes of the users and the organizational structure of the context in which it will be used must be studied in the design stage of the application. Environments to be used in an educational context have different requirements than ones to be used in practice, because experienced designers have different needs than novices.

PUBLICATION INFORMATION
PhD dissertation
Supervisor: Prof. Sevil Sariyildiz
Defended: 3 December 2009
Paperback: 218 pages
Language: English

RELATED PUBLICATIONS
Urban Design with Patterns and Shape Rules

José N. Beirão, José P. Duarte

“How Urban Design with Patterns and Shape Rules: Devising a Methodology to Create Solutions” is the ninth chapter in the book Model Town: Using Urban Simulation in New Town Planning, edited by Egbert Stolk and Marco te Brömmelstroet, which is the result of a conference on Urban Simulation Models organized by the International New Town Institute on October 11 and 12, 2007.

How to model new towns from scratch? Is it possible to simulate urban developments? And if so, are computer programmes of any help? How can urban simulation and serious gaming contribute to the urban design of our (new) cities? These questions are raised by the International New Town Institute (INTI).

The goal of an urban plan is to provide a development vision for a given territory. Three crucial issues in the conception and implementation of urban plans are how to define the program, how to convert the program into a flexible design, and how to adapt the design to changes in the program. This chapter describes the preliminary results of ongoing research aimed at devising a methodology for addressing these issues. This methodology uses Alexander’s pattern language to define the program and Stiny’s shape grammar formalism to convert the program into design solutions. A design studio has been used as the basis for developing and testing the methodology. Preliminary results suggest that the use of patterns helps to tie the urban plan to a specific development vision, and shape grammars are successful in generating alternative design solutions that match varying programs.
Virtual Context
Martijn Stellingwerff (PhD)

This research initiative addresses the issue of Design in relation to Virtual Context, investigating the characteristics and opportunities of digital visualisation media for situated approaches to architectural design in an urban environment.

Central to this study are the innovative potentials and instrumental opportunities of computer based media techniques, capable of generating interactive models and changing perspectives for the benefit of urban and architectural design. The ambition was not only to make a contribution to the existing body of knowledge concerning digital technologies and their applications, but to explore theoretical conditions which might help define and stimulate further study.

From the outset, the focus was on furthering the opportunities for computer based representation media in creative design. The subject of this research – the issue of Design in Context, or more specifically: Design(ing) in a Virtual Context – was tackled on the basis of a series of explorative studies.

During the process there was a marked shift in the conception of the subject from more or less immersive VR technologies in the direction of approaches which might be expected to become readily available in practice and education and could be effective in actual design processes. This insight also brought about a shift in emphasis from realism per-se towards creating a sense of situatedness.

The design representation system which was developed was intended not to just allow for one type of model view, but to afford an array of different views, from which the designer would be able to choose freely, depending on the phase and focus of design as well as personal preferences. A series of interface prototypes and support tools were developed especially and successively tested experimentally.

For the intended final design driven experimental study, different virtual context models were considered. Eventually, an integral –purely fictitious– design 'environment' was constructed in the computer, so that the workings of the proposed system and its components would be tested systematically.

A conscious choice was made for an in depth study, on a relatively modest scale, which would facilitate a certain amount of mutual involvement between designer and researcher, to confront the participants with the finer aspects of the proposed system in a relatively short time and to gather detailed data. A half dozen design professionals were invited to participate in a closely monitored experimental exercise.

The results of this study therefore do not offer straightforward, indisputable facts, to be considered representative for the design community as a whole, but indicate that the working methods of the individual designers –when discovering aspects of the site, developing and presenting proposals and reflecting on the qualities of represented designs– tend to vary considerably. For this reason the interactive representation system proved to be of value. Participants could express different view preferences, with more or less realistic image modes being used in different phases of their design developments, with varying experiences of situatedness. Some of the design professionals participants were very appreciative of the system’s opportunities, others tended to be more set in their ways.

The results of this experimental study indicate that there may particularly be opportunities for interface applications which are able to function interactively, offering individual designers –as well as others involved in evaluating design proposals– a variety of tools with which to approach specific design artefacts in their changing contexts. Virtual models can play an important role not only as a ‘reminder’ for the designer but also to other parties playing an active role in the design and implementation processes. Interactive environment models are promising not only as exploration tools for existing sites, but could also be valuable to test the impact of a design on its location. This could be especially interesting if the site is difficult or impossible to visit or as yet a virtual construction. Additionally such an approach might be beneficial for objective comparison and evaluation of design proposals in competitions and in education as well as in on-line collaborative design projects where the context is still in the process of being developed.
Green Building Innovation
EFN – European Façade Network

Cooperation of science, technology and industry in the field of building envelopes.

The network was initiated in 2009 with the aim to cooperate in the fields of research, education and international fund-raising.

The European Facade Network (EFN) is a cooperation of science, technology and industry between the University of Bath (UK), the Delft University of Technology (NL), the University of the Basque Country (ES), the Lucerne University of Applied Sciences (CH), the Ostwestfalen-Lippe University of Applied Sciences (D), the Federation of the European Window and Curtain Wall Manufacturer’s Associations (FAECF) and the Fundacion Technalia.

The international network will focus on the following activities:
- Collect and exchange knowledge on façade technology
- Commonly execute and promote research activities
- Arrange and organize conferences, workshops, and programs for the exchange of students and teachers
- Set up a common alumni network
- Cooperate in international fund-raising to gain additional financial resources.
It is intended to publish a European Façade Magazine beginning 2011.
Future Envelope

Conference on Building Envelopes

To a high extent, facades are responsible for energy and comfort performance of buildings and the architectural design. The have developed from separated building components to highly integrated architectural systems. The annual conference aims to explore and discuss developments that will lead to future building envelopes.

Building envelopes today are one of the most complex building components and a truly multidisciplinary discipline. This is reflected in the selection of speakers, coming from the fields architecture, climate design, structural engineering, product development, research and industry. Until now, about 50 speakers have participated and shared their knowledge and visions about the future building envelope.

Researcher and students from our partner universities use it as a meeting event. With its accompanying workshops it is a fixed part of the curricula of the Facade Master Programs in Lucerne(CH), Detmold(D), Bath(UK) and San Sebastian(ES). The goal is not merely to gather together and learn what is technologically and scientifically cutting edge, but to create a relationship between those who currently define the business and those who aim to do it in the future.

The conference is supported by the international branch organisations of the façade industry VMRG, FAECF and FAC. (more information www.bk.tudelft.nl/futureenvelope)

The Future Envelope 1
11.June 2007

The Future Envelope 2  Architecture-Climate-Skin
05.June 2008

The Future Envelope 3  Facades-The Making Of
14.May 2009

The Future Envelope 4  Next Generation
10.June 2010

PROJECT INFORMATION
Project leader: Tillmann Klein
Executed by: Ulrich Knaack, Arie Bergsma, Nellie Schuut-Baak, Usch Engelmann, Tillmann Klein
Period: Annual

RELATED PUBLICATIONS
Integrated Design Workshops

Development of future façade principles via workshops

Using the heuristic research methodology, the Façade Research Group conducts workshops with collaborators in industry, design studios and researchers to develop scenarios for possible future technologies.

Building on existing knowledge and employing classic scientific research methods – problem outline, compilation of material and knowledge, evaluation and interpretation, structuring and lastly the development of subsequent steps – the workshop for future façade principles uses the idea of heuristic development in order to faster identify future developments and their potential and risks.

The analysis does not only consider purely technical parameters (construction and energy) as deciding factors for whether or not a certain technology is worth pursuing but also social and economic criteria: it is about developing possible scenarios to motivate the designers to strive for new formative and technical solutions.

This methodology is the reversal of the traditional planning principle, which was to solve the technical issues created by the design through targeted development of technical visions and depiction of the resulting design possibilities.

It is obvious that with this method not only the best but also ideas of lesser quality are being pursued and realized, because factors other than the technical and formative parameters come into play. However, it is exciting to see which trends develop through the core of the formative, technical and economic possibilities, and sometimes being able to influence these trends through new developments.

Workshops 2006-2010:

Facade Research Group – "Future Facades 1", Faculty of Architecture, TU Delft, March 2006
Delft Design School – "Architectural Engineering 1" – Special guest: Prof. Klaus Daniels, Faculty of Architecture, TU Delft, April 2008
Facade Research Group – "Rapid Prototyping in Facade Construction?", Faculty of Architecture, TU Delft, December 2008
International Facade Master Program – “Nature Inspired Envelope Innovation”, Faculty of Architecture, TU Delft, June 2009
Façade Research Group + Students Hochschule OWL – "Imagine 3", University of Applied Sciences Hochschule OWL, Detmold, November 2009
Façade Research Group + UN Studio Architects – "Rapid Prototyping", Amsterdam, April 2010
Façade Research Group + Center for Industrial Architecture (CINARK)/ Royal Danish Academy of Fine Arts - "I am energy", Faculty of Architecture, TU Delft, June 2010
Material Design

Knowledge diffusion between designers, material specialists and material researchers

Bimonthly a discussion night is organized by the Material Design Committee with the title “the Experience of...”. The subjects of the discussion nights are material related. The purpose of these discussion nights is the creation of synergy in the collaboration between different professions on the subject of materials.

The meeting is hosted by a company related to the subject, for example a factory. The evening consists of two presentations, a tour and a discussion. Interesting cross-pollination between different involved parties bring design and development to an higher level.

The evening is visited by 30-50 participants from different backgrounds. The discussion night is organized in collaboration with Product magazine, in which bimonthly a publication is written on the subject of the meeting.

The following subjects have been subject of “the experience of ” discussion nights:

- Material
- Imitation
- Magnesium
- Color
- Cardboard
- Technical Textile
- Ceramic
- Confection Textile
- Natural Fibers
- Concrete
- Glass
- Surfaces
- Scent
- Biopolymers
- Rubber
- Recycled materials
- Artificial light
- Experience
- Felt
- Sound
- Domotica
- Metal plate
- Mobility
- Packaging material
- Composites
- Daylight

RELATED PUBLICATIONS

- Bimonthly publications on the subject of the discussion night in PRODUCT magazine; www.productmagazine.nl
MaterialZ

Knowledge diffusion between designers, material specialists and researchers

Materialization is an important issue in the design process of a building. Not just the technical functions, but also the identity and atmosphere of the building depend on the use of materials. In both practice and education the issue of materialization mostly turns up at the end of the design process. During the event ‘MaterialZ’ which took place in September 2006 and 2007, the main subject was the collaboration between materials specialists, designers and research institutes, a collaboration that includes students and education.

During both events the knowledge diffusion between different parties was the main interest. Also, the innovation side was very important. Material was not only presented from an architectural point of view, but also from the viewpoint of other industries. Innovation and knowledge from different professions can be very inspiring for the architectural practice.

Both MaterialZ events opened with a symposium at which innovative architectonic projects as well as material innovation examples were presented. The symposium was organized in collaboration with DAX magazine and was sponsored by the Delft Centre for Materials.

A material exposition was composed of inspiring materials, systems and technologies. All materials were provided with a barcode. After scanning the material an information page was opened in a material database, which is called the "Technotheek". Information on the material characteristics, application, manufacturing, material source as well as related materials were given in this database. Characteristics like fire resistance, Young modulus, tensile strength makes it possible for students to work with the materials, and calculated the application possibility in their design.

During the materialZ event in 2006, the following activities were organized;
• discussion night about technical and esthetical ceramics at the European Ceramic Centre
• excursion to Corus
• workshop hosted by 2012 architects, Jan Jongert
• business fair during the symposium

PROJECT INFORMATION
Team: Charlotte Lelieveld, Msc., Prof. Dr. Jr. Wim Poelman, Gillian Baarslag, MSc., Jolanda Dijkshoorn, Nynke Bergstra, MSc., Marije van der Laag
Period: February 2006 – November 2007
Funded by: Delft University of Technology & Delft Centre for Materials

RELATED PUBLICATIONS
• MaterialZ, eds. Lelieveld, Charlotte and W.A. Poelman, 2007
SASBE2009
3rd CIB International Conference on Smart and Sustainable Built Environments – TU Delft, 15-19 June 2009

SASBE2009 was organised by staff and students of the Faculty of Architecture. The event attracted almost 300 delegates from all over the world, predominantly from academia yet also from the public and private market. The Prince of Orange opened the conference and great keynote speeches were given by, for instance, Ken Yeang, Michael Braungart and Sir David King. SASBE2009 offered many sustainable extras, such as free bikes and organic food. CIB awarded the SASBE2009 chair with a commendation.

The SASBE series started off in 2003 (Brisbane) and had a follow-up in 2006 (Shanghai). Delft was asked to organise the event in 2009 and it will have its predecessor in 2012 (Sao Paulo).

SASBE2009 received around 250 abstracts, which through double blind peer reviews resulted in 150 papers and 90 oral presentations for the scientific programme. 12 best papers were selected, along with special contributions, to be included in the book Smart Building in a Changing Climate, presented to Willem-Alexander, Prince of Orange, after his opening.

The Sustainable Industry Day, organised to bring academia and the market together, offered 12 market presentations and several workshops.

For the 300 participants, SASBE2009 offered a great line-up of keynotes and invited contributions: the Prince of Orange, Dirk Sijmons, Ken Yeang, Nils Larsson, Thomas Rau, Jon Kristinsson, Han Brezet, Michael Braungart, Wubbo Ockels, Sir David King, Winy Maas, Jay Yang, John Worthington, Koen Steemers, Jan Jongert, Sven-Erik Jorgensen, Ronald Waterman, Liesbeth van der Pol.

The Dutch Crown Prince paid special attention to the five finalists of the CIB Student Competition, presenting their plans at SASBE2009. Furthermore, the conference hosted a PhD workshop and offered several excursions.

Every morning the SASBE Daily newspaper welcomed the delegates.

The sustainable character of the conference was brought into every detail. Participants were allowed to use a free bike or bike taxi throughout the conference, food was organic and mainly vegetarian, products fair-trade and renewable.

PROJECT INFORMATION
Project leader: Andy van den Dobbelsteen
Executed by: many, e.g. Arjan van Timmeren, Machiel van Dorst, Michel Fremouw
Period: November 2006-July 2009
Budget: € 210.000
Funded by: Denvi, SUA, Rotterdam Climate Initiative, City of Delft, DGBC, BuildDesk

RELATED PUBLICATIONS
- Dobbelsteen A. van den, Dorst M. van & Timmeren A. van (eds.); Smart Building in a Changing Climate; Techne Press, Amsterdam, 2009
- Dobbelsteen A. van den, Dorst M. van & Timmeren A. van (eds.): Proceedings SASBE2009 (on CD-rom); TU Delft, 2009
- Dobbelsteen A. van den; "SASBE2009 zet standaard voor congressen"; on website www.duurzaamgebouwd.nl
GBI: PHD RESEARCH
AUTONOMY & HETERONOMY
Integration and Closing of cycles in the built environment

There is growing heteronomy of the essential utilities, particularly energy and sanitation. For solutions to new or existing problems, technological development is mainly following the centralisation paradigm. Other, more sustainable solutions can be found by abandoning this one sided approach. This research emphasises the potentials for sustainability and resilience in case of a reciprocal relation between centralized and decentralized systems and interconnection of energy, waste and wastewater solutions on the basis of ‘quality cascading’ and integration.

Research context
Cities are like organisms, sucking in resources and emitting wastes. The larger and more complex they become, the greater the necessity of infrastructures and the greater their dependence on surrounding areas, and last but not least, the greater their vulnerability to change around them. With recent and coming perturbations of the weather as well as constantly increasing demand of energy, water and materials, this aspect of vulnerability and dependence is becoming essential for sustainability, as the world may be entering a period of scarcity.

Research focus
There are several strategies to cope with sustainability and the increased dependence and vulnerability. Two future paths could be determined. Within the globalizing world, centralization through interconnection of sustainable generation and use, connecting sustainable solutions in the different regions, and balancing both hemispheres is one. The other option is exactly the opposite: decentralization, trying to interconnect supply and demand sustainably on smaller scales, near to users, and therefore near to the origin of environmental problems, and potentials. Both future paths, heteronomy and autonomy, raise many opportunities for design and planning, however they also imply huge problems for governance. The research shows the potentials of integrating sustainable solutions concerning energy and sanitation flows on centralized and decentralized scale-levels. Introducing ‘cradle to cradle’ design options and innovative technology with the goal of functioning of buildings based on exergetic principles.

Results
The PhD project has been finished successfully in June 2006; awarded with ‘cum laude’. Many publications have been realised, of which two were awarded.
Breakthrough Building Innovation

Complex processes of Design and Engineering

Realizations of technologically innovative architecture, and especially the ones that bring forth breakthrough innovation, range from big successes to big disasters. The interaction between project team participants is recognized as an important factor in the outcome of these building realizations. This research takes a closer look at this interaction to discover how it could stimulate the achievement of breakthrough innovations for the building industry.

In order to get buildings geared up for advanced performance demands in the near future, new technology needs to be absorbed into the building industry in a fast rate. Unfortunately, it is frequently noticed during exemplary project realizations that project participants keep each other in a strangle hold that counteracts the team work collaboration that is required to achieve breakthrough building innovation.

There is little scientific publishing for architectural science that relates team work interaction to the achievement of innovation. However, other scientific fields such as economic and social sciences offer a broad choice of available publications. This research therefore undertakes a literature study in these foreign sciences to extract the scientific publications that allow for theory building within the field of architectural science.

Although innovation is a much wanted outcome, it is a complex matter to get a grip on from the perspective of achievement. This research formulates a definition for breakthrough innovation in the building industry and introduces a method to measure the achievement of breakthrough innovations for buildings as project innovativeness.

The research includes multiple case studies to gather qualitative data on the team work interaction and to validate its effect on the project outcomes and on the achievement of breakthrough innovation.

The research is aimed to make clear how we can enhance team work interaction in order to achieve breakthrough innovation in building projects.
Climate adaptation and spatial planning

How to adjust spatial planning to improve climate adaptation

Spatial planning does have difficulties to increase climate adaptation. This is caused by the fact that climate adaptation is a wicked problem and oriented on the long-term and spatial planning is used to deal with tame problems on the short term. The PhD-research explores the potentials of an adjusted spatial planning to be able to plan for long-term wicked problems. Therefore, the planning concept of swarm planning is developed and tested in practice. Climate adaptation is connected with a sustainable energy supply.

Political (max 4 years) and spatial planning timeframes (10 years) do not connect with the timeframes of climate adaptation and sustainable energy (50-100 years), fig. 1. The consequence is that climate adaptation is not integrated in spatial planning very well.

Regular planning processes tend to describe the past rather than what is required for the future. This subsequent policy processes are not able to enhance fundamental changes. It is needed to create a burning platform (sense of urgency) to do so, especially in turbulent times. The transition towards a new and stronger future is only possible after having experienced a crisis. Only then it is possible to move from A to B (instead of ending in A'), fig. 2.

Swarm planning makes use of the rules of complex adaptive systems in order to enhance this transition towards a climate adaptive region and defines the criteria, which are able to construct such a region and calculate the adaptation level of areas and plans. Swarm planning is a planning method, which starts emerging processes, by giving incentives at the right locations and thus changing the spatial system, while it still consists of the same elements. By doing so, the spatial system creates a higher adaptive capacity and is better able to deal with the effects of climate change.

The planning method is used in several design exercises for the area of Groningen: climate adaptive design (fig. 3), adaptation scenarios (fig 4) and a region without fossil energy (fig 5).
CLIMATE-RESPONSIVE DESIGN

Development of a design strategy for integration of climate-responsive building elements in the design of dwellings

The basic idea behind climate-responsive design is that you take advantage of the natural energy sources present in the built environment for passive or low-energy comfort provision. The building space and mass acts as an intermediary, where the indoor environment is controlled in close interaction with dynamic outdoor conditions. Comfort is provided when needed and delivered where needed, while buildings respond to changes in internal and external climate and to occupant intervention.

In other words, climate-responsive design embraces comfort-from-climate principles. The key in making successful use of energy potential of the built environment is to bridge the discrepancy between patterns in space and time of the natural energy supply and building energy demand. With climate-responsive design the building becomes an intermediary in its own energy housekeeping.

Many comfort aspects can be met directly from harvesting or adverting natural energy flows. This includes common principles such as passive solar heating, natural ventilation and natural illumination, but also less common principles such as solar driven ventilation. Comfort can be guaranteed from complementing energy treatment strategies such as conservation, distribution, buffering, recovery and storage.

The goal of this research is to validate the potential of climate-responsive design principles in building design of dwellings and by introducing knowledge and skills to the design process in such a way that it assists architects in their design practice. The main purpose is to make architects aware of the energy and comfort impact of their design decisions and give them knowledge on how to design according to climate-responsive design principles.

A next step is to translate climate-responsive design principles into actual design solutions, as its technical and/or architectural transformation. Many climate-responsive design solutions are based on one design principles or operate from a combination of them. They can be divided into six main categories.

The basic idea behind climate-responsive design is that you take advantage of the natural energy sources present in the built environment for passive or low-energy comfort provision. The building space and mass acts as an intermediary, where the indoor environment is controlled in close interaction with dynamic outdoor conditions. Comfort is provided when needed and delivered where needed, while buildings respond to changes in internal and external climate and to occupant intervention.

In other words, climate-responsive design embraces comfort-from-climate principles. The key in making successful use of energy potential of the built environment is to bridge the discrepancy between patterns in space and time of the natural energy supply and building energy demand. With climate-responsive design the building becomes an intermediary in its own energy housekeeping.

Many comfort aspects can be met directly from harvesting or adverting natural energy flows. This includes common principles such as passive solar heating, natural ventilation and natural illumination, but also less common principles such as solar driven ventilation. Comfort can be guaranteed from complementing energy treatment strategies such as conservation, distribution, buffering, recovery and storage.

