



**BYG•DTU**

**Research evaluation 2007  
Self evaluation report**

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**1. Summary and conclusion**

This self evaluation report is prepared by Department of Civil Engineering, Technical University of Denmark, BYG•DTU in October 2007. It is part of the material provided for an expert panel that shall carry out a future oriented evaluation of BYG•DTU's research in November 2007.

BYG•DTU's mission is research, education, industrial collaboration, and public sector service. The evaluation is limited to research. The research areas are: Construction materials, Geotechnics, Building physics and services, Structural Engineering, and Planning and management of building processes. The department is organised in five

sections corresponding to the five research areas. The section for Geotechnics is host for ARTEK; DTU's centre for interdisciplinary Arctic research. The 2006 turnover was 8.6 M€ (6.1 M€ from DTU as basic grant and 2.5 M€ from external sources). Out of the basic grant more than 56 % was spent on education, leaving only modest resources for free and co-financed research. The external funding is achieved from a wide range of diverse sources, reflecting the limited focus on construction in national and European research policy. The total staff was 160 (64 faculty and research, 46 PhD fellows, 50 technical and administrative). The technical resources include laboratory facilities and IT infrastructure at an international level.

It is the department's strategy to be broad in education and well oriented in state of the art for all our research areas, whilst we realise that international excellence can only be achieved within more narrow research topics. Thus the research groups have selected a number of research topics within the five research areas where we aim to reach an excellent international level. Our ambition is to bring together most disciplines needed for design, implementation and operation of construction projects. We consider integration of, and synergy between, disciplines as very important for the future development of the construction sector, thus the department supports interdisciplinary research across research groups and sections. A common goal for our research is to contribute to the development of an innovative and research based construction sector. We wish to do this by initiating integrated research activities together with industry and by enhancing awareness of the importance of construction research in industry and among policy makers. BYG•DTU's science is subject to international peer review. The publication record is comparable with civil engineering departments in renowned European technical universities. Besides academic publication the department also considers applied research reports, phd-thesis, patents and other practice oriented output as important ways of dissemination our research.

A key element in the self evaluation is a general SWOT analysis for the department as a whole and supplementary SWOT analyses for each research area. The general SWOT analyses show that that the department has a strong basis for development; the staff composition has undergone a renewal and the department has gained increasing reputation in industry. This together with a strong recruitment base in popular education programmes has established a strong basis for future development of research at a high level. The weaknesses and threats are mainly related to resource considerations; the relatively large education burden, recruitment difficulties and small external funding possibilities. However the research output also has to become of better quality and be more visible. Increased cross disciplinary research is seen as one way to achieve this. Opportunities are related to increased awareness of the importance of construction research, not least related to energy and sustainability issues. The sectional SWOT identify a number of specific challenges, the reader is referred to section 6.1 – 6.5 for details.

**2. SWOT**

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Renewed staff, ongoing generational change</li> <li>• Engaged, creative and flexible attitudes among researchers</li> <li>• Research strategy with a balanced width and depth</li> <li>• Comprehensive interaction with industrial and public partners in construction</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Lack of time for research due to teaching obligations and administrative tasks</li> <li>• Hitherto a too weak publication record</li> <li>• Too little cross-disciplinary research involving collaboration with other sections in the department.</li> <li>• The research organisation needs to be more professional (preparation of</li> </ul>
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<ul style="list-style-type: none"> <li>• Popular education programmes with high quality students.</li> <li>• Increased student involvement in faculty work and research projects</li> </ul>	<ul style="list-style-type: none"> <li>guidelines, general feed-back from research projects)</li> <li>• Collaboration and synergy between the increasing number of PhD projects needs to be strengthened</li> <li>• Insufficient administrative support (economy system, contract handling)</li> <li>• Old technical research infrastructure</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Improvement of international visibility and network by means of visiting professors etc.</li> <li>• A general development of the building sector to become research based instead of experience based may be stimulated by research activities in the department</li> <li>• Open faculty positions</li> <li>• Increased synergy with new DTU management department</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• EU and national research funding policy tends to ignore the need for construction research, increasingly complex application procedures, depletion of DK and DTU funds</li> <li>• Lack of domestic research community (financing, relevance, cooperation, etc.)</li> <li>• Difficulty in attracting staff: open positions for professorships, limited number of PhD students, and risk of brain drain in an increasingly competitive market</li> <li>• Teaching load increases – directly or indirectly (new forms of teaching and its evaluation: e.g. CDIO)</li> <li>• Loss of synergy between planning and management disciplines and technical disciplines following reorganisation of DTU</li> </ul>

Table 1: General SWOT analysis for BYG•DTU. Specific SWOT analyses for sections are given in sections 6.1-6.5.

### 3. Introduction

The Technical University of Denmark, DTU, has decided that the research of all departments shall be evaluated every five years. This year the Department of Civil Engineering, BYG•DTU, is chosen for evaluation. The aim of the evaluation is to have quality, quantity and prospects of the research effort assessed by a panel of world leading experts in order to enable a comparison with activities at similar university departments and to ensure that the department strategy (Annex 3) is right. The assessment is based on a three-day site visit during November 14-16, 2007 and concluded with a short report by the panel. Prior to the visit BYG•DTU has prepared the present self assessment report and made it available for the panel. The panel consists of six persons, covering the different fields of research of the Department of Civil Engineering:

Carl-Eric Hagentoft, Chalmers  
 Alberto Carpenteri, Politecnico di Torino  
 Sarah Springman, ETH  
 Arnon Bentur, Technion Israel  
 Stuart Green, University of Reading  
 Bjørn Lykke Jensen, Teknologisk Institut

The research evaluation is also part of BYG•DTU's development plan for 2008-11, UMV (Annex 4). The UMV establishes increased research quality and international recognition

as the highest prioritised goal for the planning period 2008-11. The research evaluation is intended to establish a benchmark for checking this goal by the end of the planning period. Also BYG•DTU's strategy 2008 is coming to an end, and the research evaluation shall serve as a concluding activity for the strategy period and be a basis for the department's ongoing strategy renewal activities.

#### **4. Institute profile**

Department of Civil Engineering - BYG•DTU is a university institute within the civil engineering area. The department web-page is found at: <http://www.byg.dtu.dk>.

##### **4.1 History**

The history of civil engineering at DTU began at the 'Polyteknisk Læreanstalt' on November 16. 1857. During the years civil engineering was divided into an increasing number of small departments and laboratories such as: Structural Engineering, Geological and Geotechnical Engineering, Building Materials, Thermal Insulation, Building Design, Roads, Transport and Town Planning, Construction Management, Graphical Communication, Environmental Engineering, Hydrodynamics and Hydraulic Engineering, and Acoustics. BYG•DTU was established in 2001 in order to unite the technical disciplines applied in the construction cycle. This included all the departments mentioned above except environmental, hydraulic, and acoustic engineering. The scientific staff have during all the years actively implemented their knowledge and research results in practice: For example BYG•DTU researchers contributed to The Great Belt Bridge, DTU's Zero Energy House, La Grande Arche in Paris, and implemented research results on low-energy buildings in the building code.

##### **4.2 Vision**

The vision is to become a leading European civil engineering institution and through this becoming a preferred partner in collaborations with companies and institutions in the construction sector.

##### **4.3 Mission**

BYG•DTU contributes to the establishment of social and commercial values through knowledge development within civil engineering. The department contributes to all of DTU's four *raison d'être*s:

- Research
- Education
- Innovation (industrial collaboration)
- Public sector research and consultancy

#### **Research**

The present evaluation is restricted to research. Section 5 elaborates on research.

#### **Education**

BYG•DTU manages the following education programmes:

- BEng (Civil Engineering), 3½ year programme, annual uptake: 120
- BEng (Architectural Engineering), 3½ year programme, annual uptake 45
- BEng (Arctic Technology), 4 year programme, starting with 1½ year in Sisimiut, Greenland, annual uptake 10-20
- BSc (Civil Engineering), 3 year programme, annual uptake: 60
- MSc (Civil Engineering), 2 year programme, annual uptake: 90
- MSc (Architectural Engineering), 2 year programme, annual uptake: 45, starting 2008

These programmes are among DTU's most popular, and admission is restricted using admission grade criteria. Both MSc programmes are given in English and the uptake of international students is increasing.