A next step is to translate climate-responsive design principles into actual design solutions, as its technical and/or architectural transformation. Many climate-responsive design solutions are based on one design principles or operate from a combination of them. They can be divided into six main categories.

The focus of this research is on climate-responsive building elements, which far-reaching integrates the delivery of services into architectural and structural elements.

PROJECT INFORMATION
PhD researcher: Remco Looman
Supervisors: Hans Cauberg, Andy van den Dobbelsteen & Arjan van Timmeren
Budget: € 240,000
Funded by: SenterNovem / TU Delft

RELATED PUBLICATIONS
Daylight and Outside View
The influence of windows on the visual quality of office spaces

When windows are designed it is important to consider the access of daylight and the view through the window because they contribute both to the visual quality of indoor spaces. This PhD research investigates the influence of daylight and outside view on the visual perception of office employees. Aim of the research is to develop a research and design method that can be used for the analysis of daylight and view quality simultaneously. To investigate what specific variables contribute to the visual quality of indoor spaces a field study has been started in various office buildings.

Objective
A new research method that can investigate simultaneously the access of daylight and the quality of the view through a window.

Main research question
What parameters of daylight and outside view influence the visual quality of indoor spaces?

Field study
The main body of the field study is a survey research in eight office buildings. The study took place between February 2008 and January 2010. The employees of these buildings were asked to answer a questionnaire, consisting of four parts:
1. Personal questions
2. The workplace
3. Indoor climate, focus on lighting
4. The view through the window

The total number of respondents is 558. Preliminary analysis of the results of the building with most respondents showed a significant correlation between satisfaction with the daylighting and satisfaction with the view (N = 239, p < .001, Cramer’s V =0.43).

Development of a View and Light Analysis Method
For the analysis of the daylight access and view through a window, first the view has to be recorded in an objective way. The basis of the new analysis method is a 180º projection of the windows and the view through the windows. For the analysis of the daylight access, existing charts have been transformed to make them applicable to the new method. Based on the results of the field study and a scale model study we will make an assessment method for the quality of window views.

Each respondent that took part in the field study was asked to rate 6 pictures. The higher the rating, the more they would like it to be the view from their workplace.

Different sets of 6 pictures were made and in total 22 pictures were rated. The figure shows the average results.

The basic diagram can be used to draw the projection of the window and the view through the window by hand.

Dot and sunpath diagrams are made for the analysis of the daylight access

PROJECT INFORMATION
PhD candidate: Hester Hellinga
Supervisors: Hans Cauberg, Truus de Bruin-Hordijk
Period: October 2006 – February 2011
Budget: € 240,000
Funded by: TU Delft

RELATED PUBLICATIONS
Designing the urban microclimate

A framework for the dissemination of knowledge on urban microclimates to the urban designer

For the liveability of urban environments its microclimates are of great importance, since microclimates can significantly affect the physical well-being of urban dwellers. There is a significant body of scientific knowledge on the influence of the built environment on microclimates, but it is difficult to directly apply this knowledge to urban designs and plans. This PhD project proposes a framework for the structuring and translating of scientific climatic knowledge into information that is useful in the different phases of the urban design process.

The climate of a city influences the ways in which its outdoor spaces are used. Especially public spaces intended for use by pedestrians and cyclists, such as parks, squares, residential and shopping streets, and foot- and cycle-paths will be used and enjoyed more frequently when they have a comfortable and healthy climate. In order to preserve physical well-being in a changing climate and densifying urban environment, information on climate-sensitive design is of crucial importance. Passive building strategies that support physical well-being are preferable as they serve a sustainable development in the urban environment. Promising combinations of the spatial requirements regarding the separate microclimate elements should be utilized, and conflicts solved in accordance to other design requirements. This asks for a plain presentation of the complex relations of different qualities of the urban microclimate.

The context in which this information is transferred is complex, because of the different perceptions of different actors at different steps in an urban planning process - a process in which the urban designer plays an important role. Diversity in presentation of microclimate knowledge and a variation in emphasis do not only support communication in the planning process, but are also very likely to support the different design styles of urban designers.

The information framework proposed by this PhD project can help to bring the relations between different possible design decisions to light and support decision-making. A design instrument based on the proposed framework will enable designers and planners to estimate the influence of their spatial design choices on the microclimate and help them in creating conditions for urban microclimates that favour physical well-being.

PROJECT INFORMATION
PhD researcher: Marjolein van Esch
Supervisors: Hans Cauberg, Kees Duijvestein, Truus de Bruin
Period: October 2006-October 2011
Budget: € 240,000
Funded by: TU Delft

RELATED PUBLICATIONS
- Esch, MME van, Hordijk, GJ & Duijvestein, CAJ (2007). The influence of building geometry on the physical urban climate: a revival of "light, air and space". In SK Wittkopf & BK Tan (Eds.), PLEA 2007 - Sun, wind and architecture - 24th International conference on passive and low energy architecture (pp. 396-403). Singapore: National University of Singapore, department of architecture. (TUD)
Free to Design
Free Form Design and the Architectural Classics/Universals

This research presents both a theory of methods how computers are involved in the development of Free Form Designs and an implementation of Architectural Classics (universals) in Free Form Design, focusing on the specific consequences of the different kinds of involving. General aim is to evolve Free Form Design to a more human scale/level and to give designers improved insight in the (im)possibilities of computer aided design and methodologies to maximize use of these within all phases of the design and possibly even the realization process.

First three separate literature studies were conducted:

The first literature study was conducted considering Free Form Design buildings by primary resources (buildings, models & drawings), secondary resources (theories, publications), and tertiary resources (interviews and symposia).

The second literature study was performed about design and research methodologies that might lead to insight in a general methodology for the application of computer tools in the design process of Free Form Design buildings.

Finally a third literature study was made about Architectural Classics/Universals through the ages.

The literature studies resulted in an explosion of forms and theories; Hence focusing became rather difficult. Therefor was chosen for an additional fourth step. In this fourth step the object of research – Free Form Design buildings - became separated from its context and the focus became the object itself detached from its primary, secondary and tertiary resources. This type of research solution is well known in art history. In this case was chosen to study the actual design process by redoing/redrawing the object itself (reconstructing the computer application).

More than 40 Free Form Design (FFD) objects were studied. With this information it became possible to reconstruct the FFD objects with computer models and to categorize 5 typologies of Free Form Designs: The Non-Digital, Tradi-Digital, Semi-Digital, Formal-Digital and the Pure-Digital.

It's the goal with this knowledge to involve specific architectural classics/fundamentals in Free Form designs to bring FFD Buildings to a more human scale/level.
GSRH- SD
Glocal System for Sustainable Reconstruction of Houses in Seismic Desert cities

This project deals with designing in a complex situation, in which the complexity is caused by sever circumstantial limitation that adds extra loads on the design. If these limitations exceed to more than one, the complexity increases not only due to the growth of the number of the involved items, but also by possible conflicts between the requirements for each of these constraints. Design for a sustainable reconstruction of houses in a seismic desert city (SRH-SD) is one of such cases. Systemization is the proposal solution to avoid complications and chaos in these complexities. Adjusting the proposed systemization with sustainability is the major task.

The risk of failure for a design conclusion is generally a possible phenomenon. However, probability of this failure increases due to the mentioned increase of complexity. In order to avoid chaos and complications in a SRH-SD, which may cause the design to fail to reach any appropriate conclusion, one of the crucial steps is organization of the stages prior to the conceptualization.

For example in a SRH-SD in addition to desert conditions, earthquakes are severely causing problems. Earthquake occurring 500,000 times per year (100,000 felt), is the most fatal natural phenomenon for a vast variety of lands in the world. The destructive earthquakes pose huge impacts on (i) Environment, (ii) people, and (iii) Economy. Although many researchers are working on buildings to withstand seismic motions, they are mostly focused on expensive structures, high-rises, or residential complexes, with minor efforts on houses. Thus for a SRH-SD all the aspects should be incorporated on three levels of urbanism, building, and materialisation. This design needs to be conducted under the umbrella of sustainability in an open and flexible frame.
Holistic Energy Assessment Tool

With the aim to create buildings consuming as little energy as possible, the holistic balance over the complete life cycle has to be considered. The operating energy is more and more a well integrated parameter in the design process. However, the energy concepts rarely include the energy invested to construct, maintain and demolish a building. This share -the embodied energy- can account for half of the building’s overall balance. Both the performance and the embodied energy are relevant in the design phase and need to be balanced at this stage of planning.

As today’s buildings have to meet a very high standard concerning sustainability it is essential to approach not only one parameter but regard the energy balance holistically. Throughout its life cycle the energy consumption in the context of building consists of transportation energy, the amount to operate a building and the embodied energy. This study focuses on the latter two aspects.

The most relevant component is the amount of energy necessary to operate the building. It is not only the share of the overall balance but the possibility of impacting it that makes this parameter a highly relevant one.

The energy to manufacture and demolish a building accounts for 20 years of performance energy. Although not obvious, the embedded energy is a relevant factor whose extent is defined in the design phase. The weight of the construction and the manufacturing process influence this parameter significantly. With the tendency to decrease the performance energy the relevance for the holistic energy balance of embedded energy increases.

The finding of this study is an instrument that assesses the overall energy performance over the whole life cycle including the building materials, comfort zone and the service life of the building. The insights gained from developing the tool and assessing the case studies will be put into a comprehensible format for architects to use during the design phase.

Embodied energy in material groups for 1 kg
Indoor Climate in the Tropics

Dwellings Improvement in a Hot-Humid Climate

Dwellings in tropical countries experience problems of high temperature in collaboration with high humidity. Dwellings, especially which are owned by low-income households also likely to have indoor air pollutants due to the fuels used of cooking activity. Research is aimed to observe how indoor conditions in these types of buildings is, formulate design principles, and create guideline for improving the indoor climate of these low-income dwellings in the tropics.

This research is important to enhance dwelling quality of the low-income people in a hot-humid climate. Research will be taken placed in Surakarta, one of dense cities in Central Java, Indonesia. Research is aimed to get knowledge of existing condition by assessing thermal sensation, indoor air quality, and health level of the people, so that the principles of design can be formulated to create the guideline for dwellings improvement.

7-point thermal sensation scale in images

**RELATED PUBLICATIONS**

Integrated Façade Components
A new product architecture for metal-glass façades

Metal-glass facades belong to the most successful products in the building industry. Since their invention at the end of the 19th century they have developed from architectural applications to highly developed façade systems, but their constructional principle has remained unchanged. New requirements in saving energy ask for a rethinking of this type of façade.

Simply spoken the purpose of metal-glass facades is to connect different façade fillings, such as glass panels. It is responsible for wind/water tightness and architectural design. The constantly rising need for saving energy has resulted in a need for better U-values and that has lead to a high complexity of this subtle interface.

An improvement of metal-glass facades is hardly possible. Another issue that proves to be a new challenge for façade construction is the need to integrate building services components into the physical façade area. Basically façade system are facing the problem to become innovation blockers.

In this PhD research the product architecture of existing façade constructions is analysed. The comparison with other disciplines, such as the automotive and maritime industries, shows how radical changes can effect construction from design to production and assembly processes.

New constructional concepts are developed and it becomes clear that they will have to face the incrementally evolved building industry. Will the market determine future façade construction or will a new way of construction create a different kind of façade industry?
International Facades

A guideline for climate related façade solutions

In the course of globalization, façade constructions developed for central European climate zones are being used worldwide. In many cases, these façades can only fulfill the requirements of the respective location by massive application of mechanical service components. High energy consumption needed to fulfill the required comfort level in the offices is of lesser importance than the desired look. Are we able to learn from the past to create more appropriate façade solution?

Subject
How and with which methods can one realize optimized façades for office buildings that provide maximum comfort as well as economic efficiency in the facility operation for specific climate zones?

Goal
The research project shall present an overview of façade requirements in different climate zones, useable as a guideline for architects and planners to increase the comfort level and reduce the energy consumption in the beginning of their design process.

Expected Results
In addition, new façade constructions shall be identified that exemplify improved adaptation to the regional climate over current projects. As a vision for the future, new areas for research and development will be presented that provide potential for the development of façades. Beside the general design advise, a software tool will be developed that indicates the requirements of façade type and the use of different mechanical service components. The system will use weather files to indicate the climate environment. The tool is supported by Transsolar Energietechnik GmbH.

PROJECT INFORMATION
Phd student: Dipl. -Ing. Marcel Bilow
Promoted by: Prof. Dr.-Ing. Ulrich Knaack
Prof. Dr.-Ing. Mick Eeckhout
Period: 2006 – 2010

RELATED PUBLICATIONS
• VDI Symposium "Fassade – Blick in die Zukunft",International Façade – Ein Planungstool zur Ermittlung der Anforderungen von Fassaden in verschiedenen Klimazonen, april 2008, Düsseldorf
• Future envelope symposium – Architecture -Climate - Skin, CROFT – Climate Related Optimized Facade Technologies, June 2008, Delft
• Fassade 2007, symposium, International Facades – A phd study into climate related facade constructions, october 2007, Delft
Interrelating Essential Flows
Designing Connected and Closed Cycles in the Built Environment

The objective of this research is contributing to an optimized durable building and environment by providing knowledge and insight to architects and developers in ways to connect and close cycles (in the flows of) energy, water and building materials in the building and its surroundings.

Gradually the building sector is becoming aware of the necessity to integrate sustainability in buildings, whether it concerns renovation or new development. Over the last fifteen years the Dutch government has emphasised mainly on energy reduction through regulation which has resulted in a limited view on the meaning of sustainability. Furthermore, though architects and developers intend including sustainability in their projects, the vast majority still considers sustainable design as a series of single interventions in the building design, such as solar panels, heat pumps, etc.. This can result in a weak fundament concerning sustainable design.

To improve and fortify the sustainability of a building, it is of importance to involve the entire scope of essential flows in and around the building. Correlation between the essential flows is desired, as well as closing the cycles of these individual flows.

The main focus of the research will be on the correlation of the flows. The interrelation between the sustainability of materials and the increasing legislation on energy reduction by the government will embody a part of this research. The material can be assessed on embodied energy, durability, recyclability, finiteness of recourses, etc. By considering the quality of a material which is applied in a system for energy reduction it is expected that a clearer decision can be made in designing a sustainable energy concept for a building.

Closing and connecting cycles (image by Dobbelsteen, 2008)]

PROJECT INFORMATION
PHD researcher: Suzanne van Dijk
Supervisor: Andy van den Dobbelsteen
Period: June 2009 – May 2013
Budget: € 240.000
Funded by: Dura Vermeer, Search, Unica

RELATED PUBLICATIONS
• Dobbelsteen A, van den & Grinten, B van der; Cradle to cradle en de nieuwe stappenstrategie – nieuw elan voor de duurzame bouw; Duurzaam Bouwen, 2008, p. 1-29
• Timmeren A, van; Autonomie & Heteronomie – integratie en verduurzaming van essentiële stromen in de gebouwde omgeving; Eburon, Delft, 2006
• Braungart M. & McDonough W.; Cradle to Cradle – Voedsel = Voedsel (Remaking the way we make things); Search Knowledge/Scriptum, Heeswijk, 2007
Livable Carbon Neutral Cities

Systematic city planning approach and urban planning tools to transform to livable carbon neutral cities.

Cities and metropolitan regions are responsible for approximately 75% of the CO2 emissions. They play a big role in the global greenhouse gas emissions. This PhD research aims to contribute to the fight against global warming and help in energy security by providing cities a systematic urban approach to reach carbon neutrality and become independent from fossil energy and at the same time reinvent themselves into comfortable renewable cities.

There are few if any urban strategies to reduce CO₂ emissions. One of the problems is that there is no systematic urban planning approach for the transition from the existing cities to livable carbon neutral cities by 2050.

At the scale of a single building a lot of research has been done regarding energy, water and material use. Energy producing buildings have been built and are being built more and more. However, before 2005 energy and CO₂ have rarely been part of urban plans at a higher scale like neighbourhoods, districts, cities and regions. As such energy and CO₂ are much more abstract than classical themes in urban planning like infrastructure, public space and housing. CO₂ issues and energy principles need to be translated to spatial, urban principles to make energy and CO₂ a major theme in urban planning, projects and cities.

The aim is to develop an urban strategy and define principles and tools, which help existing cities transform into livable carbon neutral cities by 2050.

For this four Case Studies will be studied. The Innercity of Rotterdam, Stadshavens (portcity), Zuidplein and a suburb in Rotterdam. These studies will be compared nad combined with other research on greencity indexes, green labels and assessment tools for areas. They will be upscaled to the citylevel.

Practical result: With the gained knowledge, combined with existing approaches, a systematic approach to reach liveable carbon neutral cities will be built. This approach will provide insight into the effects of various planning choices concerning carbon neutrality. This method should be easy to understand and flexible in use. It should be a translation from CO₂ and energy goals into spatial urban rules and principles.

PROJECT INFORMATION
PhD candidate: Ir. Nico Tillie
Promoter: Prof. Dr. Ir. Andy van den Dobbelsteen
Promotie: Prof. Ir. Dirk Sijmons
Sponsor: City of Rotterdam and Rotterdam Climate Initiative
Period: May 2009 – May 2014

RELATED PUBLICATIONS
- Dobbelsteen, A. van den, Tillie, N., Conference paper, Fifth Urban Research Symposium of the Worldbank, Cities and Climate Change: Responding to an urgent agenda, Marseille, 28/6 – 1/7 2009.
- Tillie N., Dobbelsteen A. van den, Doepel D., Jager W. de, Joubert M. & Mayenburg D.; REAP – Rotterdam Energy Approach & Planning; Rotterdam Climate Initiative, Rotterdam, 2009 (English)
Living Envelopes

Biomimicry for adaptive building envelopes

The growing interest in biomimicry suggests that engineers are becoming increasingly aware that nature has much to offer in order to improve the way our systems function. Biomimicry already achieved and realized some of the advanced and efficient technologies in materials and products. However, it is still largely unrealized in the architectural design. This research focuses on applying biomimicry for the development of technologies for, lighting, ventilation and thermoregulation in building envelopes.

Nature presents an infinite source for research, has always inspired technology, and led to effective algorithms, methods, materials, processes, structures, tools, mechanisms, and systems. Living organisms have unique integration geometries and techniques that allow them to adapt to different environments. They can sense and react to local changes causing a global behavior.

We tend to design one function at a time, resulting in separate solutions for different tasks. The final product would be the assembly of the different parts together, but in this case the whole will be only the sum of its parts. Biomimicry in architecture could achieve and create buildings that function as systems and organisms or as their integration.

Our approach is not nature imitation, but the observation at their principles and methods, and the transformation and development of these principles to realize sophisticated technological solutions for adaptive building envelopes in terms of lighting, ventilation, and thermoregulation.

Ongoing exploration:
1) An adaptive shading system
As a result of the transformation of principles and methods used in plants for reacting to sun radiation, a shading system is being explored. The system has the ability to track the range of sun radiation throughout a day, and to adjust for different inclinations and distances from the envelope.
2) A breathing envelope
The Asconoide sponge, respiration systems, blood veins, and the skeleton and surface of a sea sponge are investigated for this case. We have designed a skin that reacts to changing conditions and influences the air pressure on the surface to perform a process of inhaling and exhaling. Such a system is an integral part of the building envelope, which functions as a protective layer too.
3) A thermo regulating envelope
Organisms based on their habitats and physiological characteristics adopt different strategies (active or passive), they perform thermoregulation by physiological, behavioural, or morphological means. Organisms succeed in maintaining an adequate balance between heat gain and heat loss without seeking air-tightness and water-tightness. Such adaptation solutions by organisms could be applied in buildings with similar challenges.

RESEARCH INFORMATION
Phd candidate: Lidia Badarnah
Period: December 2006 – April 2011

RELATED PUBLICATIONS
Making the Difference

Individual Thermal Comfort Demand Profiles for Dwellings

In addition to physical parameters, the temperature at which people feel comfortable changes with adaptation: adjustment (e.g. clothes), acclimatization (long term physiological reactions), habituation (long term behavioral reactions) and expectation. In dwellings people are considered in charge of their own environment and the comfort system should facilitate the occupant to control the temperature individually in time and place. This shifts the focus from an actual temperature to a range and variability of comfort temperatures likely to occur.

As civilization is advancing, the demand for thermal comfort is increasing. Technically, it is possible to provide any thermal environment requested. However, the greater the difference between offered outdoor climate and requested indoor climate, the more energy is required to supply and maintain this climate. In this respect it is essential to define the circumstances under which people feel comfortable, optimizing conditions for health and productivity while limiting energy consumption. The first theory on predicting the comfort temperature to be applied globally was Fangers’ physiological heat balance model of the human body, which calculates the temperature of thermal equilibrium between body and environment, regarding this to be the same as the comfort temperature.

However, various studies point out that, besides with the physical parameters, the temperature of thermal comfort changes with adaptation; adjustment, acclimatization, habituation and expectation. Research has found a clear relationship between comfort temperature and expectations of the occupant based on past experiences. A basic equation can be found, that relates the comfort temperature to a running mean outdoor temperature; \( T_c = a \cdot T_{rm} + b \). The constants \( a \) and \( b \) can be influenced by numerous aspects like gender, individual preferences, culture, behaviour and even building type. Theoretically, a different \( a \) and \( b \) value can even be found for each individual and by means of statistical regression analysis different average values for \( a \) and \( b \) can be found for each regarded population. However, in dwellings people are considered in charge of their own environment and they can control their setpoint temperature individually. The dwelling and the comfort system should facilitate the occupant to create his own environment. This shifts focus from an actual temperature to a range of temperatures likely to occur and the variability and bandwidth.

This research will explore the process of formulating different realistic occupant profiles for Dutch dwellings, based on statistical analysis of comfort surveys and time use surveys, consisting of a description of presence and comfort temperature range, varying over time and place. Together with weather profiles and availability profiles of renewable energy, to formulate new concepts of comfort delivery systems in dwellings, based on the notion of occupant control and (intelligent) systems that can optimize energy use and comfort delivery on demand.

**PROJECT INFORMATION**

- PhD researcher: Noortje Alders
- Supervisors: Hans Cauberg, Stanley Kurvers
- Period: January 2008 – January 2011
- Budget: € 240,000
- Funded by: SenterNovem

**RELATED PUBLICATIONS**

Material design

The effects of material design on adoption of new materials

Materials are used everywhere in daily life as well as industry and can be seen as “general purpose” technology. This type of technology is of interest because of its potential for value creation across a broad range of industries, including the world of building and construction. Within one industry a material innovation can start different product innovations. Unless the potential for value creation, advanced materials face high barriers to commercialisation. This research will investigate the roll of material properties in the adoption process of innovative materials. The main goal is to develop a methodical approach to determine the material properties that dominate the adoption of new materials.

Scope:
This research will be focused on materials used by product designers and processed by moulding technologies from the group of metals, polymers and ceramics.

Approach:
The first research question: What are the characteristics of adoption processes of new materials? will be investigated by doing literature study to technology diffusion and material properties.

The second question: What is the effect of material properties on adoption of new materials? will be answered by a comparative case study. The cases will be collected at advanced material companies like Corus or DSM.

Since there are many different parties involved in the material adoption process, one of the barriers for adoption is a lack of shared material knowledge. This results in the third research question: How does combining of material properties improve the insight and prediction of materials performance?

The above mentioned research output will give input to the development of a new material design method. This methodic approach will be tested by the development of Engineered Cementitious Composites (ECC). ECC is a class of ultra ductile fibre reinforced concrete. ECC most outstanding feature is its mechanical behaviour under tension. ECC behaves like a metal in a ductile way.

Figure 1: Adoption delay of new materials (Ashby, 2002)

Figure 2: Influence model of value creation for advanced materials (AM) (Maine, 2006)
Rapid Prototyping in Architecture

PhD research about the influence of Additive Layered Fabrication Processes on building technology and architecture

Rapid Prototyping technologies change the way of developing from “design for production” to “design for function”. The technology enables integrated functions and free-form shapes of any kind to be implemented into architecture in any aspect. The PhD research deals with the latest developments in the technology and transfers this to real applications.

Additive Layered Manufacturing Technologies (ALM) are unique, as they generate physical models directly from 3D data by adding material layer by layer, without the use of any extra tooling or molding.

In the beginning, the only purpose for the invention was to manufacture prototypes from 3D data in a (relatively) short period of time - compared to standard tooling time for industrial design models.

Development moved on, so today there are different fields of applications: prototyping, tooling and manufacturing.

During the last 25 years, over twenty different kinds of processes have been developed. Some have already ceased to exist, others just start to develop their full range of usage. All have in common the great potential they bear for specific applications in e.g. aerospace, automotive-industry and medical-application.

Rapid Prototyping (RP) and, in further progress, Rapid Manufacturing (RM) are becoming more and more popular in applications for end-use-products. Still, most companies use ALM mostly for prototyping (fit and assembly, design studies, display models) or pre-cast-modeling and not for real end-use-application. But end-use-application is the range of application where it is heading. Therefore, it is important to find suitable applications for the technology in design, building construction and architecture.

For building construction and architecture ALM has not been applied yet. “Printed” parts are not used in architecture except as visual aids, such as display models. With the improvement of CAAD software and the development of the ALM technologies the influence of it on today’s architecture and building construction is a subject that must be considered by the future planer and architect.

As the technologies and materials have developed since their invention, also ideas and applications for building construction and architecture appear. Therefore, the aspects of how future building construction and architecture in combination with the Additive Layered Manufacturing Technologies could work and how they could be designed will be researched with this PhD work.

PROJECT INFORMATION
PhD researcher: Dipl.Ing. Holger Strauss
Mentor: Prof. Dr.Ing. Ulrich Knaack, TU Delft
Project time: September 2008 – September 2012

RELATED PUBLICATIONS
• Imagine 04 - RAPIDS; Uitgever: Knaack, Klein, Bilow; 010 publishers, Rotterdam, 2010
• An Industrial Approach towards the use of layered fabrication for building construction and architecture; paper in: facade2009, conference volume; editors: Potgiesser, Knaack, Strauss; Detmold, Germany, November 2009
• Funktionales Konstruieren; Holger Strauss; Hochschule OWL, Detmold, Germany, 2008
Re-Face

Refurbishment Strategies for the Technical Improvement of Office Facades
Dissertation Thiemo Ebbert

This thesis rediscovers the knowledge bolder buildings in general and their façade constructions in particular. It develops a typology that demonstrates the variety and distribution of the existing façades and their individual challenges. The intensive assessment of representative case studies has resulted in a set of very promising refurbishment strategies, tested on building structural level as well as on detail level.

Two thirds of all office real estate in Europe is older than 30 years. Practice has shown that at this age the façades and climate installations of a building do no longer fulfil demands and are responsible for an extraordinary high energy consumption. This thesis evaluates existing façade types and develops refurbishment strategies that can be applied with minimal intervention.

First, it evaluates the existing stock of office façades in Western Europe. It defines the typical office façades and sorts them into 22 categories, which are characterised by structural features and similar refurbishment challenges. With this typology at hand, the distribution of these office façades is evaluated in different locations in the Netherlands, the United Kingdom, and in Germany.

The following step generates appropriate evaluation tools covering the measurable and “soft” features of the special task of refurbishment. The central part of the research lies in intensively assessing seven case studies that can stand representative for the most common façade types. In these studies, the typical problems of each façade typology come to light. For each case, different refurbishment concepts are developed and evaluated in terms of architecture, function, comfort, investment, material consumption, and energy saving potential.

The case studies results in a matrix, which presents the features of each refurbishment concept and relates the concepts to the different existing types of façades. Thus, it will be of use for architects and specialist consultants in the early planning stage to clarify the building task and to identify the most promising refurbishment concepts.

PROJECT INFORMATION
Project leader: Thiemo Ebbert
Executed by: Thiemo Ebbert
Defence: 15. February 2010

RELATED PUBLICATIONS (selection)
Residential building E-no-vation

Façade refurbishment strategies for technical improvement and energy efficiency of multi-residential buildings

In the context of climate change and the need to decarbonize the residential building sector, the real challenge is to properly retrofit existing buildings in a manner that will use minimum energy, produce minimum air pollution as a result of the building operating systems, all with acceptable investment and operating costs, while improving the indoor environment for comfort and health. The research aims to investigate effective refurbishment strategies to technically improve the façade and the performance of the aging residential buildings.

The existing buildings stock in European countries accounts for about 40% of final energy consumption in the European Union member states. The subject of the research is the residential building stock as the residential use accounts for 2/3 of the energy consumption in the buildings sector. Moreover, residential buildings amount to almost 70% of the building floor area and consequently the importance on its condition and the impact it has is considerable.

The existing residential stock exceeds the number of newly built dwellings by far. While new buildings add about 1% a year to the existing stock, the other 99% are already built and produce 27% of all carbon emissions. Regarding materials and waste, studies show that the environmental impact of life cycle extension is definitely lower than demolition and new construction.

The attention should therefore be more focused on existing buildings. It is clear that far more energy conservation and other sustainable benefits can be reached in the existing building stock than in newly built buildings.

The focus of the research will be on the multi-storey residential buildings of the post-war period, namely constructed in the years 1945-1975 after World War II and before the oil crisis. This particular part accounting for 29% of the stock, is a particularly salient issue in this regard as their poor energy efficiency is regarded as a “moderate” to “major” problem by 18 out of 27 housing ministries who responded to a Europe-wide survey.

The methodology will be based on case-study buildings. Multi-residential buildings of the post-war period in need for refurbishment will be selected and analyzed. Subsequently a number of different strategies will be proposed, designed and calculated in detail and finally compared and evaluated.

The result of the research will be a tool to provide answers to refurbishment as a design question. The outcome will be an impact decision instrument that will support designers and stakeholders through the refurbishment development process.

RESEARCH INFORMATION
PhD researcher: Thaleia Konstantinou
Promotor: Prof. Dr. Ing. Ulrich Knaack
Co-promotor: ir. Arjan van Timmeren
Period: Sept 2009 – Sept 2013
Chair: Design of Construction

RELATED PUBLICATIONS
- Eibert, T., Re-Face: Refurbishment Strategies for the Technical Improvement of Office Façades, TU Delft, 2010
Smart Composites

The realization of adaptable architecture with the use of smart materials

This research focuses on the fabrication, characterization, design and performance of smart materials in architectural components to generate adaptable building environments. Smart materials have shown significant advances over the past years in many researches and applications. In this research the realization of an adaptive architectural component is the main focus, of which the shape can be deformed for functional purposes.

Smart materials have the characteristic to change their performance under the influence of external stimuli. This means that these materials have both actuation and sensory properties. An example can be given of Shape Memory Alloy, which has a low Young modulus and tensile strength at low temperatures, which means that the material can easily be deformed. When heating above a transition temperature, the material will change to a stiffer (austenite) phase. When deformed in its weak (martensite) phase, the material changes to its initial shape upon heating. As the material can recover under constrain, the material can be used as an actuator to deform other materials. The material performs due to changed material properties.

In combination with Shape Memory Polymer (SMP), Shape Memory Alloy (SMA) has the possibility to act as a smart composite by deformation. SMP becomes rubbery above its glass transition temperature, and can be transformed easily. By cooling the matrix the deformation will be fixated, constant energy input is unnecessary. By heating again the material will recover. However, SMP can only recover itself.

The main goal is to generate a strip material which can deform upon activation and fixate this deformation. Next to that the material should be able to return back to its original shape. Different design concepts show the application of the principle; it can be scaled up to furniture level (figure 2) or on a smaller scale to façade tessellation for ventilation and/or sun shading properties (figure 3).

Torsion tests on the deforming moment of SMP and the actuation moment of SMA, show promising results (figure 4). Further research on adaptable architecture and smart materials and the assemblage of a working prototype will show the feasibility of advanced material application in architecture.

PROJECT INFORMATION

RELATED PUBLICATIONS
- Poelman, WA, C.MJ.L. Lelieveld; From nano to macro : application of dynamic materials in architecture, IAASS Conference, Venice 2007
SREX: Synergy of Regional Planning and Exergy

SREX is a 4-year research program started in 2006, it is financed by Agentschap NL and part of EOS-LT (Energy Research Strategy - Long Term). It is an interdisciplinary research project conducted by researchers of the universities of Delft, Wageningen and Groningen, the Hogeschool Zuyd and of TNO. SREX stands for Synergy of Regional planning and Exergy and the project goal is to develop a model for spatial planners to design more optimal energy systems based on the exergy principle; the optimal use of (the regional) energy potentials.

With an exergetic system for a region, a more sustainable energy system is referred to, which is based on using energy in a more effective, cascaded way. Nowadays the focus mainly is on using it efficiently only for each different function. The scheme visualizes a sustainable low-ex system in which residual energy flows of one function are used for the next.

SREX uses 2 regions in the Netherlands as a case study for the exergetic model to be developed: South Limburg and South-east Drenthe. Underneath, the model will be described, how to come to integrated energy visions.

The 5-step strategy towards future energy visions

1. Identification and mapping of present conditions of the region (spatial structure and energy system, incl. renewables)
2. Mapping of near-future changes
3. Development of 4 different possible far-future scenarios
4. Composing different energy visions for the scenarios; As input for these energy visions, expert meetings are used to generate ideas for the region in question.
5. Composing the final energy vision with the robust strategies. With a comparative analysis and exergetic calculations, these strategies are identified out of all possible energy-conscious interventions of the different energy visions. They appear in most visions and are therefore less sensible for future uncertainties.

The table above shows the most robust strategies for the South-east Drenthe case. With these the final energy visions have been made for 2040 and by means of back-casting for 2020. The map underneath shows the integrated energy vision for 2040.

**Integrated energy vision 2040**

The table above shows the most robust strategies for the South-east Drenthe case. With these the final energy visions have been made for 2040 and by means of back-casting for 2020. The map underneath shows the integrated energy vision for 2040.
The Climate Adaptive Skin
Creating autonomous climate control using the environment

The Climate Adaptive Skin (CAS) is a façade concept that aims to create a comfortable indoor office climate while consuming as little primary energy as possible. By integrating building services into the façade itself at office-room scale, the office adjacent to the façade is made independent of centralised HVAC systems and the indoor environment becomes optimally adjustable by the user, increasing comfort perception and reducing energy consumption in case of absence.

Research has been carried out in search of a façade concept that is able to condition an office space autonomously using mostly passive technologies. To validate the concept, a simulation model is developed which in turn is validated using two test units and a climate chamber.

The simulation model suggests that it is possible to create a comfortable indoor environment throughout the year using the Climate Adaptive Skin concept, as long some extra heating is provided in the cold season. The heating can be provided in different ways, e.g. through heating of the PCM plates to stay within the concept of autonomous operation, or alternatively e.g. through floor heating. Application of the concept, including the ventilation unit, means that no centralised climate control is needed for cooling or ventilation.

If photovoltaic panels are fitted to the façade to power the fans that drive the ventilation, the façade is in theory able to ventilate and cool the adjacent office autonomously and energy neutrally over the year, with the fans for ventilation being the only moving parts.

Tests performed on ventilation units that are similar to those simulated display results that are close to what can be expected based on the simulations; the tests indicate that the ventilation unit is able to condition ventilation air as intended.

With the validated simulation model the behaviour of the Climate Adaptive Skin in real life situations can be predicted. Building and testing a full-scale fully functional prototype is the next step before market introduction.

Schematic representation of the CAS concept in an office
Test ventilation units in the climate chamber during testing
The Sustainable Office

An exploration of the potential for factor 20 environmental improvement of office accommodation

The factor 20 improvement of environmental metabolism, needed for sustainable development as deduced by Speth [1989] and Ehrlich & Ehrlich [1990] was often regarded as a metaphor for the immense changes needed, but in this PhD research it was taken as the objective for improvement of office accommodation. Starting with the building design and technology, the project ended with new concepts of flexibility, space use and the organisation of work. On the way there new methods for environmental assessment were developed and tested.

As a starting-point for this project, twelve government offices were assessed, which revealed that the average environmental improvement so far was not more than 1.2-1.4, lagging behind the intended goals. In order to make a great leap of improvement, effectiveness is key.

**Effectiveness = Significance x Improvement**

Reckoning with a lifespan of 75 years, almost 80% of the environmental load in offices is caused by the use of energy during operation. Hence, the use of renewable energy sources is most effective. Comprising 60% of the environmental load of building materials the supporting structure’s sustainable design is also significant. Further studies demonstrated that in the building design improvement may be achieved through optimal building geometries, related to the net floor requirements.

Studying lifespan scenarios showed that the current way of building should be altered to new flexible monumentalism or short-cyclic demountability: these would lead to improvement by a factor of 3.

Improving the use of space was a next aim, showing the importance of office layouts more open than the common Dutch cellular plan. On a broader scale, intensive an multiple use of space in an urban setting could add up to 50% environmental improvement, regardless of the building design.

Although tested at the end, the organisation of office work should be the start for sustainable offices, which need not be buildings in the traditional sense, as proposed in the thesis and potentially leading to factor 2 improvement at the start.

Applying all effective solutions, environmental improvement by a factor of 50 turned out to be possible.
Uncertainty Analysis
Probabilistic Method for Assessment of Ventilation System in Dwellings

The performances of many ventilation systems under practical condition give a low compliance rate to the assessed performances. This problem is partly due to the inaccuracy and limitation of the assessment method, which may be caused by the uncertainties existing in the assessment process. It is expected to improve current assessment method by inputting more factors which will influence the performance of a ventilation system and addressing the influence of the uncertainties in the assessment process.

The uncertainties existing in mainly in two aspects: the uncertainties inside the ventilation system (ventilation provisions, building properties, occupants and outdoor environment) & the assessment method itself (focusing points and assumptions).

Problem Definition:
Though it is well known that the uncertainties do exist in the parameters included in the assessment process of ventilation systems, but the influences of such uncertainties on the results and which parameters are most influential are not known yet.

Research questions:
What should be the content of an assessment method to ensure good working, comfortable and sustainable ventilation systems in dwellings? What are the influences of the uncertainties for the addressed goals or qualities of ventilation systems on the results and which parameters are most influential?

Objective:
The main aim is to establish an assessment method based on the probabilistic approach which can be used for assessment of different ventilation systems in dwellings.

Research method:
The main research approach is to use the probabilistic approach, combining with the deterministic approach which is mainly used in assessment of ventilation systems in dwellings.
URBAN BUILDING DESIGN [1/2]

passive solar design – where urban and building design meet

Urban layout has a significant impact on the outdoor microclimate in the city. The urban fabric can limit solar access, but also has the ability to store and trap heat. This may lead to uncomfortable or even unhealthy situations outdoors. The indoor thermal environment can be controlled independent of dynamic outdoor conditions. However, this is undesirable from a comfortable and sustainable point of view. It is therefore preferable to find passive building strategies to support a comfortable thermal environment outdoors as well as indoors.

In temperate climates, buildings facing south are preferable, as they yield the largest solar gain in the heating season and the smallest in summer. However, south facing row houses imply east-west running streets, which have larger street irradiance in summer – possibly leading to heat stress - and a smaller street irradiance in winter compared to north-south running streets. In addition to orientation, the height to width ratio of streets is also of great importance since it defines the obstruction angle; buildings may cast shadows on the street or on the opposite building facade with as result reduced solar gains.

Conclusions

Larger transparent openings and improved insulation are evidently beneficial to the contribution of solar gains in meeting residential heat demand in the Netherlands. So are south facing windows (in the Northern Hemisphere).

In order to benefit from the heating potential of the sun in an urban environment, shadows cast by neighbouring objects should be kept to a minimum. From this point of view, shed roof design proofs to be beneficial over gable and flat roofs when it comes to solar exposure of lower floor levels. The advantage of shed roof design is most evident at smaller street widths (10 m and 15 m). The impact of roof design becomes of less importance at larger street widths (from 25 m).

Windows at the top floor of a building are less obstructed by identically shaped buildings in their surroundings. Therefore they collect solar radiation, even at lower sun angles in winter. This makes such windows beneficial in a passive solar heating strategy.

PROJECT INFORMATION

Project leader: Remco Looman & Marjolein van Esch
Executed by: Remco Looman & Marjolein van Esch
Period: 2010+

RELATED PUBLICATIONS

Passive solar design – where urban and building design meet

Urban layout has a significant impact on the outdoor microclimate in the city. The urban fabric can limit solar access, but also has the ability to store and trap heat. This may lead to uncomfortable or even unhealthy situations outdoors. The indoor thermal environment can be controlled independent of dynamic outdoor conditions. However, this is undesirable from a comfortable and sustainable point of view. It is therefore preferable to find passive building strategies to support a comfortable thermal environment outdoors as well as indoors.

A series of street canyons is studied on their solar access. The influence of street width, orientation, as well as roof shape of the adjoining dwellings on the percentage of directly irradiated street surface is determined with the help of simple trigonometry (see figure 2).

Conclusions

The orientation of a street evidently has a great influence on its solar access. North-south running streets have the benefit of being directly irradiated in winter. Even on the shortest day of the year the street surface is completely irradiated around noon, when the sun has unobstructed access to the street. In summer, however, this may lead to uncomfortable or unhealthy situations, as there is practically no shade during the hottest hours of the day. Shade may be provided by (deciduous) trees.

East-west running streets yield large percentages of directly irradiated street surfaces in the morning and afternoon in summer- leading to a prolonged period of warming of surfaces and air - but provide some shade for comfort during the hottest hours of the day. Again, extra shade could be provided by trees or other solar controls. East-west running streets also have the benefit of constant direct irradiation (and shade) in spring and fall. In winter, north-south running streets get little sun.

For both orientations, the effects roof shape and street width are most prominent for lower solar angles; in the colder months (except for December in case of the north-south running street), and in the early morning and late afternoon.

Fig. 1 Roof shapes

![Diagram of roof shapes]

Fig.2 Threshold angles and lengths; section through the canyon in a plane parallel to azimuth $j$ (above), and top view of an east-west running canyon (below).

![Diagram of threshold angles and lengths]

### Project Information
- **Project leader:** Marjolein van Esch & Remco Looman
- **Executed by:** Marjolein van Esch & Remco Looman
- **Period:** 2010+

### Related Publications
VIP A B C
Vacuum insulation panels applied in building constructions

A Vacuum Insulation Panel is an innovative thermal insulator which has recently caught the attention of the building sector. Since VIPs have properties different from traditional insulators, they have been subjected to scientific inquiry in a doctoral research project. The aim of this study was to develop tools and methods for specifying their performance and to show how they can be meticulously integrated in buildings. On 1 February 2010 the resulting dissertation was successfully defended in front of the doctoral examination committee.

To achieve a sustainable future, it is desired to reduce greenhouse gas emissions drastically. One contributor to these emissions is the burning of fossil fuels for generating power and electricity to be used in and for buildings. Buildings are responsible for about 40% of the primary energy consumption in the European Union. More than half of this energy is applied for heating systems in dwellings and commercial buildings. Increasing the insulation value of the envelope of buildings may contribute to a reduction of primary energy use. Two strategies can be followed. The first is to increase the thickness of the thermal insulation layer. If, however, Passivhaus standard is applied, the thickness of this insulation layer would increase to beyond 30 cm, resulting in very thick facades. The second, more innovative, strategy would be the application of more effective thermal insulators. One type of effective thermal insulator is a vacuum insulation panel, or VIP.