## Innovation

Industry collaboration (innovation) is given increased focus; especially the number of industry-PhD projects is increasing. The industry PhD is a Danish PhD-programme where the Ministry of Research part finances the cost of a PhD-project where the student is employed by a private company.

BYG•DTU manages the continued education Master Programmes:

- Master in Fire Engineering, 2 year programme for ½ time study, biannual uptake 30-40, tuition fee: 9,000 €
- Master in Construction Management, 2 year programme for ½ time study, biannual uptake 15-20, tuition fee: 12,000 €

The Master Programmes are fully financed through the tuition fees.

## Public sector research and consultancy

Public sector research and consultancy was included in DTUs portfolio through the merger on January 1<sup>st</sup>, 2007, see section 4.3. BYG•DTU is currently investigating if public funding can be established for a research group in road building engineering.

## 4.4 Organisation

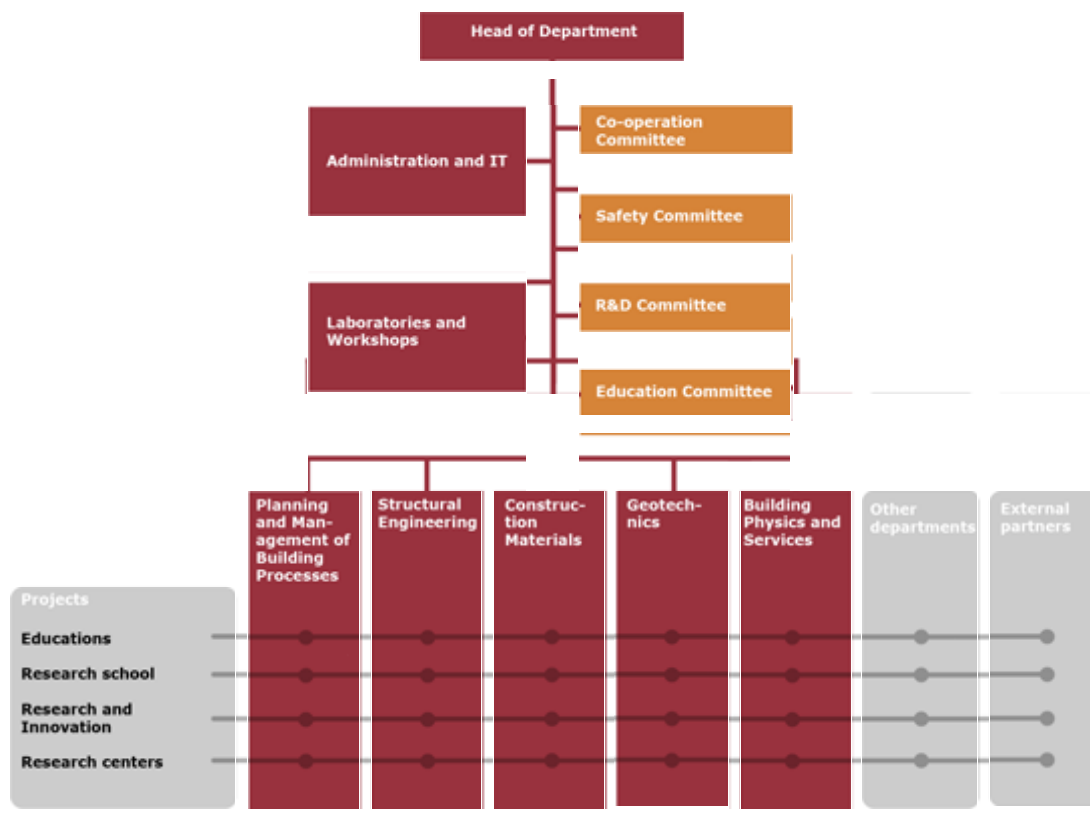


Fig. 1: Organization for BYG•DTU

## Sections and Departments

BYG•DTU is organized in sections with a professional identity, corresponding to the research focus areas. Joint institute resources are organized in sub departments.