A VIP consists of an open-celled core material which is evacuated and then tightly sealed into a barrier envelope to maintain this vacuum. This vacuum reduces the thermal conductivity of the product significantly making it a very promising material for future use in buildings. However, integration into buildings must be performed very meticulously for several reasons; first, due to its nature a VIP cannot be processed on site and needs careful planning in advance; second, it is very sensitive to mechanical damage; third, thermal bridges along the panel’s edges reduce its performance; and fourth, the composite system is highly subjected to aging. This doctoral research therefore looked into many of these aspects, presented several calculation tools and showed how VIPs can be applied in façade panels and EPS insulation boards. With the wide-spread proliferation of VIPs in buildings a more sustainable and healthy environment can then be achieved.
BUILT ENVIRONMENT & E-MOBILITY
Integration of electric mobility for renewable energy strategies

The scenario development study is part of a research project executed by researchers of the TUD and the Schiphol Group, called ‘DIEMIGO’, and is part of TRANSUMO, a Dutch National research program to initiate and support a transition to a sustainable mobility system. Its main focus, large scale implementation of charging station infrastructure for e-mobility and interfaces with buildings and urban planning has hardly been addressed. It also focuses on integration of charging (stations) in terms of design, grid implications, location choices, and public use aspects.

Research goals
Main objectives: to develop a preliminary methodology to select and design effective solutions for the implementation of large scale electric mobility and electric charging infrastructure into the built environment; and to develop and design a scenario for ‘the Grounds’ location at Schiphol (including electric mobility solutions, charging interfaces, power grid, urban design implications, and location choice).

Research outcome
The research shows opportunities as for development of the Schiphol ‘the Grounds’ location to include sustainability based EV integration in the Built Environment including introduction of chain mobility with new public transportation connections and improved EV integration with attached renewable energy supply. Furthermore, improvements as for outdoor climate and comfort and self-sufficiency aiming strategies based on decentralization with compact clustering and additional opportunities for urban comfort at larger scales, EV charging with integrated renewable sources and smart use and exchange of V2G (vehicle to grid) and G2V (grid to vehicle) for both economical and sustainable backup. In the latter, EV batteries are used as ancillary storage for the electricity network and become a part of Schiphol’s sustainable energy system. The EVs are connected to the grid by means of a bi-directional charging device and can be used by Schiphol for ‘peak shaving’ of renewable energy generation and in times of peak demand.

Outlook
The electricity grid network must cope with an increasing number of decentralized electricity producers supplying various amounts of electricity to the national grid network. The integration of these decentralized producers demands that the electrical grid be restructured. This provides the unique opportunity to take strategic measures.

PROJECT INFORMATION

TUD Faculties involved: Faculty of Architecture, Faculty of Electrical Engineering, Mathematics and Computer Sciences, Faculty of Industrial Design Engineering, Applied Ergonomics and Design, Faculty of Technology, Policy and Management, Faculty of Mechanical, Maritime and Materials Engineering, Valorisation Centre.

RELATED PUBLICATIONS (DIEMIGO Project finished in November 2009; Press release April 2010; Publications post 2009)
Involved researchers: Pavel Bauer (EWI), Satish Kumar Beella (Ide), Siebe Broersma (A), Carlos Castillo Cortes (A), Stephan van Dijk (3ME), Jeremy Doppler (EWI), Chandler Elizabeth Hatton (Ide), Kas Hemmes (TPM), Frank van der Hoeven (A), Jessica Abad Kelly (Ide), Peter van Kouwen (TPM), Marin Licina (Ide), Gregorio Muraca (Ide), Jaco Quist (TPM), Paul de Ruitter (A), Sacha Silvester (Ide), Stefan van der Spek (A), Neil Stembridge (EWI), Koen Terra (TPM), Arjan van Timmeren (A), Anne-Lorene Brigitte (TPM), Helene Vernay (TPM), Yi Zhou (EWI).

Funding by TRANSUMO (100k€) and Schiphol Group (100k€).

The DIEMIGO research will have follow up research projects in 2010/2011.
Carbon Fiber Reinforced Composites

The first generation of shells in the 1960-ies were made of thin single reinforced concrete with pure mathematical forms. The new generation of sandwich shells has an arbitrary form and requires a set-up with higher bending rigidity due to expected loads and unfavorable forms and support points. Carbon fiber reinforced composites are expensive for the building industry, but by transfer and adaptation of technology from aeronautics and yacht building the technology could be imported to the building industry.

Goal
Develop an appropriate stressed skin sandwich principle in carbon fiber reinforced epoxy composites for continuously curved free form shell structures inclusive the chemical composition and reinforcements, structural behavior, structural analysis methods, CAD/CAM engineering, molding production methods, on site assembly, connections and erections.

Strategy
Departing from desired shell forms in architectural designs, the appropriate technology of vacuum injection and oven curing will be transferred from the yacht and airplane fuselage industry to the building industry, where the characteristic is one-off segments that assembled together form mega surfaces which have to be working in a structural way to make large spans between 6 to 50 m. An economical adaptation in the chemical composition of resins and reinforcements, CAD/CAM processing, transport sizing of segments, structural jointing technique and on site finishing has to be developed in principle and prototypes have to be made to investigate the solidity of the hypotheses.

Expected Results
A structural, architectonical and industrial vocabulary of sandwich shells made of carbon fiber reinforced epoxy in novel material designs of economical chemical compositions of resins and reinforcements for free form design as a guide to designing & engineering, to production and installations.

Proposal design drawings by Octatube of the carbon fiber shell structure for the Mediateque of Pau, France, as designed by architect Zaha Hadid, London.
Ceramic dodecahedron sculpture

Structural assessment and solution for assembling and jointing a Dodecahedron sculpture made of single Terracotta elements.

The dream. A sign in the air like a tattoo - A cutwork dome of which it is unclear whether it’s hanging or floating. Decoration of earthy ceramics pushed apart by colorful crystals. Eastern ornamentation with Western structure.

The commission to research possible solutions for realizing a terracotta sculpture is based on pentakis dodecahedron geometry. The artist Christine Jetten and the architect Joris Molenaar were developing this sculpture related to their earlier studies on façade elements for residential buildings.

The work includes the structural analysis but also solving the assembly sequence while simultaneously being able to disassemble the sculpture completely. Solutions for the jointing became therefore the main design focus.

The pentakis dodecahedron consists of 60 equilateral triangles which have in this case an edge length of 1,32m, adding up to a sculpture with a diameter of around 4 meters. The 60 triangles are further subdivided into 3 triangle terracotta frames which make up the sculpture. This chosen basic geometry and the decision to place the connectors between the triangle’s edges rather than on the tips limited the variations and complexity of the joints and simultaneously complied with the architects and artist wish for the least as possible joints.

This resulted in having two different connector types in total. A manifold of geometric, material and jointing solutions between the connectors and the terra cotta elements were looked at.

The most promising and further investigated options were holes drilled into the 6x6cm front side and fixing bolts or internal threads with adhesive anchors to the hollow core steel connectors.

After the production of the initial prototypes of the terracotta frames at Boston Valley Terra Cotta in the US further prototypes for the hollow core connectors will be done in the Netherlands. Further will the proposed construction be tested if it fulfils requirements concerning shear, tension and bending forces within the terra cotta elements as well as the bolts fixing the connectors.

Related publications:

- Final research report, Delft 2009
- Teuffel Patrick, Heinzelmann Florian; “Ceramic dodecahedron sculpture”; proceedings IASS symposium 2010 in Shanghai, 2010 (to be published November 2010)
Comfort in BK-City
Investigation of the indoor climate of BK-City

After the fire of May 13th 2008, the Faculty of Architecture was accommodated in Tents and after a few months in the refurbished building on the Julianalaan. Several Master-students Research and Design investigated the indoor comfort in both the tents and the new building. Special study was made of Thermal comfort, Acoustics and Lighting.

The tents were a good temporary solution. It offered students and other personnel within a very short time a place to work after the tragedy of the fire. The indoor climate in a tent is, in general, not suitable for office work. The climate system was not able to generate a comfortable thermal indoor climate without constant readjustment. The cooling capacity in summer was also too small. It was, luckily, a bad summer.

Research of the Julianalaan building showed that the indoor comfort had room for improvement. The research helped facility management in realizing their improvements.

** RELATED PUBLICATIONS **
- MSc reports AR3B300
- NVBV artikel 2009

** PROJECT INFORMATION **
Project leader: Regina Bokel
Executed by: MSc Students Kevin, Modest, Dennis, Lies and Bert
Period: Sept 2008 – January 2010
Concept House Prototype

Energy producing plug & play apartment blocks

Project Concept House Prototype aims on developing innovations for the building industry in cooperation with a variety of market parties. The innovation focus is twofold: aiming on the industrialisation of the building process and on the development of customized apartment blocks conform extremely high sustainability standards. The resulting construction system should set a national example of efficient sustainable building practice.

The definite concept will be developed in a period of three years, according to increasingly high demands to its performance. The project is executed by a team with members of both industrial and academic background. An important aspect of the development process is the construction of prototypes, which sets collective goals to concrete results that can be both tested and experienced.

Within the context of project Concept House Prototype, sustainability concerns the footprint of production and end-of-life cycles as well as during inhabitation. Components are designed for disassembly and recycling, and are preferably based on ‘green’ materials as wood an ceramics.

A special feature in the system design is the integration of all installation components in the prefabricated bathroom unit, so that the contemporary apartment blocks can be equipped with a complex installation without concessions to building speed, quality control or flexibility.

Architects and development companies can apply the building system in the construction of a wide variety of high quality apartment blocks, with floor plans ranging from 65 to 125 m², in a variety of lay-outs and architectural compositions – and sustainable by definition.

RELATED PUBLICATIONS

- [www.concepthouse.bk.tudelft.nl](http://www.concepthouse.bk.tudelft.nl)

PROJECT INFORMATION

Project leader: Mick Eekhout
Executed by: Thijs Asselbergs, Mick Eekhout, Jaap van Kemenade, Arjan van Timmeren, Joris Veerman
Period: April 2009 – May 2010
Budget: € 90.000 in 2009
Funded by: industrial partners
Daylight and Outside View
Assessment of daylight and view quality through a scale model of an office room

The research aims to understand how both daylight and outside view influence visual comfort of workplaces. Past researches indicated that there is a correlation between the assessment of daylight and view quality. To investigate what specific aspects on daylight and outside view contribute to the visual comfort, a comparison between measurements and subjective perception is necessary.

Introduction
The research combines knowledge from two research fields, namely building physics and environmental psychology. It tries to relate objective and subjective measures of visual quality.

Objective of the study
1. Develop a research method to investigate simultaneously the impact of daylight and outside view on the visual perception.
2. To verify whether indoor architectural parameters influence both outside view and daylight perception.
3. Establish a list of the most important parameters influencing visual comfort in order to simplify future full scale studies.

General questions
What makes a view a good view? When will people be satisfied about the daylight access? Are people more satisfied with daylight if there is a good view?

Method
A scale model of an office at scale 1:5 was built. It is placed at two different location inside the Faculty of Architecture of the TU Delft.
Seven different facades were made in order to verify whether window design affects visual perception. On every location the light conditions in the model and the window view can be measured (luminance camera and lux meter) and analysed (projection method). Furthermore students and other subjects will be asked to assess the lighting in the room, the window view and the overall perception.

Questionnaire / Qualification
1. Personal information
2. Overall perception:
   Global comfort, comfort for work, MAGNITUDE WINDOW
3. Outside view quality:
   Attractive / Repulsive, bright / dark, diverse / monotonous...
4. Daylight quality:
   light level, light distribution, glare discomfort

Measurements / Quantification
- Aperture, gitter, size, distance, most preferred element in a view
- Perception of color, size, position and area of windows
- Brightness, detail, coherence, contrast, content
- Daylight factor, gradation of light, luminance ratio

Sample of specific hypothesis to test
How does the assessment of outside view influence the assessment of daylight? Does light distribution affect perception of detail of the outside view? Does window position influence the perception of the light level? Is the best window configuration the one which provides the most information of the outside view?
Deflateables
Low pressure concepts in building technology

The inherent force of air-pressure can be used as an integrated element in the structural system of facades. Considering this enormous potential, methods are developed to take advantage of this principle. The benefit lies in the light weight and the potential of high insulation.

What a deflated construction basically needs is an envelope, an inner spacing structure and vacuum. Whereas today, pneumatic structures are widely applied, deflated structures are rather unusual in building construction. Their disadvantage lies in the sufficiently high, but in comparison lower strength, limited to the pre-tensioning force of outside air-pressure. The advantage is a potentially higher insulation value and the possibility to “freeze” structures in a pre-defined shape.

Numerous mock-ups have been built to explore the field. Different foil and spacer combinations have been tested. Facades with cardboard spacing frames have been designed. To test structural calculations, a 10m spanning bridge has been erected in Delft on several occasions, such as the “Design in Delft” event 2008.

The range of possible applications is broad. Currently, they are used for interior design and furniture and temporary structures or moulding systems. The rapid development in membrane and foil technologies provides a positive outlook for deflateables, such as free form structures.

The project was conducted by professional research staff, and is linked to the master program of TU Delft, Detmolder Schule (D) and Hochschule Frankfurt (D). Westdeutscher Rundfunk (WDR) chose the deflated bridge to be broadcasted in “Die Sendung mit der Maus, Sachgeschichten”; a famous program that focuses on bringing technology to children.

PROJECT INFORMATION
Project leader: Tillmann Klein; Marcel Bilow
Executed by: Tillmann Klein, Marcel Bilow, Raymond van Sabben, Andrew Borgart, Wouter Blondeel, MSc students
Period: 2006-2008

RELATED PUBLICATIONS
- Knaack, Klein & Bilow; Imagine 02 deflateables, 010 Publisher, Rotterdam, 2008
Façade Research Group
Development of future research topics

The goal of the Façade Research Group is to improve the performance of the building envelope as a part of the entire building and to enhance the possibilities for architectural design by exploring new strategies, design tools, construction and production possibilities.

Ongoing PhD research:

**Design Tools/Methods**
CROFT Climate related Optimized Building Envelopes - Marcel Bilow
Holistic Energy Assessment Tool - Linda Hildebrand

**Façade Construction**
Integrated Façade Components – Tillmann Klein
Biomimicry for High Performance Building Envelopes - Lidia Badahnah

**Production / Assembly**
Free-Form Cladding Manufacturing - Daan Rietbergen
Rapid Architecture, Rapid Manufacturing for Building Envelopes - Holger Strauss

**Strategies/Application**
Refurbishment Strategies for Technical Improvement of Office Facades - Thiem Ebbert
Refurbishment Strategies for Large Scale Housing - Thaleia Konstantinou

The building envelope is largely responsible for the energy use of a building and the user comfort. It integrally needs to become attuned to the other building components such as the primary structure and building services. Three topics will have a major impact on future façade construction: first, the building’s energy use and its embodied energy, secondly the integration of new components and materials, mainly with the purpose to reduce constructional complexity. Finally, the building envelope will become more adaptive to react on changing exterior conditions and interior needs.
DUTCH BLOB TECHNOLOGY
Developing an adjustable mould for freely curved panels

An adjustable mould that was developed in an earlier stage, is now being scaled up to function in a new advanced furnace. The bending process, based on a patent held by the TU Delft, will not only make freely curved facades possible, but also affordable. The making of moulds for other materials, like for concrete and composites, is facilitated by the developed technology. The project is supported by a STW-Valorisation Grant Phase 2.

Architecture increasingly features freely curving facades. Until recently, these were only feasible with flat-, not with curved glass panels.

In 2001 the Blob Group was founded by Professor Eekhout of the Chair of Product Development. It combined all the Chairs of the Building Technology department, to materialise the new architecture that became feasible by the introduction of CAD-CAM technologies. The Blob Group in time developed into the new Chair of Architectural Engineering. The Blob Façade Group, works on materialising freely curved facades. The team members come from the Chair of Product Development and the Chair Design of Construction.

Current production facilities will by the new technology be highly optimized as to labour-, material- and energy saving, and the designed furnace will have an increased output.

With our new production process, we make freely curved panes possible and affordable. They will be applied in prestigious offices, but also in houses, with for example small cupolas or bay windows.

The panes are marketed and co-produced by Free-D Glass, a spin-off of TU Delft and Tetterode Glas Voorthuizen.

PROJECT INFORMATION
Project leader: Dr Ir Karel Vollers
Executed by: Karel Vollers (Chair of Product Development), Daan Reitbergen (Chair of Design of Construction)
Period: Jan 2010 – Jan 2012
Budget: € 200.000
Funded by: SenterNovem

RELATED PUBLICATIONS
- Development of sustainable moulds as a necessity to improve production sustainability of freely doublecurved glass, Proceedings of Bologna Delft seminar, November 2005
- Upgrading building appearances by improved reflections on glass panes Glass Processing Days June 2007, Tampere, Finland
Energy Saving Energy Supplier

Feasibility studies on the refurbishment potentials of two properties for Energie Baden-Wurttemberg (EnBW), Energy Supplier, Germany

EnBW is one of the largest energy suppliers in Germany. The PhD research “Re-Face” analysed two of their administration buildings on the potentials for façade refurbishment.

EnBW head office, Stuttgart, Germany

The former head office in the city centre of Stuttgart requires a new function. The feasibility study evaluates how retrofitting the façade can contribute to the improvement of the exterior impression, the flexibility of use, and the improvement of indoor comfort. The proposals combine the building envelope with different HVAC concepts, and evaluate energy saving, life-cycle costs, and building process.

EnBW administration building, Esslingen, Germany

First, the condition of the existing façade was examined. Under consideration of possible combinations with innovative building services, four façade concepts were developed that optimize the existing structure in building physical performance and energy requirements. The case study has proven the flexibility of a modular façade structure and ventilated cladding. Finally, the best cost performance could be achieved by replacing the windows, additional insulation, and re-coating the cladding.

PROJECT INFORMATION
Project leader: Thiemo Ebbert
Executed by: Ulrich Knaack, Thiemo Ebbert, Tillmann Klein
Budget: 26,000 €
Funded by: Client

RELATED PUBLICATIONS
Towards Sustainable Developments

EOS-LT TRANSEP-DGO: Research for sustainable transition of communal energy systems

The Netherlands aim at an energy saving of 2% per year and a quote of at least 20% of renewable energy production until 2020. For this an integral approach between the large scale of settlement development, the building environment, transport and regional planning is needed. Goals in energy saving are within this a part in the larger aim for “sustainable settlement development”, that aim for high ambitions in the three sectors of sustainability ecology, social aspects and economy.

Communities have a central and active role within this process, in the topics of goals for climate protection and energy savings, the implementation and realization of political goals and the communication between other governments, involved market partners and the public. Even though energy, climate protection and sustainability rank high on the political agenda and many Dutch communities have set themselves broad goals in terms of sustainability, the implementation and realization of the different involved parties and actors towards a CO2-neutral city seems to fail or hardly improve from the current state. For this, several reasons can be named:

1. Deficits in the administrative structure
2. Fragmented approach toward settlement development
3. Incomplete knowledge and tools

The goal of this research project is to come to fundamentally new knowledge and following the boundary conditions and outlines for a transition in administrative and processes issues for a sustainable settlement development and connected with this an energy transition, in which the realization between sustainable demand and supply in the building environment becomes feasible and current obstacles in administration, organization, financial and jurisdictional areas are overcome.

This fundamental research will deliver a number of new aspects and approaches that shall lead to a process and energy transition towards sustainable community development on a short term which shall in a long term shall lead to actual technical and organizational energy visions with good chances for implementation which shall lead to CO2 neutral cities after 2040.

Central objective of the project is the development of a holistic tool-set to cover the key parameters of all deficit fields to enable communities to enhance their decision making processes. The four associated case communities Almere, Apeldoorn, Nijmegen and Tilburg various energy concepts are developed. Via the TU Delft PhD involvement additionally a German case study is included in the project.
EPM Almere

Energy potential studies for the Almere Scale Leap

The Municipality of Almere asked TU Delft to conduct several studies of Energy Potential Mapping (EPM) profiting their plans to significantly extend and redevelop the existing city – known as the Scale Leap. GBI researchers studied the energy potentials of Almere as a whole, including its environs, the particular extension case of Almere-Oost and first steps were made for a similar study on Almere-Pampus and the inner-city redevelopment. These latter two were never finished due to political reasons, but Almere-Oost yielded a mind-shifting report.

Energy Potential Mapping is a structured approach to chart energy potentials of an area, be it a region, province, city or district. Local characteristics, from climate to underground and surroundings, are analysed and translated to energy properties, which are mapped to become the energetic basis for a new urban plan.

As intended, doubling the number of inhabitants (adding 60,000 dwellings), Almere posed an ambitious goal, which needs to be combined with sustainability prerequisites, as stated in the Almere Principles, for which William McDonough was involved.

We were asked to conduct our EPM study when Almere already had some urban concepts, for Almere-Oost and other new parts. We however started as if no decisions had been made yet. For Almere-Oost we investigated the current, predominantly agricultural area, as well as the usual basic information on climate, underground, previous studies and so on.

Particularly interesting in the area were the farms with biomass potentials, fo which we calculated that a combination with around 30 ‘farmcourt’ dwellings could become energy neutral, based on bio-fermentation. In the original plans all farms were erased from the map.

Preserving the farms would leave a low-density district, but we also found that good heat and cold storage potentials were only available in the northern part of the area, enabling a high density concentration of a mix of functions, exchanging and storing energy, next to the A6 motorway. Together with housing next to an industrial area, a substantial amount of built-up area could be established in an energy-efficient way.

(top) Potential map for heat and cold
(bottom) One of the proposed variants, saving the large agricultural farms for energy-neutral living (sketch insert)
EPM De Groene Compagnie

Energy potential study for an energy-producing new district

The method of Energy Potential Mapping (EPM) has developed over the years, through explorative studies in Groningen, Almere and Schiphol. The Province of Groningen and Municipality of Hoogezand-Sappemeer asked GBI researchers to conduct an EPM study in order to lay foundations of a sustainable new district south of Hoogezand, De Groene Compagnie. Based on the plan proposed on the basis of local energy potentials, the district is capable of becoming energy-producing.

Energy Potential Mapping is a structured approach to chart energy potentials of an area, be it a region, province, city or district. Local characteristics, from climate to underground and surroundings, are analysed and translated to energy properties at different heights and depths, which are stacked to give a complete image of the total energy potential.

The method was scientifically enhanced through the latest EPM study in Hoogezand, producing a general energy potential report of the entire province of Groningen and zooming into a detailed study of De Groene Compagnie, where - apart from common sources as sun, wind and waste - local opportunities from agricultural enterprises, cardboard industry, a gas drilling station and underground storage possibilities can be seized in the new development.

Three extreme plans were proposed, assessed and brought to an integrated plan that according to the calculations can become energy-producing.
EXERGY PLANNING IN HEERLEN (NL)
An optimal energysystem for the campus Xperience Parkstad

The development of an optimal energy system for the Heerlen campus, based on the principles of exergy-planning. Exergy-planning is the realisation of spatial conditions for improved use of unused (residual) energy flows.

Exergy planning means:
- Improved use of the quality of energy
- Realisation of spatial energy cascades
- Use of residual energy flows (waste = food)
- Realisation of low-exergy energy demand (LowEx)
- Better use of high-exergy residual energy supply

Why exergy-planning?
- 30-40% of the energy demand comes from the built environment.
- Energy saving efforts are mostly done on the scale of the building
- Potentials of the regional scale have been undervalued till now
- Principles of exergy are not often used to reduce energy demand

Method
- Inventory of local present (residual) energy sources
- Inventory of sinks (demand for heat, cold, electricity and fuel)
- Apply techniques for conversion, transport and storage of energy
- Develop a plan based on up- and downcycling (cascade) of energy

Results
A plan for the school campus in east Heerlen, making use of the local potentials and exergy principles:
- Use roof area for solar gain (electricity and heat).
- Windturbines along road for electricity production.
- Use waste biomass from agriculture, maintenance of nature and residential garbage for producing bio gas.
- Transport biogas in pipelines to urban areas to CHP.
- Convert biogas in CHP to electricity and heat for grid.
- Cascade heat demand for different temperatures.
- Create a LowExergy energy demand for the buildings.
- Create LowExergy thermal grids for new districts
- Use existing heat grids in heat cascades
- Use local former coal mines for heat and cold storage.
- Connect heat and cold grid to regional thermal network
- Regional (Parkstad Limburg) thermal network is connected to industrial areas for residual heat, sand quarry lakes for cold, and Colemines for large scale storage.
- Clean residual from biogas production returns as fertilizer to the agricultural area around Heerlen.

PROJECT INFORMATION
Project leader: J. Stefens (Open University, Heerlen (NL)
Executed by: Leo Gommans (Delft University of Technology)
Period: June 2009 – March 2010
Funded by: Agentschap NL

RELATED PUBLICATIONS
- An Exergy planning approach for the region Parkstad Limburg – Gommans & Van Kann, 2009, Delft (NL)
- Energievisie Onderwijscampus Heerlen – Gauwberg-Huygen, Raadgevend ingenieurs BV, Maastricht (NL) 2009
- Mogelijkheden voor het gebruik van geothermische energie voor Open Universiteit te Heerlen – VITO NV (B) 2007
AN EXERGY PLANNING APPROACH

Exergy planning for the region Parkstad Limburg (NL)

Exergy as a thermodynamic principle is mainly studied at the building-scale or even lower. Here we argue for using the exergy principle within regional planning, also referring to sustainable spatial design. Then exergy planning can be understood as realisation of spatial conditions under which an improved use of unused (residual) energy flows of various qualities can take place. (SREX, 2009)

### Energy demand and residual potentials in Parkstad:

An exergy planning approach on a regional scale focuses on:

1. better use of qualities of energy;
2. making use of energy cascades of spatial functions;
3. making improved use of residual flows (waste=food).

Potentials of Parkstad Limburg (area indicated on maps): energy demand consist for a large part of a low-exergetic heat demand, next to industries that need process heat. That is itself a main source of low-exergetic heat. Sun, wind and hydropower are next to organic waste an exergy potential.

### Distribution and storage of energy; grids and cascades:

An important aspect or exergy planning is (besides energy demand and potentials), an inventory of the possibilities for energy conversion, distribution and storage to deliver the most suitable form of energy in the right place and at the right time (Gommans and Van den Dobbelsteen, 2007-103). Distribution of heat and cold (low-exergetic value) is of special interest. A cascade of heat grids running on various temperatures is crucial in order to match supply and demand, like is true for storage capacities. See figures → →

### Parkstad Limburg through exergetic glasses; concepts

In two examples, Park Gravenrode and Brunssummerheide East, is shown how exergy planning can work out, if the previous steps are applied.

1. Scan the area specific spatial structure;
2. Identify related energy demand and energy potentials;
3. Classify spatial functions based on energy qualities, both in terms of input and output;
4. Identify sources (high exergy supply) and sinks (low exergy demand);
5. Design a scheme of cascaded heat grids; 6. Strengthen the residual flows.

### RELATED PUBLICATIONS

- Van Kann F.M.G., Gommans L.J.H.M.; An exergy planning approach for the region Parkstad Limburg (NL); in proceedings of conference SASBE 2009; Delft (NL), 16-19 June 2009
Experimental Prototypes and Realizations for Blob Claddings

In the process of developing new blob technology Octatube of Delft is playing its role at the forefront of experimentation with structures and claddings, as it has done for almost 25 years now. Through its experimental eagerness the company was involved in a number of realizations of ‘free form’ designs in the last decade, which all had to be build without an existing Blob cladding technology.

Thanks to the discipline of handling experimental developments and real completion dates at the same time in many cases the required technology could be developed just-in-time and the project building could be realized including the new technologies. Developments are incremental for the subsequent projects: a continuous row of small steps ahead in each project means in a longer period quite a strong innovative power in the building industry. This is the general philosophy.

The chair of Product Development choose its position as the designing, development & researching of new technology laid down in new products, new building systems, new materials, new elements, new components and new building parts or new buildings. In the part-time full-professorship the relationship between the experimenting and building practical side and the philosophizing and theorizing academic side keep a remarkable balance, typical for a practice professor, being in the lead on both sides.

Claddings came into the picture when spatial structures were non-rectangular and claddings had to be transparent: glass panels. The frameless glass façade for the town hall of Alphen a/d Rijn (NL) was developed as the first Dutch permanent semi-Blob building. In the row of eight blob projects from 1995 onwards, the first four all failed as the free form designs made by architects could not be realized due to the lack of corresponding and fitting Blob technologies, nor was ample time given to develop these for the projects before tendering. Either the tender prices were sky-high, or the competing successful producers who dared to take up these experimental projects, went bankrupt. The Town Hall of Alphen proved to be the first commercially successful Blob glazing project (2003).

RELATED PUBLICATIONS

- Eekhout, M., Blob in the Faculty’, in Blob in the Faculty 2004, (page 8-17), 2004
Experimental Prototypes and Realizations for Blob Structures

In the process of developing new Blob Technology the ‘Design & Build’ company Octatube, Delft is playing the same role it has played in the 1980-ies when space frames were developed and build and in the 1990-ies when frameless glazing structures and claddings were developed. In the new millennium the company has been involved, through its experimental eagerness, in a number of realizations of ‘free form’ or Blob building designs, which all had to be build buy without an existing Blob cladding technology.

Thanks to the discipline of handling experimental developments and real completion dates at the same time in many cases the required technology could be developed just-in-time and the project building could be realized including the new technologies.

The attention for free form structures was born from the time of the space structures, the 1970-ies and 1980-ies, which were closed off with the dissertation “Architecture in Space Structures”, revealing a tendency towards more complicated space frame forms, usually still regular and the tendency towards transparent claddings. Space frames became very eloquent spatial structures in the 1990-ies.

Many of the experimental projects which were assisted by the Blobs research group were realized in the flesh and published on by prof. Eekhout. These projects contained: DG Bank in Berlin (architect Frank Gehry, Santa Monica USA), Metro Covering of Wilhelmshof, Berlin, (architect Moshe Zwarts), Cardboard Dome (architect Shigeru Ban, Tokyo/Paris), early design Provincial Pavilion Floriade (architect Kas Oosterhuis), Municipal Pavilion Floriade (architect Asymptote Architects, New York) Glass House Malmö (architect Moniac Gora, Stockholm) and Rabin Center Wings (architect Moshe Safdie, Boston).

And sometimes new materials came into the picture. The Glass fiber reinforced polyester sandwich structures for the Rabin Center were intentionally proposed as alternatives for the tender and successfully developed in this experimental project up to the very realization and completion early in 2007. The entire project took 4 years: 2003 for design and prototyping, 2004 for engineering and testing, 2005 for production and installation and the complete year 2006 for completion and snagging.

RELATED PUBLICATIONS
- Eekhout, M., Blob shells: Design, Development and Research an Composite Stressed Skin Roofs for Liquid Design Architecture, lecture at IASS conference, Venice , 3 December 2007
Experiments in Frameless Glazing
From Zappi to Blobs

The design, development, research, engineering, productions and realizations of glass constructions, structures and structural glass in architecture, induced form the design & build approach of the author’s practice of Octatube in Delft over a period of more than 20 years from 1988 to 2010.

Goals
A description in ambitions, development of technology, experimentations and prototyping and applications in realized and non-realized projects in texts and illustrations (photographs and drawings).

Research Question
The documentation of the ambition to innovate, to experiment to prototype and to realize in an incremental approach via projects and publications as a novel type of building technology that became leading in the Dutch glass industry in the last 2 decades.

Strategy
Incremental development of a new technology of daring glass constructions and load bearing glass structures on a novel level with regular publications as an inspiration of the European glass industry. Academia (in the form of graduating students form 3TU) has played a role in study and research of theories and detail potentialities and possibilities in dialogue with practice.

The writing has been done in multiple publications. The photographs of the subsequent projects and graduation works will be collected; the texts will be adapted accordingly and the general technical overview, the fitting in the world of architecture has to be written.

Expected Results
The historic innovative frameless glass projects have been realized in the last 2 decades. Graduation studies have been performed and led sometimes to innovations in building technology. The overall contemplation regards the mainstream development in regards to international developments at the same time of later.
Free Form Technology from Delft

Overview of research, development and designs in projects 2001-2009 in the Chair of Product Development TU Delft

In the years 2001-2009 the research group Blobs has delt with research projects, PhD studies, experimental projects in the laboratories of the chair staff and education projects like Master studies. The body of knowledge has been collected in a book on the results of this research period. The Blobs group has been an independent group from the beginning, but with changing budgets in the faculty of architecture the focus became more and more of practical projects of Blobs Product Development by Mick Eekhout and the projects of Karel Vollers.

Two different types of realizations have colored the research, development & Design activities concerning Free Form Technology of the TU Delft Chair of Product Development in the last decade. First is the dissertation of dr. Karel Vollers ‘Twist & Build’ in which he elaborates on the relationship between Urban Design, Architecture, Building Technology and Material Technology in regards of Free Form Buildings. He was the first scientist to relate these fields of expertise and force them to collaborate. After his work and the many publications and contributions all over the world, his visions were known and a growing number of architects used them to design Free Form buildings, notably high rises. Vollers is the Godfather of the Free Form Skyscraper.

The second is Mick Eekhout’s approach as a design & build engineer to undertake new projects, new materials, new details and new designs, to have control over both the design phase as well as the engineering, production and realization phases, as he integrates architectural design, structural design and industrial design. He is an engineer-architect, an entrepreneur and a scientist. And he contemplates on these activities and analyses them as a scientist. He introduced the topic of ‘Blobs’ or Free Form Technology in his Chair as a research topic.

The group of Blob Research at TU Delft has been small but quite awake. And it enjoyed the interest of many PhD students and Delft Master students in the past years in the axiom of ‘Research Driven Education’. The seed has been sown, the waiting is for better times and more experience-driven prototype Research & Development projects in the near future.
**Free-D Facades Manufacturing**

**Principles for Computer Aided Formative Processes**

For the last three decades, subtractive manufacturing processes such as cutting and milling have been connected to the computer. Nowadays these techniques are explored intensively by architects. Additive and formative methods however are only scarcely available, restricting the possibility for designers to realize the shapes they have generated. This research focuses on creating principles and applications to create computer aided formative processes, such as an adjustable mould to create unique freely curved glass panes.

**Existing process**

1. Geometry
2. Engineer mould: Determine time-temperature path
3. Build mould
4. Cut glass (oversized)
5. Bend glass
6. Produce cutting mould
7. Cut glass to size
8. After-treatments such as toughening, laminating or assembling
9. Final product

**New process**

1. Geometry
2. Determine settings mould: Determine time-temperature path
3. Cut glass to size
4. Bend glass
5. After-treatments such as toughening, laminating or assembling
6. Final product

Existing processes to create unique doubly curved glass panes involve many delicate and labour intensive steps. The process is artisan and the risk of breakage often results in many steps which need to be redone.

By replacing the different moulds with a computer controlled adjustable mould, the process becomes more synoptic. The amount of breakage decreases and less time, material and energy are consumed. Moreover, the new process gives way to industrialize the process. Other materials such as special concretes, acrylics or aluminium can be formed in a similar fashion. It will enable architects to create a new CAM-generated architecture.
Free-D Glass
Production optimization for freely curved glass panes

Since the beginning of the digital revolution, architects have used the power of the computer to create freely curved and lushly patterned facades. Glass is often used to express these freely curved surfaces. Producing these glass panes is an artisan and expensive process. Together with the glass bending company Tetterode Glas Voorthuizen, Delft University of Technology industrialized the glass bending process by developing an adjustable mould.

PROJECT INFORMATION
Project leader: Daan Rietbergen & Karel Vollers
Executed by: Daan Rietbergen, Karel Vollers, Jaap Wiersema, Frans van der Laan
Budget: € 30.000
Funded by: Stichting Toegepaste Wetenschappen

RELATED PUBLICATIONS
- Rietbergen, D. - Glass Processing Days - Shaping techniques for architectural curved glass.
- Vollers, K. - Glass Processing Days - Upgrading building appearances by improved pane reflections.
From Space Structures to Spatial Structures

An essay on the development and engineering and practical applications of space structures, from the regular Octatube space frame designs of 1973 produced based regular nodal systems to the contemporary project-based three-dimensional designs of spatial structures for specific projects, resulting from direct collaborations with project-architects.

Insight in the past, present and future of structural design of space structures in the world on the basis of the author’s portfolio as the main designer of Octatube of Delft.

Contemplation on the technical development, interfered and answered by simultaneous architectural development in the last 35 years of the practice of structural design and engineering spatial structures. The theory of regular space frames and their applications at that time in architecture up to 1990; the change over towards individualization, from producer-related system design to consumer-related project design with a high degree of independent characteristics and the simultaneous development of free form architecture adding a whole new perspective to the possibilities of space structures for future development in free form architecture.

Writings are based on the author’s dissertation in 1989, publications in the last 16 years of the author’s professorship, on the experiences in the design and build company Octatube as one of Europe’s leading firms in that domain. Collection of materials, collections of visual material, redrawing of visual material, writing of the contemplations regarding to technology developments and rewriting of the projects; editing of the information to the level of an internationally interesting book.

A book of 160 pages in full color, with drawings, details analysis and project descriptions including the structural design developments of the systems time and the incremental developments of the later project era. To be published by a structural engineering interested publishing house.

PROJECT INFORMATION
Project leader: Mick Eekhout
Executed by: Mick Eekhout, Stephan Niderehe
Period: 1973 - 2010
Budget: 100.00,-
Funded by: Octatube Holding bv, Delft

RELATED PUBLICATIONS
- Eekhout, M., Advanced Glass Space Structures, op 4th International Conference on Space Structures, proceedings, Surrey University, 1993
Future Façade Principles

Imagining the future of enveloping technologies by developing various scenarios of technical solutions and applications

Combining different disciplines and technologies, the Façade Research Group is interested in the development of façades and envelopes by using alternative, new and maybe such technologies that are not even fully developed yet.

Using the heuristic research method of suggesting possible scenarios, the anticipated development is expressed and represented. To make the research accessible to a broad public, the results are expressed in the series of design and transformation oriented books “Imagine”, to offer a collection of future principles for the façade.

The results are organized by topic and represent the main idea with sketches, pictures and explanatory text. Keywords were used to organize the developed ideas in a database, and are highlighted for quick orientation.

RELATED PUBLICATIONS
- Knaack, Klein & Bilo; imagine 01 facades, 010 Publisher, Rotterdam, 2008
- Knaack, Klein & Bilo; imagine 02 deflateables, 010 Publisher, Rotterdam, 2008
- Knaack, Straus & Bilo; imagine 04 rapids, 010 Publisher, Rotterdam, 2010
Future Markets for a System Provider

Market analysis and product development for Alcoa Architectural Systems

Alcoa Architectural System commissioned the Chair Design of Construction at the Faculty of Architecture at TU Delft to research the field of “façades for the refurbishment of office buildings”. The goal of the research project was to develop façade systems for office-refurbishment, which are suitable for reasonable shares of the real estate market.

The project provides a detailed insight into the office market in the Netherlands, Germany, and the United Kingdom. Based on on-site spot checks of 600 buildings in these countries, it presents an overview of the different office façade structures used for office buildings from the 1950s to the early 1980s. The results clearly indicate the two most common façade typologies: Load-bearing walls (window-facades or skeleton structures) and post-and beam façades.

The “Refurbishment Window” is a concept to combine window constructions and building services installations for the retrofitting of load-bearing façades. It facilitates the retrofitting of window facades by mounting new building services and windows with minimal disturbance to the user and in very short time frames.

For the refurbishment of post-and-beam façades the "Post-and-Beam-Adapter" has been developed. The adapter is a profile, which is mounted on top of old façade structure and is fully compatible with current profile systems. It makes it possible to completely upgrade post-and-beam façades to today’s standards with no more effort (and nuisance) than simple re-glazing. The concept has been patented.
Grounds for Change
A sustainable energy system for the Northern Netherlands

The Northern Netherlands, especially the province of Groningen, has traditionally been the national energy provider. After peat and mineral oil this service is currently based on natural gas reserves, of which depletion is expected within 25 years. This urges anticipation for a novel system based on renewable energy. In the Grounds for Change project a designer team, involving a GBI staff member, and another technical team worked on a proposed sustainable energy system for the Northern provinces, spawning the method of Energy Potential Mapping.

The Northern Netherlands are formed by three provinces: Frisia, Groningen and Drenthe. By 2005 collaborative initiatives had started on the development of a renewed energy-based region called Energy Valley, involving the provincial organisations, knowledge institutes and market parties such as the Gas Union, which is currently responsible for the exploitation of natural gas.

In June 2005 a large convention was held by the name of Grounds for Change, set up as a ‘charrette’, with pressure cooker sessions to come up with ideas for a sustainable region. After this, a research project commenced on the elaboration and quantification of the charrette explorations. Two teams were formed that collaborated closely together, one with designers, the other with technical experts.

In the design team the foundations were laid for a new method to chart the local opportunities of energy in the region: Energy Potential Mapping (EPM), which was later enhanced through various projects.

In June 2006 two reports were presented during the World Gas Conference in Amsterdam, with the results of the Grounds for Change project. Earlier, based on the charrette method introduced by the project, a part of the Shanghai region was similarly approached. Recently a second Grounds for Change conference was held in Drenthe.
HEAT MAPS

Mapping heat characteristics in the Netherlands

Energy Potential Mapping provides insight in geographic distribution of available energy potentials. In this project, the method of EPM is applied specifically to heat characteristics, both in the Netherlands as a whole as well as selected target areas. 3D maps were developed to show the balance between area heat supply and demand, and in the process reveal any unmatched potentials. The second part investigates visualisation of exergetic heat content within a region.

The methodology of Energy Potential Mapping (EPM) was developed to chart local supply and demand of energy, in order to map the local potentials for a built environment based on renewable energy sources. EPM has been used to direct spatial planning towards a process where energy becomes an extra parameter to deal with when aiming for sustainable built environments.

Following several EPM studies in 2009 we were asked to conduct a study to map the heat demand and supply of the Netherlands. The heat (and cold) demand of the built environment was investigated through available statistics, discerning different functions and years of construction, for instance. The heat potentials included natural sources, such as solar and geothermal heat, as well as anthropogenic residual energy, such as industrial waste heat.

A general heat map of the Netherlands was drawn, involving both potential supply and demand, presented in a graphically clear way. More in-depth studies were done of two cases: the rural city of Emmen and the centre of Rotterdam. These latter studies revealed more detail in the 3D heat landscape pattern as local typical urban functions became distinct. Finally a proposal was made to include the energy quality (exergy) or temperature of the heat needed or provided.

This study may be very valuable for future (re)developments where local functions can start exchanging their surplus or deficiency of heat or cold. This will strongly reduce the demand for primary energy currently used to heat and cool buildings. And, not least, making better use of waste energy will avoid further warming of cities in a changing climate.

The paper will discuss the heat mapping study, its methodology, the regional cases investigated in-depth, as well as future perspectives and considerations.

PROJECT INFORMATION
Project leader: Prof. Dr. Ir. Andy van den Dobbelsteen
Executed by: Ir. Siebe Broersma and Michiel Fremouw (TUD) with a contribution from Ir. Ronald Rovers (Wageningen University and Research Centre)
Period: February – November 2010
Budget: € 30,000
Funded by: Agentschap NL
Innovating and Experimenting with Prototypes in Practice

Lessons learned from 25 years of practical experiences with experimenting and prototyping in design and build approach of design of constructions and structures in membranes, steel, aluminium, composites and cardboard. The design & build company of Octatube in Delft serves as the laboratory of prof. Mick Eekhout. From his experiences with projects, their results and projects processes a treatise is written on 25 years of experimenting.

Goals
Overview of the design and build approach in architecture and of experimenting and prototyping more specific in the speeding up of inventions and innovations in the building industry. The technical development of new structural systems, new detail connections, material and element improvements, surface improvements, positioning methods up to sometimes fundamental material research and developments necessary to achieve a large leap forward; inclusive the inspiration from a market leader to the international market of followers and the collaborations with academia in the form of practice students, graduating students and PhD students in house. The fruitful connection with the TU Delft in the different faculties of Architecture, Civil Engineering, Industrial Design, Mechanical, Marine and Material Engineering (3ME) and Aeronautics, initiating a collaboration as in Silicone Valley but in a restricted scale.

Research Question
Typical approach conditions, hazards and advantages of this approach in incremental improvements and the fruits of this approach in the conservative building industry. Balance between unknown aspects of experimentation and the trustworthy and calculating state-of-the-art.

Strategy
Selecting pictures from projects and writing commentary texts with the projects plus a separate line of design and build and experimenting and prototyping, plus the realization of architectural, structural and industrial design in one package.

RELATED PUBLICATIONS

PROJECT INFORMATION
Project leader: Mick Eekhout
Executed by: Mick Eekhout, Caroline Kruit
Period: 1983 – 2010
Budget: 100.000
Funded by: Octatube Holding bv
IPC Cassette Façade

A façade refurbishment system for improved sustainable performance of office buildings

With an “IPC” (Innovation Performance Contract) allowance track, VMRG has brought a number of companies from the Dutch façade industry and Delft University of Technology together in the development of a shared concept for façade refurbishment: the Cassette Façade.

The Cassette Façade concept by Façadis Geveltechniek, de Groot en Visser, van Hengstum, Heycop Systemen, Kremers Aluminium, Licotec Daklicht, Merford, Vorsselmans and Delft University of Technology is being developed to upgrade office façades in terms of climatic functionality, energy performance and sustainable material use.

The Cassette Façade system consists of a supporting structure and a variety of infill cassettes that determine specific façade functions at their locations. Cassettes for dynamic sun shading, solar energy generation, balanced ventilation, heat buffering, façade openings etc. are placed in the supporting structure and connected to the integrated network of pipes and wiring.

Cassettes can be exchanged or replaced due to changing demands on the refurbished building – e.g. for a second refreshment after 15 years. The cassettes are developed independently, based on new technologies and increasing legislation demands per function. This ensures that refurbished buildings can be kept up to date during its remaining lifetime.

The Cassette Façade concept is developed to increase the refurbished building’s BREEAM score, through improved energy performance and the conscious application of materials with respect to recycling issues, emissions and embodied energy.

The initial system development is based on a case study on one of the university buildings that is to be refurbished in the near future. For this case, a 1:1 prototype element will be constructed.
IPC – The Living Skin

Research cooperation of façade construction industry and Delft Technical University

The research program between the Facade Research Group at the Delft Technical University, the VMRG (Dutch association for the metal façade industry) and mid-sized façade construction companies aims for knowledge transfer in the field of facade refurbishment.

The Living Skin –IPC project (Collective Innovation Plan) is funded by Senter Novem. Using a collaborative approach the aim is to exchange and collect knowledge about the field of sustainable facade refurbishment.

The refurbishment of the outdated building stock is one of the key issues of the building industry. Hereby facades play a crucial role when it comes to energetic improvement. The target is to define constructional strategies and processes that will lead to the best results. The special interest of the involved companies lies in the development of facade related products and marketing possibilities.

The project is executed by organising interdisciplinary workshops in combination with brainstorm session. Results are collected, and then evaluated in terms of their potential for the facade market.

The project will result in a book. It will include a collection of background knowledge, the principle possibilities of façade refurbishment technologies, best practices and potentials for future solutions. It will be published within the “imagine” book series with 010 publishers, Rotterdam.

PROJECT INFORMATION
Project leader: Ulrich Knaack
Executed by: Ulrich Knaack, Marcel Bilow; Thalia Konstantinou
Period: 2009 - 2011
Budget: 37500 Euro
Funded by: TU Delft, VMRG
LEAN CONSTRUCTION & aE

Engineer Architecture, Create Value and Banish Waste

The built environment gives ample evidence that it is hard to get the quality right and keep it right. How can the construction industry contribute? How can we create value without waste for an unknown future?

Lean Construction (lean: how to create value for the end user) and Open Building (open: how to build for an unknown future) are complementary Third Wave strategies from initiative, design, construction management and use.

This project explores their synergies as a source for implementation guidelines. The value we create is the built environment.

If we define construction as a production process, we can learn from the history of production that has shifted its emphasis from transformation to flow to value; from product to process to customer.

In the lean vocabulary seven wastes⁴ in the production process are identified. Some say there are more. How can we in order to create value identify process waste in the construction industry?

The chair of Architectural Engineering provides the perfect environment to build bridges between design, engineering, construction and management. Lean in turn gives food for thought to create value and banish waste from the construction industry. research and education.

* overproduction, waiting, transporting, over-processing, inventories, moving, rework.

PROJECT INFORMATION
Project leader: Ypz Cuperus
Executed by: Ype Cuperus
Period: Ongoing

RELATED PUBLICATIONS
Lord of the Wings
From idea to realization of a new generation of composite sandwich constructions for Free Form Architecture

The description of the process of architectural design tendering and technical redesign, engineering, testing, prototyping, productions, transport, assemblies and installations of a new generation of structural sandwich wings, specially developed for the roofs of the Yitzhak Rabin Center in Tel Aviv, ending with completion of the building.

Goal
A description in an internationally published book on an prototypical development with world novelty and application in a realized project with ample illustrations, considerations of design, development, research, methodology and experimental production and installations as the birth of a new type of building construction system.

Research Question
Research question at the start of the project was how to develop a trustworthy new technology of load bearing composite sandwich structures for free form design applications; the research goal of the book is an accurate description of the entire prototype development and practical realization.

Strategy
Describe the historical development from the design letters of Eekhout and Safdie, the engineering reports, the testing reports and the production and realization logbooks (Siep Wychers); Combine the technical dates with a more philosophical description of the entire process (Mick Eekhout) and with a positioning of the technical development in the development of architecture (Liane Lefaivre).

Expected Results
An internationally published book at Birkhaeuser on the experimental development of this new type of load bearing sandwich structures for free form shells with abundant illustrations and reflections on the development possibilities of technical architecture.
Methodology for Product Development

A monograph with ample considerations on the methodology of design, development and research of building components, building products and systems; written from the point of view of a practical designer and illustrated with real prototype developments of different nature in all of its stages.

Writing and composing of a scientific publication in the form of an international book for architectural students and professional architects, for building technicians, building managers and clients.

How could the typical product development process of new standard building products, new system products and of special building components be described in different stages, in their mutual sequences be described; what are the general considerations of employing methodical approaches in new development projects and where are they applicable; How could they be illustrated with realistic cases in different stages to enlighten the subject. How does methodology fit in the general approach of the building industry and in building projects?

Yellow book ‘Popo, of ontwerpmethoden voor bouwproducten en bouwcomponenten’, written in Dutch language and edited in 1996 by DUP, Delft has been used as a starting point. It has to be translated, enriched with state-of-the-art exemplary cases; Some of the theoretical chapters have to be shortened; all hand-made drawings have to be redrawn by computer drawings and illustrations in black-and-white photographs.

A new book for the international market of students and professionals in architectural product development, that can be used for projects to illustrate for clients the complexity of a development process, the motivations and the pitfalls and illustrates the sequences of the different stages of a development process. The manuscript has been reviewed by international peers. Publisher IOS Press in Amsterdam.

PROJECT INFORMATION
Project leader: Mick Eekhout
Executed by: Mick Eekhout
Period: 2006-2008
Budget:
Funded by: Chair of Product Development / TU Delft

RELATED PUBLICATIONS
Modular Facades
Development of a modular façade system

The need for higher energy performance and the integration of two traditionally different disciplines poses a new challenge for façade construction. The goal of this research project was the development of a catalogue of demands for building services integrated façades and a roadmap for new constructional solutions.

Kawneer Alcoa is a major façade system supplier. Their curtain wall and window systems are widely applied. On one hand, the architectural market asks for customization and on the other, it needs a standardized product range with a manageable amount of parts. The integration of building services components in façade construction asks for a new modular approach in combining these disciplines.

Essential for the success of a façade product are the construction phases from pre-design via production and assembly to the re-use of components and the involvement of different stakeholders. Who decides what when? This has been analysed and on the basis of the outcome several new constructional concepts for services integration have been developed.

The project has resulted in the design of a façade system with vertically integrated media and a European patent no. EP 2117091 A2.
Natural and hybrid ventilation

Increasing the awareness of the value of natural or mixed mode ventilation for existing and new buildings

Buildings can be ventilated in an energy-efficient and comfortable way making use of natural ventilation, generally with a mixed mode system. The aim of the research is the development of advanced ventilation with attention for draught prevention and heat recovery.

Advantages of natural ventilation are improved contact with nature, reduction of fan- and cooling energy and the availability of large air flows being able to create excellent air quality. However, a lack of heat recovery, filtering and occurrence of draught may be serious disadvantages. Even several special designed natural ventilated buildings have showed some disappointing results, although this is often effected by the kind of occupant satisfaction evaluation.

In most buildings it is possible to make use of operable windows. This generally improves air quality and temperature control, resulting in more occupant satisfaction and productivity. Second skin windows have additional potential and are able to act as a major air supply system. Moreover, with night ventilation the thermal building mass can be cooled in order to reduce the cooling capacity during the day.

Some designers do not make use of operable windows, which seems to make the façades and building services less expensive. A more detailed cost-benefit analysis is necessary to overcome this dilemma and occupant preferences should be involved in this choice as well.

The state of the art and recent developments of natural and mixed mode ventilation will be presented in a European Guide (REHVA) in order to support designers in their decision process.

Even a monumental building like the Erasmus Medical Faculty in Rotterdam might be equipped with an additional type of natural ventilation via the façade columns.

Natural ventilation system of the ROC of Twente

It is important to know how to improve the performance of natural ventilated buildings. Draught can be prevented by a smart design of the inlet-system and heat recovery is possible in several ways, making use of a heat pump, a thin wire heat exchanger, the thermal mass and CO₂- and heat source related air flow control.

PROJECT INFORMATION
Project leader: Peter van den Engel
Executed by: Peter van den Engel, Stanley Kurvers,
Regina Bokel and master students
Period: September 2010 -
Budget: Not yet available
Funded by: Not yet available

RELATED PUBLICATIONS
Netherlands 2040

The future needs of the built environment in 2040 reasoning from challenging society needs in 2040

In 2009 discussions are initiated from the 3TU Spearhead Building Research to stimulate the scouting of the far future of the Dutch built environment. The future built environment is believed to be formatted tightly around the future needs of the Dutch society, like a glove fits over a hand. Scouting Research will be done for the future of the Netherlands in 2040 form the viewpoint of researchers and designers. The building sector has to follow the desired modifications of the current built environment by her actions accordingly.

The Dutch built environment has to be adapted according to the challenges and problems that besiege the Dutch society in the coming decades. Effectiveness and efficiency in economic means are of major importance in the 2010s when economic means are becoming more scarce and the usual growth is substituted by occasional growth and occasional shrinkage.

The critical societal challenges are amongst others: Population, Ageing, Prosperity, Individualisation, Process complexity, Mobility, Safety, Accessibility, Energy, Building efficiency, Sustainability, Legal complexity, Performance of services, Cultural experience, Urbanization, Building in the delta, Health and Information services.

In the discussions on the future of the built environment and the building sector, it is not important to keep the current building sector upright in size and organization, but to adapt the capacities of the building sector in all of its different segments (principals and clients, architects and engineers, contractors and suppliers, governments and authorities) to the actual and future needs of society.

This society-directed or demand driven approach will result in another result than the supply driven approach of the recent decades. Due to the different crises like the credit crisis, the housing crisis, the environmental crisis, the food crisis and so on that are recognized to torment society since the turning of the millennium, a complete new approach of the existing, the adapted and the new environment is required.

This focus on the future in 3 decades brings many discussions with many professions and future scouters as well as discussions with shorter sighted politicians.

PROJECT INFORMATION
Project leader: Mick Eekhout
Executed by: Mick Eekhout, Taeke de Jong, Atelier Rijksbouwmeester, Building Brains
Period: January 2009 – December 2012
Budget: €200.000
Funded by: Ministry of Social affairs, Housing, 3TU.

RELATED PUBLICATIONS
NEXT Active Facades
Development of Building Services Integrated Façades

The integration of building services and facades can contribute significantly to a lower use of energy in buildings. Both disciplines are traditionally separated, but their combination has a great potential for the building market.

A trend can be observed to place building services components into the physical façade area. This combination can have a positive effect for the energy consumption of buildings and the user comfort. Both disciplines together make 40-50% of the total building costs. This alone illustrates the potential of this approach. The impact on façade construction and the traditionally separated markets will be great.
Several façade and building services installation combinations have been built in the past, but always as unique projects, bearing a great planning effort and severe risk for the participating parties. The research project focuses not on designing completely new facades, but on the development of a combination of existing and well tested products. The project team is strategically arranged to cover all aspects from architectural design to product and assembly of facades and installations.

In a first step, possible façade and services combinations have been defined and a strategy to approach the different decision makers has been designed. In a final step a computer tool is created to explain the potential effect of the product combination on energy savings and user comfort.

The project is executed jointly by the Façade Research Group and the Climate Design Group of the Department of Building Technology.
A mock-up of a NEXT archetype façade was exhibited on the real estate exposition PROVADA 2010.

RELATED PUBLICATIONS
PROJECT INFORMATION
Project leader: Tillmann Klein
Executed by: Tillmann Klein, Eric van den Ham
Period: 2009- August 2010
Budget: € 22.000
Funded by: Alcoa Architectural Systems,
TROX Technik, Somfy
**OSSB – Sustainable Housing**

**Comparison of a lightweight construction from Oriented Structural Straw Board (OSSB) and a conventional Chinese brick house.**

This research was produced for Panel Board Holding BV and it contains the comparison of lightweight construction from Oriented Structured Straw Boards and a conventional Chinese brick house in terms of environmental impact. A Life Cycle Assessment and an Energy Simulation calculate the embodied energy, the operating energy and the resulting CO2 – Footprint.

The objective of the assessment was to evaluate the Ecological Footprint of a residential building based on a Light Gauge Steel / OSSB construction in comparison to a conventional Chinese residential building from brick and concrete.

The comparison to rate the impact on the environment consists of two work packages. In the first part of the procedure the embodied energy of the building’s material is evaluated on basis of a Life Cycle Assessment. The second part identifies the level of indoor comfort for the two cases. Sustainability includes parameters from three disciplines. Ecology is the most obvious one. In order to rate the environmental impact a building has in nature, the building is assessed over its whole service life. The Life Cycle Assessment deals with this aspect.

Social Aspects contain various parameters which are difficult to measure. Comfort is the most important one which can be quantified and compared by the amount of energy to operate the building. Economic aspects are provided by a comparison of the two building cost. In the focus of this research are the ecological aspects. The building material and the operating energy are assessed and compared in order to judge which type is more eco friendly and sustainable.

The OSSB -house has to offer the same level of indoor quality as the common construction methods in brick and concrete for Chinese houses. A thermal simulation compares the light-weight and a massive construction. The simulation will incorporate Chinese climate conditions specifically for Chengdu, the capital of the province Sichuan where 60km to the north-east the houses are located.

**PROJECT INFORMATION**

Project leader: Patrick Teuffel, Ulrich Knaack
Executed by: Linda Hildebrand, Florian Heinzelmann, Remco Looman
Period: June 2009- October 2009
Budget: undisclosed
Funded by: Panel Board Holding BV.

**RELATED PUBLICATIONS**

- Final research report, Delft 2009
- Teuffel Patrick, Linda Hildebrand "Oriented Structural Straw Board – A new material for sustainable housing concepts", proceedings IASS symposium 2010 in Shanghai, 2010 (to be published November 2010)
POP Energy Groningen
Charting the energy potentials for the Province of Groningen

After the Grounds for Change project had spawned a crude method for charting of energy potentials, Groningen asked TU Delft/GBI to conduct a study on the energy potentials of the province. Alongside social-cultural, economic and climate change issues, as a new factor to spatial planning, energy would be integrated in the POP (provincial environmental plan). This enabled the enhancement and elaboration of the Energy Potential Mapping method, which through this project became the standard for similar studies.

The POP Groningen project turned out to be a challenging and extensive labour, as the methodology of energy potential mapping was constituted in its definite form during the investigations, which to a large extent consisted of gathering detailed information from the province, industries and general databanks. And finally, all information acquired needed to be converted to proposals for spatial interventions based on energy grounds.

Collecting the correct energy data proved to be complex sometimes and often we needed to convert more generic values to specific functions of the studied area. Nevertheless, with the help of ADECS, we could produce detailed, GIS-based maps of energy potential maps referring to various sources of fuel, heat and cold, electricity and even CO₂ sequestration possibilities.

On the basis of these we proposed spatial interventions for a more energy-autonomous province. We calculated the energy performance after these interventions and found that 50% of the current energy demand could be solved by sustainable energy, and even 80% of CO₂ emissions could be avoided through our proposals.

The Province of Groningen took our findings seriously and included them in the provincial plans. Later, we were asked several times more for additional studies, such as the EPM for De Groene Compagnie. Through the POP energy project a lot of (inter)national interest was expressed in the approach and ever since EPM have been conducted on various sites in the Netherlands.

(top) Energy potential map for heat and cold
(middle) Energy potential map for power generation
(bottom) Map of proposed interventions

PROJECT INFORMATION
Project leader: Andy van den Dobbelsteen
Executed by: Andy van den Dobbelsteen, Sabine Jansen, Arjan van Timmeren, Jan Leemans (ADECS, for the graphics)
Period: January 2007 – June 2007
Budget: € 24.000
Funded by: Province of Groningen

RELATED PUBLICATIONS
- Dobbelsteen A. van den, Jansen S. & Timmeren A. van; ‘Naar een energiegestuurd Omgevingsplan voor Groningen; TU Delft, 2007
Rapid Prototyping in Facades
Development of a modular façade system

Over the last years, Rapid Prototyping, and in further evolution, Additive Layered Manufacturing (ALM) changed from a small niche application for prototypes to a serious production technology. Therefore, the façade industry tries to adopt the new production principles to their range of products. In this project the first steps towards an enhanced use of the new ALM processes for free-form facades are taken. In cooperation between TU Delft and Kawneer-Alcoa, this project develops from first sketches and ideas to live size mock-ups and upgraded products.

Introduction
Additive Layered Manufacturing is gaining in importance not only in the aerospace, automotive and the medical industries. The building industry is also increasingly aware of the possibilities that this technology offers to create unusual structures and details. Kawneer-Alcoa, an international company has been working with additive methods for some time. The initial focus lies in identifying possibilities to produce components that complement the standard products used in system facades. Against this background, the research project “Influence of additive processes on the development of façade constructions” was established at the University of Applied Sciences – Hochschule Ostwestfalen-Lippe in Detmold, Germany in cooperation with the TU Delft. In addition to complementing research and education at the university with practice and goal-oriented activities, the results support the PhD work of the project leader Holger Strauss at the Technical University Delft, chair Design of Construction under Prof. Dr. Ing Ulrich Knaack. At both universities, this future-oriented topic allows for an interdisciplinary cooperation between different faculties and areas of study.

Research in cooperation with the industry
To limit the number of expected results, the developmental steps conceivable today were divided into time periods. An initial time span of one to three years, where results are immediately realizable with existing technologies; another time span of five to ten years where conceived results are realizable in the foreseeable future, and finally a time span of twenty-five to thirty years which encompasses visions that, with our current knowledge are not yet realizable.

With help of this categorization a direct connection can be drawn between today’s production and future requirements for modified product design. What begins with a mere optimization of standard components produced with current production methods, will, over the course of the project time span develop into a visionary approach for holistic façade solutions.

Outlook
The availability of Rapid Technologies, specifically the fast developments of ‘Direct Metal Fabrication’ with additive manufacturing methods, might make it possible that, in the near future free-form nodal points can be digitally designed and adapted, and then “printed” as a sensible to clients or as an enhancement of the façade suppliers’ production.

PROJECT INFORMATION
Project leader: Dipl.Ing. Holger Strauss
Executed by: Jeroen Scheepmaker (Alcoa architectuursystemen), Klaus-Martin Hees (Kawneer), Prof. Dr.Ing Ulrich Knaack (TU Delft), Dipl.Ing. Marcel Bluw (TU Delft), Dipl.Ing. Holger Strauss (TU Delft)
Period: September 2008 – September 2010
Budget: € 55,000
Funded by: Kawneer - Alcoa

RELATED PUBLICATIONS
- Imagine 04 - RAPIDS; Uitgever: Knaack, Kleis, Bilow; 010 publishers, Rotterdam, 2010
- An Industrial Approach towards the use of layered fabrication for building construction and architecture; paper in: facade2009, conference volume; editors: Potgiesser, Knaack, Strauss; Detmold, Germany, November 2009
- Funktionales Konstruieren; Holger Strauss; Hochschule OWL, Detmold, Germany, 2008
Research in graduation work of the International Façade Design Master (IFM)

An integral part of the International Façade Design Master Program is the close relationship both to practice and architectural design and to the research program of the Façade Research Group.

For the benefit of all, it is desired to interconnect the graduation or research project and PhD work of the Façade Research Group, as well as to the industry. The students get provided with knowledge that is “cutting edge” and a next generation of researchers is educated. At the same time, this approach provides valuable input and manpower to the research group. The industry is asked to name their relevant issues. A relationship is created between those who currently define the business and those who aim to do it in the future.

A list with graduation topics is created via the cooperation, knowledge and research exchange with the VMRG (Dutch Façade Builder Association), the KCG (Knowledge Centre of the Dutch façade industry) and several related façade manufacturers (Permasteelisa / Scheldebouw and Oskomera).

Some examples of graduation work façade design:

  Connected to research field: PhD Tillmann Klein, Supported by: Alcoa Architectural Systems


- “Materialising the life cycle of the building skin, designing strategies by means of LCA studies”, Charlotte Heesbeen, 2010. Connected to research field: PhD Linda Hildebrand, Supported by: Transsolar Stuttgart.

- “Study on potential of façade systems with varying U-values”, Chenjie Wu, 2010. Supported by Oskomera (in-company research & design project in cooperation with TU Delft).

- “Rapid prototyping and manufacturing in future façade design”, Leonie van Ginkel, 2010. Connected to research field: PhD Holger Strauss, Rapid Manufacturing

- “Study on the production of double curved concrete panels”, Koen Huyghe, Arnoud Schoofs. Connected to research field: PhD Daan Rietbergen, Supported by Hurks Beton

See related PhD research work

RELATED PUBLICATIONS

PROJECT INFORMATION
Coordination: Arie Bergsma / Ultrich Knaack / Tillmann Klein
Period: since 2008
Budget: approx. -
Funded by: VMRG, KCG, Oskomera and Scheldebouw
Robust Climate Design
The Building Robustness Hypothesis

Epidemiological studies consistently show that in buildings with more technological devices to control the indoor environment health symptoms and discomfort are more prevalent than in buildings with a more passive indoor climate control. Since in most cases these more complex systems primarily aim at better compliance with the standards, and generally use more energy, the higher levels of symptoms and dissatisfaction seem odd.

The most frequent explanation of this phenomenon is that more complex HVAC systems contain more potential sources of indoor air pollution, like filter sections, cooling sections and humidifiers and that more complex systems are more prone to malfunctioning due to inadequate maintenance.

Though in itself correct, this is only part of the explanation, and that a more comprehensive explanation can be hypothesised.

The robustness of an office building, including its HVAC system, is defined as the measure by which the building lives up to its design purpose when it is use by occupants in a real life situation.

Future research should aim at the possible mechanisms influencing the magnitude of robustness.

Examples at the level of the behavior of the building:

- Active and passive climate control.
- Control of indoor air pollution sources and control of ventilation.
- Control of internal and external heat sources and use of thermal inertia.
- Sensitivity to aberrations from designs assumptions.
- Maintenance requirements.
- Separation or combination heating, cooling and ventilation.
- Varying air volumes over time to control the indoor environment.

Examples on the level of the occupant-building interface:

- Transparency of climate control to occupants and to building management staff.
- Occupants’ control of various aspects of their indoor environment.
- Occupants can trade off positive and negative results of choices
- Occupants are presented with an environmental “gestalt” that promotes acceptance of the indoor environment as a whole.

PROJECT INFORMATION
Project leader: Stanley Kurvers
Executed by: Stanley Kurvers, Joe Leyten, Eric van den Ham, Regina Bokel.
Period: Proposal
Budget: -
Funded by: -

RELATED PUBLICATIONS
Slimme Gevel – Metadecor
A research project about façade cladding

Metadecor asked for a cooperation to develop a new concept or product to broaden their product range. In addition, they are also working on a new headquarter building in Kempen. Thus, the research takes the building design into consideration but will be more general to discover the possibilities of a new facade cladding.

The cladding will be a second layer, positioned in front of a watertight, airtight and insulated first facade cladding, which could be a post and beam system or a load bearing facade.

The entire project was executed at the chair Design of construction at TU Delft / Faculty of Architecture under Prof. Dr. Ulrich Knaack with use of an innovation voucher.

Metadecor presents the design of their headquarter in Kampen, designed by Wiel Arets architects.

The building will have an iconic appearance, visible from a distance as a unique building.

During the design / working sessions, Matthias Rudolph / Transsolar mentioned that there will be a problem of overheating during the summertime caused by the huge amount of glass in the office space in comparison to the usable ceiling area for cooling using an active concrete cooling.

The overheating problem leads directly into a discussion about the building’s sun shading.

The building itself is oriented app. 45° off north, which requires sun-shading on all sides of the building. The lower sun during the winter provides the possibility to use solar energy to heat up the building during colder periods.

The further development of the project focuses on the cladding of the building which will have an adapted metal screen cover that provides sun shading as well as light redirection possibilities.
Smart & Bioclimatic Design (S&BCD) is a design approach that uses local circumstances intelligently in sustainable architecture and urban planning. At TU Delft it is also the name of an elective course, coordinated by staff from Green Building Innovation, which aims to connect research to education of Master’s students. The course combines (guest) lectures, workshops and an excursion with the assignment to write a designer’s manual on a chosen topic of S&BCD. It has proven to be a very effective learning means.

The Smart & Bioclimatic Design offers lectures on sustainable architecture and planning, building technology and climate design, which are concentrated in the first four weeks of the elective course. These lectures are given by experienced staff from the Faculty of Architecture and guest lecturers, such as Prof Greg Keeffe from Leeds University (on biomimetic architecture), yet also PhD candidates who present their ongoing research and convey the enthusiasm for being at the frontline of innovation. Through the series of lectures students get their basic information for a chosen topic of S&BC, which needs to be enlarged by desk and literature research.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The Smart & Bioclimatic Design offers lectures on sustainable architecture and planning, building technology and climate design, which are concentrated in the first four weeks of the elective course. These lectures are given by experienced staff from the Faculty of Architecture and guest lecturers, such as Prof Greg Keeffe from Leeds University (on biomimetic architecture), yet also PhD candidates who present their ongoing research and convey the enthusiasm for being at the frontline of innovation. Through the series of lectures students get their basic information for a chosen topic of S&BC, which needs to be enlarged by desk and literature research.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.

Additional to this work of content, students are taught about conveying information to designers as themselves in an effective way. For this a workshop is organised in the first course week. Books, manuals and other available matter for architects and urban planners are meticulously analysed to learn the basic features of communicating the essential technical knowledge necessary for sustainable design. The students use this in writing their own designer manual on the topic chosen in an early stage. It supports a focused and effective investigation of academic matter.

The S&BCD course started 2005 and has been successful ever since, especially with respect to the great number of elective courses available at TU Delft. S&BCD has become a compulsory part of several master’s tracks at the Faculties of Architecture and Civil Engineering. A 2007 educational evaluation produced very good results for S&BCD, but more importantly most of the students keep using the products of the course after finishing. The course was presented at the international conference of PLEA2007 (Singapore), including samples of student manuals and received acclaim there.

The enthusiasm for being at the frontline of innovation.
Green Building Innovation: IN4M-IBA 2011

Smart Material Housing-IN4M
Inspiration, Innovation, Integration, Industrialization and Materialization

Germany has a history of organizing International Building exhibitions of which the main focus is to generate ideas for shaping the future of urban life. In 2013 the exhibition will be located in Hamburg, in the neighbourhood Wilhelmsburg, an isolated rural area. This will also be the location of the International Gardenshow. In collaboration with Architectuurcentrale Thijs Asselbergs (aTA) the chair Architectural Engineering was selected to participate in the second phase of the Smart material Housing design competition.

The design goal was the intelligent use of smart technologies, materials and constructions, as well as the optimization of material flow in the subject of materials. The building should meet the 2007 Energy Conservation Regulation standards on energy usage. As the building location is surrounded with noisy traffic areas, noise insulation was an important design constrain.

The building concept is based on a closed North façade, which is facing the main noise source. Also routing areas, such as elevation are located on the North side of the building. The east and west façade are designed with a semi-open character. The south façade is designed as an open façade. With the use of peer+ glass, an active shading system is established. Peer+ glass is based on liquid crystal technology, and in combination with solar cells, no extra energy is needed to activate the sun shading system.

The North façade is determined as a green façade and utilized with a active noise reduction system. Piezo elements detect noise, and react with an antiphase, blocking the sound. Also, the use of green on the façade can be seen as noise reduction elements and adds to CO₂ reduction as well as water storage.

The building is fully constructed out of wood and straw material (OSSB), as wood is determined as the most sustainable building material during construction, building life as well as demolition.

With the IN4M building the balance between advanced material technology, energy usage and harvesting, sustainability and design is met.

PROJECT INFORMATION
Project leaders: Prof. ir. Thijs Asselbergs & Prof. Dr.Ing. Patrick Teuffel
In collaboration with: Arjan van Timmeren, Remco Looman, Marko Koops, TEUFFEL ENGINEERING CONSULTANTS, Wenzel+Wenzel, Geert Ravenshorst, Christoph Hofmann
Period: October 2009 – June 2010

Funded by: Internationale Bauausstellung, Hamburg, Germany
Budget: € 15.000
Solarlux

Development of a double layered folding façade for the new office of a façade manufacturer

Solarlux is the leading company for folding-sliding walls for winter gardens and shop entrances. The Façade Research Group was asked to develop an application of their product for the office façade of the future.

Double facades have many advantages such as the heat buffer effect in winter and the protection of sun blinds from wind. However, their drawbacks lie in overheating in summer and the usual need for elaborate HVAC systems.

This concepts takes the double façade back to its roots as historic opening box windows. It consists of an inner insulated façade made of timber profiles and an exterior single glass screen. Both folding walls are 3.10m high and can open to various extents. For minimal ventilation in winter, the outer layer is closed, the inner façade is only opened a few centimetres. In summer, the outer layer is fully opened, the inner façade is opened according to individual needs. In windy situations, only parts of the outer wall are opened, the cavity functions as a corridor façade. It is even possible to open across the full height and width of both layers and work “as a balcony”.

PROJECT INFORMATION
Project leader: Thiemo Ebbert
Executed by: Ulrich Knaack, Thiemo Ebbert, Tillmann Klein, Marcel Bilow
Period: September 2006 – June 2010
Budget:
Funded by: Solarlux b.v.

RELATED PUBLICATIONS

Principle sketch of the folding system
Impressions during construction
Unlimited folding and sliding options
Sparkasse Ludwigshafen
New façades and building services for Sparkasse Vorderpfalz, Ludwigshafen, Germany

Sparkasse Vorderpfalz is a regional Bank in southern Germany. The PhD research “Re-Face” developed a refurbishment solution for this building, which was applied in practise. The major challenge was that the entire building process had to take place while the building was kept in operation. The final solution managed to renew façade and HVAC within 8 working days per floor and improves the energy performance by 75%.

The refurbishment proposal for the office façades takes advantage of the existing service platforms. It places an additional façade layer on the outer position of the service platforms. Vertical profiles, suspended from a steel-framework, which rests on the main bearing structure, carry vertical loads. Horizontal loads are brought into the existing consoles. After the outer façade was closed, the interior façade could be renovated independently of the weather. The sub-structure of the original façade could stay in place. Only the filling elements are replaced by new windows and insulated panels. New climate units are installed inside the cavity.

For the refurbishment of the outer corners of the tower a very simple and effective solution was found. The cavity provided sufficient space for additional insulation. The original aluminium panels have proven to be of a very high quality. They were cleaned, anodized to prevent filiform corrosion, newly coated, and re-mounted onto the existing structure using the old pressure plates and new gaskets. Thus, more than 80% (approximately 700m²) of the old façade could be preserved.

The climate concept uses the double façade. Decentralised HVAC units in each room provide individual ventilation with heat recovery as well as heating or cooling by water-air heat exchangers. In winter, the incoming air preconditioned by solar irradiation and taken from the cavity. Used air is extracted by horizontal ducts directly to the outside. In summer the system is reversed. The stack effect inside the cavity draws air from the rooms; no fan power is needed. Fresh air is fed from the outside.

This project has achieved the European “Green Building Certificate” and the first prize in the international “Re-Skinning Award” in the category “Large Commercial”. 

PROJECT INFORMATION
Project leader: Thiem Ebbert
Executed by: Ulrich Knaack, Thiem Ebbert, Tillmann Klein, Marcel Blom
Period: September 2006 – June 2010
Budget:
Funded by: Client

RELATED PUBLICATIONS (selection)
- Ebbert, T., Evers, R. (2008), „Energetische Gebäudemodernisierung durch kombiniertes Fassaden- und Klima-Engineering“. Symposium Architektur und Glas, Kirchberg im Hunsrück, Germany
- Ebbert, T., Knaack, U. (2006), „The Integral Envelope Applied for Sustainable Office Refurbishment”, Conference on Smart and Sustainable built Environments, Shanghai, China
Stylos Pavilion

Competition, design and realisation of the new Stylos Pavilion

Every five years the society of architecture students of Delft, STYLOS, holds a competition among students to design a pavilion for common use. The chair Design of Construction guided the project organisationally and technically.

The design chosen in 2006 represents a “black box” of 10 by 10 meters which will continuously turn green by plants growing on all five surfaces. The design and construction of the building with its 9 meter high “platform-frame” construction was planned and executed by students of Delft Technical University.

The main structure of the pavilion consisted of only 4 wall units, each measuring 10 x 9 meters, and 5 roof plates of 10 x 2 meters, which were mounted in only one day.

The vertical green facades create the main appearance of the pavilion. The façade was equipped with different species of plants, alternating flowering periods, varying with the seasons of nature. The construction has been widely published and quoted.

PROJECT INFORMATION
Project leader: Ulrich Knaack
Executed by: Ulrich Knaack, Thiemo Ebbert,
Budget:
Funded by:

RELATED PUBLICATIONS
Super Slim Glass Façade system for INHolland, Delft

The Super Slim façade applied in the INHolland Polytechnic of Delft is a result of an initial SIA-RAAK subsidy, supervised by the Composites Laboratory of INHolland which resulted in a real size mock-up, and the further development and research by Octatube with the goal practical application in the new premises of INHolland in Delft. The ambitions were to realise the set-up of the mock-up, but despite extensive testing on parts, details and materials, the associated glass panel manufacturer was not able to certify the glass panels with the integrated tubes.

The initial conceptual ‘wild idea’ for the INHolland project by architect Rijk Rietveld, New York, was elaborated through different design brainstorms towards a radical innovative system for ultra-slim glass façades.

In this façade system insulated glass panels of a depth of maximum 50 mm are integrated with internal pre-stressed structural composite cables, stabilising the façade against wind forces. Dead weight to be taken over by vertical deadweight rods in between the vertical silicone seams between the panels. The insulated glass panels are sealed by composite spacer frames.

Many different solitary tests were done with the sealing and the carbon fibre components, with adhesion of silicone sealant on the carbon fibre frames and on the perforation of the carbon fibre used through the frames.

In the actual engineering phase structural analysis was performed and tests on several levels were executed. The composite frames were substituted by conventional metal frames. Due to the refusal by the glass panel manufacturer to supply a guarantee on inadequate number of tests with inadequate quality, the integrated system had to be changed into a duo-system with internal pre-stressed cables and integrated dead weight suspension rods. The façade had to keep in pace with the progress on site. In this way the two large facades were made.

The third façade, only 3 m wide and 13 m high as well was fully executed according to the original concept with carbon fibre spacers, separate hydrogenic material, carbon fibre tubes and aramid cables through the carbon fibre tubes in the central space of the glass panels. This façade, is regarded as the true experimental façade of INHolland and is watched regularly by the School staff.

Project leader: Mick Eekhout, Peter van de Rotten, Michiel Hagenbeek
Executed by: Mick Eekhout, Ulrich Knaack, Michiel Hagenbeek, Composites Laboratory et al, Peter van de Rotten, Octatube Engineering et al, Barbara van Gelder.
Period: 2006-2009
Budget: € 300.000
Funded by: SIA-RAAK
THE 1.3 METER PLAN

Flood proof and flood robust dwelling typologies for the Netherlands’ deepest polder

New housing can be designed to withstand rising flood waters, without loss of function or the need to evacuate. The 1.3 METER PLAN identifies several typologies of housing capable of dealing with this challenge, and show how they can offer attractive lifestyles in a polder under threat of flooding. A selection of these typologies has been studied with respect to the special considerations required, as well as alternative solutions to solve issues such as access, foundations/ anchoring, waterproofing, technical utilities, health & safety and quality of living.

Climate change involves several complex disruptions in the global balance, and the first thing that - especially in the Netherlands - springs to mind, is the problem of rising sea levels and flooding. Rather than resisting by continuously improving traditional water defences (dikes, seawalls, locks), this problem could also be dealt with adaptively, through building design.

Instead of pushing the water aside (and thereby exacerbating the problem for surrounding areas), it is worth considering whether we can accept these occasional floods, and turn something traditionally perceived as a threat into a positive – and even interesting – phenomenon.

The 1.3m plan shows how new housing can be designed to withstand rising flood waters, without loss of function or the need to evacuate. Several typologies of housing capable of dealing with this challenge are identified, which can offer attractive lifestyles in a polder under threat of flooding. A selection of these typologies has been studied with respect to the special considerations required, as well as alternative solutions to solve issues such as access, foundations/ anchoring, waterproofing, technical utilities, health & safety and quality of living.

It is possible to design dwellings with minor negative consequences in case of flooding, providing unique added qualities while at the same time allowing ample space for emergency water catchment and storage.

As part of the Hotspot programme, a plan for the Zuidplaspolder, presently the Netherlands’ deepest polder, is proposed combining the various typologies, as a showcase for possible future delta habitation.

PROJECT INFORMATION
Project leader: Andy van den Dobbelsteen
Executed by: Andy van den Dobbelsteen, Ann Karina Lassen, Michiel Fremouw
Period: Jun 2007 – Feb 2009
Budget: € 25.000
Funded by: Province of Zuid-Holland

RELATED PUBLICATIONS
• Xporelab; Hotspot Zuidplaspolder – Klimaatadaptatie in de Zuidplaspolder (2009), ISBN 978 90 8815 006 7
THE SLIM-SLIDE BACKING SYSTEM
Fastening freely curved panels quickly with high precision

Fixing freely curved panels to a building usually is costly as all connections must be positioned very precise. Repetition in one of the coordinates, typical for conventional fastening systems, (normally they lie in flat panes, sometimes in cylindrical planes), doesn’t happen in Freely curved facades. With the variation in coordinates, until now fastening panes to facades was extremely labor-intensive. The researchers developed a new fixing system, that save hugely on assemblage, and improves the facade appearances.

To showcase four fluently interconnecting freely curved glass panels, that researchers of the Blob Facade Cladding Group, they produced a frame to hold the panes.

To achieve regular curving reflections, both the panels and the backing system were produced with very high precision.

The backing system follows a completely new concept. By parametric drawing procedures, the data were produced to cnc cut the components. They are all uniquely shaped.

Assemblage is like a 3D jigsaw puzzle. Components slide together with such small tolerances that no adjustment at the fixings is possible – or necessary.

Each column has six fixing points for the glass. The only adjusting of the column is done where it connects to the floor.

This implies a great reduction on assemblage time, and greatly reduces adjusting mistakes, inherent to manual operations. The system saves greatly on labour and results in an extremely exact positioning of the panes.

PROJECT INFORMATION
Project leader: Dr Ir Karel Vollers
Executed by: Karel Vollers (Chair of Product Development)
Daan Rietbergen (Chair of Design of Construction)
Period: Jan 2010 – Jan 2012
Budget: € 200,000
Funded by: SenterNovem

RELATED PUBLICATIONS
- Development of sustainable moulds as a necessity to improve production sustainability of freely doublecurved glass, Proceedings of Bologna Delft seminar, November 2005
- Upgrading building appearances by improved reflections on glass panes
  Glass Processing Days June 2007, Tampere, Finland
Tubular Structures in Architecture

A book on the contemporary technology, composition and architectural appearance of steel tubular structures in architecture and the mutual relationship between the technology of tubular structures and architectural design and detailing.

Goal
Inspirational texts and illustrations from current international practice and descriptions on topics related to the use of tubular structures in architecture as an inspirational source for readers: architects and architecture students. How has the recent tubular technology influenced contemporary architecture? How will future developments influence future architecture further?

Research Question
What is the special appearance of tubular structures in architecture, what is their unique contribution to architectural quality and how is this appearance realized? What future developments from tubular technology and influential on architecture are expected? How is futuristic architectural design originating new developments in tubular structures?

Strategy
The first edition of this book was published in 1996 in 5 languages; English, German, French, Spanish and Dutch and was printed 25,000 copies. Sold out after 2 years. The times have changed and the tendencies for tubular structures now also encompass free form design. The text has to be rewritten and most of the illustrations have to changed and updated.

Expected Results
A new book co-edited by Cidect, Geneva, in more than the original 5 languages for popularization of tubular structures amongst architects and structural engineers, for architectural students and structural engineering students. Size around 170 full color pages.

RELATED PUBLICATIONS

PROJECT INFORMATION
Project leader: Mick Eekhout
Executed by: Mick Eekhout
Period: 2008 - 2010
Budget: 150,000€
Funded by: Cidect and tube manufacturers
University of Bielefeld
Feasibility study on the refurbishment potential of Bielefeld University, Germany

The University of Bielefeld was built in the 1970s. Today the building envelope and building services are outdated in terms of performance and appearance. Within the PhD research “Re-Face” this project has played a major role as a case study. It contributed important findings in the areas of function, climate concepts, and construction process for the large field of façade refurbishment.

For the campus, four different strategic approaches have been developed, which consider the structural conditions and future use of the 300,000 m² building complex. The proposed façade refurbishment solutions span the range from a simple restoration of the existing buildings, via the addition of a double façade, to the replacement of the original building envelope with a new façade that contains all HVAC installations and permits very flexible up-and downgrading of function according to the individual users’ needs for each room. Furthermore, a concept has been developed, which takes advantage of the building geometry and covers the open courtyards with huge “climate gardens”. These do not only generate additional usable space but also reduce the demands for the original building envelope, and are part of an intelligent climate concept.

All of these proposals have been evaluated on their energy saving potential, the practical applicability, and the associated life-cycle costs. The results show that even the “wrap-up option” is competitive and results in lowest operational costs in the future.

Comparison of Life-Cycle Costs

Related Publications
VIP A B C

Analytical models for calculating thermal bridge effects caused by high barrier envelopes around vacuum insulation panels

A Vacuum Insulation Panel (VIP) is an innovative thermal insulator which has recently caught the attention of the building sector. These panels were subjected to scientific inquiry in a doctoral research project which was successfully defended on 1 February 2010. In the framework of this study, eight refereed journal articles were published or will be published soon. One of these articles discusses the influence of thermal bridge effects on the overall thermal performance of VIPs. This article is presented below.

Although VIPs are thermal insulators with very low centre-of-panel thermal conductivity, their effective thermal conductivity is raised significantly due to large edge heat fluxes caused by a continuously enveloping barrier laminate, especially if metal based foils are applied. This paper therefore presents and validates two analytical approximating models for calculating this thermal edge effect for thin barrier laminates around VIPs.

The proposed models on the one hand complement existing numerical and experimental data and on the other hand demonstrate that the linear thermal transmittance, representing this edge effect, amongst others depends on envelope thickness and thermal conductivity, panel thickness and centre-of-panel thermal conductivity. By showing these influences and by giving prediction values, the models will help designers and manufacturers in creating thermally well-performing vacuum insulation panels.

A comparison of these models with numerical simulations shows that they can be applied with an inaccuracy of less than 5% for idealized laminates, considering the limitations specified. Moreover, this paper shows that these models are able to estimate the linear thermal transmittance resulting from more realistic VIPs with seams near their edges, as well. For these realistic panels, deviations between numerical data and prediction model maximally amount to about 9%. A limitation of the models’ validity however relates to the thickness of the barrier laminate at the panel’s edge. This thickness should be smaller than 1 mm or a few millimetres.

PROJECT INFORMATION
Project leader: Martin Tenpierik
Child: Martin Tenpierik and Hans Cauberg
Period: 2007
Budget: Funded by:

RELATED PUBLICATIONS
Visual Comfort for Seniors

Measurements and questionnaires in senior dwellings and nursery homes

The sharp rise of the ageing population is a problem of the near future, but poses new challenges for the building industry. More senior dwellings are needed and the independent generation of the 60+ people will demand a high level of comfort. In this research we pay attention to visual comfort for seniors. Elderly eyes need a higher level of light and luminance contrasts than the young ones, but glare and veiling images causes more problems. So, it demands other requirements and design rules for senior dwellings then for buildings in general.

Objective
To develop requirements and design rules for the visual comfort in senior dwellings and nursery homes.

Main research question
In which way are parameters of daylight and outside view different for seniors in comparison with young people.

The study
Exploratory measurements were done in 5 senior dwellings and a nursery home in order to see what kind of lighting levels are present in the senior environment. After that, the real research was start.

10 dwellings and 4 nursery homes were visited. Seniors were asked to answer questionnaires about the indoor visual climate. In case of the nursery homes caretakers were asked too.

Measurements of the illuminance levels were done in living rooms of the senior dwellings. Photographs with the luminance camera were made in order to see the luminance contrasts.

In the nursery homes the same measurements of illuminances and luminances were done, not only in the personal living rooms of the seniors, but also in the corridors, the restaurants and the common rooms.

This is an ongoing study, so more dwellings and nursery homes will be studied, but the first results show that mostly only in the neighbourhood of the windows the light levels are high enough for reading and needlework. The corridors show sometimes poor lighting situations, for seniors to read a simple inscription or for caretakers to hand out medicines.

Designers not always create comfortable situations for seniors sitting in their homes

Seniors prefer a chair in the neighbourhood of the window to read a book or to do their needlework (real situation with a fish-eye lens and false color picture of the luminances)

With only a vertical illuminance of 13 lux this senior asked help to read the inscriptions at the drawers

PROJECT INFORMATION
Project leader: Truus de Bruin-Hordijk
Graduate students: Anouk Pelzer, Dennis Bankersen
Period: January 2008 – ongoing

RELATED PUBLICATIONS
- P.R. Boyce, Human factors in lighting, 2e druk, Londen: Taylor & Francis 2003, Hoofdstuk 12: Lighting for the elderly
- Visueel comfort voor ouderen – graduate study Anouk Pelzer
- Licht en senioren – graduate study Dennis Bankersen
A New Indoor Climate

Comfort, health and productivity: importance forgotten

In only 11% of the buildings the occupants are satisfied about thermal comfort and in 26% of the buildings they are satisfied about the indoor air Quality (see opposite figure). Furthermore in naturally ventilated or free running buildings the occupants are more satisfied than in air-conditioned buildings. In air-conditioned buildings the goal is to maintain narrow temperature limits and high ventilation rates for high comfort. So fossil fuels are burned to obtain higher levels of dissatisfaction and health symptoms. This paradox is highly unwanted.

But it is even worse, in airconditioned buildings health symptoms are higher at higher temperatures in winter and lower temperatures in summer. A waist!

Often, these airconditioning systems are necessary to control the climate in large office rooms or office landscapes. However, research also shows that the larger the office space gets, with more occupants sharing that space, the higher the dissatisfaction and health symptoms will be (see opposite figure).

What we need is a new view on thermal comfort and office layout. Recent research show that people adapt remarkably to their prevailing indoor environment and use adaptive opportunities to adjust their thermal comfort to the average temperature in a building. This temperature should therefore be predictable and following the natural outdoor fluctuation. Control over the environment is crucial to adjust personal perception to the prevailing levels of the indoor environment. This can not be achieved in large office spaces.

So to create a comfortable, healthy and productive office environment the climate should be free running over a span of outdoor temperatures as wide as possible (see opposite figure).

Office layout should be a combination of various smaller spaces, preferably in 1 or 2 person rooms for work that requires concentration. Larger room, with adequate acoustics could be used for interactive work.

Chapter “Robust climate design” by Stanley Kurvers in "The Brainworker", edited by Iris Bakker
Adaptation to Climate Change: A Spatial Challenge

Climate change adaptation seen as a challenge for spatial planning

Climate adaptation is often seen as a technical problem. Because of this thematic professionals each try to tackle the problem. This approach leads to thematic oriented standards and sectoral solutions. The solution in one sector can lead to new problems in another. Therefore integrated spatial solutions offer the possibility for innovative, extraordinary and climate adaptive plans. The book describes national and international examples.

The key statement of the book is that better results can be reached if climate adaptation is tackled in an integrative manner. Subsequent chapters describe (inter)national examples for different issues: Climate adaptation strategies, Design as solution, Coastal climate projects, Water management examples, Ecological climate projects, Energy and spatial planning, the Urban environment and a foresight for a future climate and energy landscape.

Endorsements:

"Mounting evidence suggests climate change is going to be much worse much sooner than most people expect with little chance remaining of capping the rise in global temperatures at just two degrees and no better than a 50-50 chance of stabilising at a four degree increase. So a book like this is absolutely vital as a guide to what we can do and how we can cope".
Ken Livingstone, former mayor of London

"We must urgently phase out coal emissions and move to the post fossil fuel era, if we wish to preserve a tolerable planet for our children and grandchildren. Yet even so, society must prepare for some effects of climate change that have become inevitable. This book shows how."
James E. Hansen, Director NASA Goddard Institute for Space Studies and Adjunct Professor Earth and Environmental Sciences, Columbia University, New York

"Climate change is one of the biggest global problems mankind faces in the next centuries. People all over the world will need to save energy and use sustainable resources only. Meanwhile, they need to adapt to the effects of climate change urgently. In this book a very important contribution is made on the possibilities of spatial planning and design to enhance a high-qualitative adaptation, which can be applied over the entire globe."
Prof. Dr. Victor Sergeev, MGIMO University - Center for the Studies of Global Problems, Moscow, Russia

"The necessity to adapt to climate change offers us also a chance: this enhances us to improve the spatial quality of regions and to create valuable, liveable and worthwhile landscapes and urban environments. This book illuminates the way adaptation to climate change can be tackled in a spatial way. The many examples from Groningen province illustrate our frontrunner position in this field."
Marc Calon, Regional Minister of Spatial Affairs, Finance, Area Development and Estate Development Corporation Policy, Province of Groningen
Book of chairs

Overview of all building related chairs ate the faculties of the 3TUs in the Netherlands that have been filed as being interested and capable to do building research. In this overview all chairs of the faculty of Architecture at TU Delft and TU Eindhoven, of Civil Engineering at TU Delft and the faculty CTW U Twente, a number of supporting chairs at the faculty of TBM TU Delft and the Institute OTB at TU Delft. In all there are 91 chairs and research groups contained in this overview.

Mobility / Space
The study ‘Randstad 2040’ was made from the ministry of ‘VROM’. How will the Netherlands function in 30 years time? Shall we scout the future and deduct the nearer future?

Mobility / infrastructure
The Netherlands are open and internationally orientated. A crossing of contacts, networks and infrastructure. The Singapore of Western Europe.

Environment / Town
Environment requires in a densely populated Netherlands continous attention: higher and deeper cities and more intense at pedestrian level.

Environment / Renovation
Example Rotterdam, but there is also ‘Brabantcity’. The Dutch Housing Corporations will invest 40 biljon Euro in renovations in the coming decade. Failure costs (10-20%) to be dramatically reduced.

Health / Health
The theme of Health knows 2 subthemes: Health and Safety both with their typical aspects and stakeholders.

Health / Safely
Health contains hospitals, housing for the elderly and domotics. Safety not only human but also material: structural safety of buildings.

Energy / Energy
Energy knows a production and consumption side. 99% of the existing buildings and houses need drastic renovation/updating. Also psycho/sociofactor and industrial design are important.

Energy / Sustainability
Sustainability: We educate 20 students per year and the Netherlands need a few hundred per year in the coming decade. There will be a gigantic sustainability update challenge!
Bridging the gap

Final report starting scouting for the 3TU Spearhead Building Research 2010-2015

3TU Building Research has as its goal to valorise the knowledge and insight of the 3TU Building Faculties in the Netherlands towards society. To stimulate the built environment and the building sector in its future development. The research programming on the Dutch building faculties will be directed for a major part to the academic contribution to urgent and critical societal challenges. The idea is that working on societal challenges will involve societal parties in the research of academia and will lead to funding of research from that side.

Eighteen societal problems were listed and concentrated into an entire new programming around 4 themes: Mobility, Environment, Health and Energy. Each theme to consist of two sub-themes: Space & Infrastructure; Town & Renovation; Health & Safety; Energy & Sustainability. The idea being to study these aspects, to propose interesting new ideas and projects and together with external partners on the subject tender for project financings. In taking societal challenges and collaborating with specialists, there is external funding possible for 3TU research PhD students. So that in a duration of 5 years a complete new programming will be build, completely externally funded based on societal challenges, in stead of the current programming mainly built on the specific interests of the professors.

In the new 3TU Building Research programming starting 2010 onwards and gradually substituting the existing building research programming, design has a major position for two reasons:
1. Design is an important part of the trio Design, Development & Research, as it connects research to society. Design is a tunnel between fundamental technical research and society.
2. In order to get a grip on the future the building sector is taken in the coming generation of 30 years, the first activities would concern the Design, Development & Research Laboratory Netherlands 2040, targeting at scenarios of the built environment around the year 2040, 30 years form now, that suits the then society. For that reason all society problems have to be taken up as societal challenges and combined into future scenarios. In these scenarios designers are leading the research.

RELATED PUBLICATIONS
- Eekhout, M., Bridging the Gap – 3TU Spearhead Building Research, Lecture 20th May 2010, Eindhoven

PROJECT INFORMATION
Project leader: Mick Eekhout
Executed by: Mick Eekhout, Frans Bijlaard, Geert Dewulf, Frank van der Hoeven, Bert Snijder, Joost Wallaven
Period: January 2009 – December 2009
Budget: € 153,000
Funded by: 3TU
Imagine Book Series

Topic related, inspiring books with background information and concept ideas

The Imagine Book Series investigates technology and materials developments to provide architects and designers with ideas for their design. Published: facades, deflateables and rapids.

In preparation: energy, performance driven envelope, friends in mind....

A sneak peak into the content of the books

PROJECT INFORMATION
Edited by: Ulrich Knaack, Tillmann Klein, Marcel Bilow
Authors: Ulrich Knaack, Tillmann Klein, Marcel Bilow and guest authors related to the book topics, to be named up to now:
Holger Strauss, Raymon van Sabben, Lidia Badarnah, Arie Bergsma, Linda Hildebrand, Daan Rietbergen, Thiemo Ebbert and others.

Period: started in 2008
Funded by: TU Delft

RELATED PUBLICATIONS
- Knaack, Klein & Bilow; imagine 01 facades, O10 Publisher, Rotterdam, 2008
- Knaack, Klein & Bilow; imagine 02 deflateables, O10 Publisher, Rotterdam, 2008
- Knaack, Strauss & Bilow; imagine 04 rapids, O10 Publisher, Rotterdam, 2010
MIA Bouw
Societal Innovation Agenda for the Building Sector from 2010

The Dutch cabinet has initiated several Societal Innovation Agendas. In 2009 discussions are initiated from the ministry of Economic Affairs to stimulate the formation of a SIA for the building sector. Actually it is directed to the Built Environment, which is believed to be formatted tightly around the future needs of the future society of the Dutch society, like a glove fits over a hand. Scouting Research will be done for the future of the Netherlands in 2040. The building sector adapts the current built environment by her adaptations accordingly.

The Dutch built environment has to be adapted according to the challenges and problems that besiege the Dutch society in the coming decades. Effectiveness and efficiency in economic means are of major importance in the 2010s when economic means are becoming more scarce and the usual growth is substituted by occasional growth and occasional shrinkage.

The critical societal challenges are amongst others: Population, Ageing, Prosperity, Individualisation, Process complexity, Mobility, Safety, Accessibility, Energy, Building efficiency, Sustainability, Legal complexity, Performance of services, Cultural experience, Urbanization, Building in the delta, Health and Information services.

In the discussions on the future of the built environment and the building sector, it is not important to keep the current building sector upright in size and organization, but to adapt the capacities of the building sector in all of its different segments (principals and clients, architects and engineers, contractors and suppliers, governments and authorities) to the actual and future needs of society.

This society-directed or demand driven approach will result in another result than the supply driven approach of the recent decades. Due to the different crises like the credit crisis, the housing crisis, the environmental crisis, the food crisis and so on that are recognized to torment society since the turning of the millennium, a complete new approach of the existing, the adapted and the new environment is required. Inevitably this will lead to a penetrating change of relationships and capacities in the building sector. The current size of 400.000 workers will be changed radically according to requirements and means of the building sector, which is only a minor part of society.
Principles of Construction

Educational book series
Birkhäuser - Basel, boston, Berlin

Principles of Construction is an educational book series which provides young professionals and students with systematic structured principle knowledge of building technologies.

The amount of building construction related knowledge and the amount of existing constructional solutions are enormous. There is no point in attempting to create books that contain all this knowledge and all these solutions since this would lead to a voluminous, expensive and rapidly out-of-date product. Moreover, it would not challenge or tempt students or young professionals to design their own constructional solutions because many solutions are already given.

Thus, the concept is to describe problem types and solution types on an abstract level, suitable for a technical understanding. The main task is to identify and describe the typology of problems and solutions in a systematic manner. The aim is not to describe as much as possible, but as little as possible, to give the reader a theoretic foundation, that can be used for his/her own design.

A series of books was developed that organizes the principle of construction according to different topics and perspectives.

The following books are published:
Meijs, Knaack: Components and Connections
Knaack, Klein, Bilow, Auer: Facades

The following books are planned:
Knaack, Chung-Klatte, Hasselbach: Systems
Knaack, Techen: Structures and Function
Knaack, Klein, Bilow, Meijs: Material and Detail

Publisher:
Birkhäuser – Basel, Berlin, Boston
All books are published in German and English.
The Future Envelope
Scientific book series
IOS Publishers, Amsterdam

The Future Envelope is published in the series “Research in Architectural Engineering”. It focuses on the future role of the building envelope for our architectural environment.

Façades convey the image of new architecture. Today, the planning of this very complex building component requires a collaboration of many specialists. A multitude of possibilities are being projected into the building envelope. Design, visionary construction, new materials, the desire to achieve optimum energy performance or even energy generation all meet with predominantly conventional crafts. What is the future of the façade and how can we get there? What are current trends and future developments?

What all books of the series have in common is a multidisciplinary approach. Speakers from different fields share their experience and their visions. This creates new insights about the future role of the building envelope in terms of design, construction and building processes. The Future Envelope originates in the annual conference at the TU Delft with the same name. The conference submissions are discussed and developed into a coherent content.

The following books are published:
Knaack U., Klein T. (Eds.), 2007: Future Envelope 1 A Multidisciplinary Approach
Knaack U., Klein T. (Eds.), 2008: Future Envelope 2 Architecture-Climate-Skin

The following books are planned:
Knaack U., Klein T. (Eds.), 2010: Future Envelope 4 Next Generation

Publisher:
IOS Press, Amsterdam
The books are published in English.
Tietgen Dormitory by Lundgaard & Tranberg
Department Wide Projects
Adaptive Building Systems
Materials - Tools - Concepts

The design process in architecture and engineering involves various methods to develop the shape, the topology and the materials of a building. Obviously this depends on the type of building, the boundary conditions and lots of other aspects, such as architectural, technical, ecological, social or economic concerns. Consequently there is an interesting interaction between the above mentioned design drivers and design enablers, such as new materials, new tools, new manufacturing processes, which will be within the research focus of the AE Chair.

Various design aspects influence the building performance such as architectural criteria, multiple environmental impacts and user behavior. Specific examples are sun, wind, temperatures, function, occupancy, socio-cultural aspects and other contextual aspects and needs. Even though these aspects are acknowledged to be variable, conventional buildings are conceived to provide one design solution, represented in a static configuration. Due to the changes in needs and context, a static building cannot guarantee the same level of performances over time.

This will lead to a discrepancy between the building and the environment. On a long term, this discrepancy is currently approached through refurbishment and transformations; on the short term this discrepancy is currently tackled through minor refurbishment and installations. However, conventional buildings are not designed for adaptation to contextual aspects and needs. Current adaptation on both short and long term will lead to a considerable amount of effort and costs. The Adaptive Building System group focuses on the instant adaptation of the building, in order to facilitate an effortless adaptation to context and needs. Different levels of adaptation are defined within our research group.

The purpose of this collaboration is knowledge transfer between the different levels and disciplines within the subject of adaptive building systems. Two main levels are approached based on interdisciplinary collaborations: the integral interdisciplinary design process and the integration in architecture of advanced technical solutions. On the design process level, an integral design approach is in fact needed while tackling building performances; on the other hand, developments in different fields on the level of technological innovation should be integrated on the architectural level.

PROJECT INFORMATION
Project leader: Patrick Teuffel
Executed by: Lidia Badarnah, Michela Turin, Christian Friedrich, Nora Schueler, Tomasz Jaskiewicz, Noortje Alders, Charlotte Leleveld, Florian Henszelmann
Period: from 2008
Budget: to be confirmed
Funded by: misc

RELATED PUBLICATIONS
Solar Decathlon 2011/12

Student competition for designing and building 75m² homes exclusively powered by solar energy

Buildings account for one third of the total energy consumption worldwide and are equally responsible for their share of CO2 emissions. Further do the building industries produce 25-40% of all solid wastes worldwide and use approximately one half of all primary resources.

TU Delft Building Technology with the chair of Architectural Engineering currently contributes as an advisor for the successful application and participation of the University of Tennessee for the next US Solar Decathlon in 2011.

The Solar Decathlon is originally a competition organized by the U.S. Department of Energy in which universities from across the globe meet to design and build an energetically self-sufficient house that runs only on solar energy and incorporates technologies that maximize its energy efficiency. In a selection process 20 Universities are chosen to design their solar powered house which is eventually built up before the actual competition period at the National Mall in Washington DC. The whole process is accompanied by seminars, workshop and public relationship events, where the final display in Washington attracts 307,502 house visits by the public over the course of ten days.

The current American Solar Decathlon and the incredible success of the TU Delft with the Nuon Solar Team and their Nuna race car inspires us to set up a similar team, for developing a energy efficient Solar house in order to participate for the European Solar Decathlon in 2012.

Solar Decathlon Europe
For the first time, this year will be a similar event in Europe. For that reason the Government of Spain’s Ministry of Housing and the United States Government signed an agreement to organize independently the Solar Decathlon Europe (SD Europe) with its own selection process and teams from different universities.

For the next round of the European Solar Decathlon in 2012 TU Delft Building Technology in collaboration with the TU Delft Energy Club are currently in the preparation phase to make this new endeavor a success.
alleen namen op posters?
of wel iedereen?

Christof Erban
C.eurban@tudelft.nl

Ipek Gürsel
i.gursel@tudelft.nl

Eric van den Ham
e.r.vandenham@tudelft.nl

Alexi Herve
a.j.herve@tudelft.nl

Irem Erbas
i.erbas@tudelft.nl

Irene Hildebrand
i.hildebrand@tudelft.nl

Geertje Hobbeiman
gi.hobbeiman@tudelft.nl

Ronald Hogendoorn
7. CONTACT

GENERAL
http://www.bk.tudelft.nl/bt/
+31 (0)15 2784094
bouwtechnologie-bk@tudelft.nl

VISITING ADDRESS
Department of Building Technology
Julianalaan 134
2628 BL Delft

POSTAL ADDRESS
Delft University of Technology
Faculty of Architecture
Department of Building Technology
P.O. Box 5043
2600 GA Delft