## Committees

Transverse coordination of activities in education, research and innovation as well as safety and cooperation are carried out through the department committees:

- Education Committee (In Danish: Studienævn), elected as stated in the University Law
- Co-operation Committee, elected as stated in Government Directive
- Safety Committee, elected as stated in Government Directive
- R&D Committee, appointed by BYG•DTU management

### **Project organisation**

Activities are organised in projects that transverse sections, departments and organisations. Transverse co-ordination of projects and collaboration with partners outside DTU may take place in research centres:

- *ARTEK*: Centre for Arctic Technology is an interdisciplinary project organisation focusing on research, innovation and education in the Arctic. ARTEK was established 2000.
- *IRS@BYG*: The International Research School for Civil Engineering at BYG•DTU was created in 2004 to bring together existing activities relating to the education of PhD fellows. Research Schools are instituted by the University law by 2007.
- *C•PROSAM*: The Centre for protective Structures and Materials is a research and industry network with 13 partners. The centre investigates materials and structures under extreme loads such as ballistic and explosive impact. Est. 2005.
- *LavEByg*: High technology networks regarding integrated low energy solutions in buildings is a research and industry network with 98 partners. LavEByg is to ensure that the great potential for energy savings is achieved - both in connection with new buildings and with energy renovation of existing buildings. Established 2005.
- *Centre for Facilities Management*: The Realdania Foundation has accepted a proposal for a 5 year, 3,4 M€ grant for a centre for facilities management research. The centre will be located at BYG•DTU (pending the coming organisational changes, see below) and include researchers from a number of other institutions. The centre will start January 2008.
- *BYG•Innovation*: In order to increase industry collaboration on commercial terms BYG•DTU has established a project organisation BYG•innovation. Since 2007 BYG•innovation collaborates with the DTU controlled private innovation and development company IPU, see [www.ipu.dk/English.aspx](http://www.ipu.dk/English.aspx).
- *National Centre Structural and Materials Testing*: BYG•DTU is heading an initiative to establish a national centre for advanced mechanical testing. The Danish Research Council has prequalified the proposal and financially supports the work for a full proposal. If accepted the centre will be granted 3-6 M€ for advanced equipment and testing facilities.

### **Coming organisational changes**

On January 1<sup>st</sup>, 2007 a number of university and national research institute mergers took place in Denmark. As part of this national consolidation DTU merged with Risø National Laboratory, Danish Food and Veterinary Institute, Danish Fisheries Institute, Danish Space Centre and Dansk Transport Research Institute. Following the merger DTU is undergoing organisational changes. At the present (October 2007) it is not finally decided to what extent these changes will affect BYG•DTU.

BYG•DTU's management expects that parts of BYG•DTU's research groups Urban Management, Construction Management, and Facilities Management, will move to a new DTU department for management engineering. BYG•DTU strongly recommends that the International Centre for Indoor Environment and Energy, [www.ie.dtu.dk](http://www.ie.dtu.dk) be merged with BYG•DTU's Section for Buildings Physics and Services, and that it is considered to integrate Hydraulic (Coastal) Engineering and some elements of basic structural engineering presently being part of Department of Mechanical Engineering; [www.mek.dtu.dk](http://www.mek.dtu.dk) with BYG•DTU.

#### 4.5 Planning cycle and communication

The department strategy was approved by the board of directors at DTU in March 2003. The strategy is put into action through a yearly planning cycle, where the rolling four year developments plan (UMV), the annual actions plan, and the annual report are evaluated and adjusted continuously.

BYG•DTU maintains a Danish and English web site, [www.byg.dtu.dk](http://www.byg.dtu.dk). The site is part of DTU's common web site and content management system. News and research results are posted on the site and RSS feed is available. An increasing number of visitors and news paper quotes show that the site is becoming well established in the Danish Civil Engineering Community.

BYG•DTU supports DTU's Alumni Association, and an Alumni Group for Civil Engineering was established 2005. Today 1881 members relate to BYG•DTU.

#### 4.6 Resources

##### Economy

<b>Economy and research funding</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>
Core funding from DTU	38,2 (5,1)	37,8 (5,1)	38,7 (5,2)	41,0 (5,5)	45,6 (6,1)
External research grants	21,2 (2,9)	10,8 (1,5)	13,5 (1,8)	11,4 (1,5)	11,8 (1,6)
Funding from private sources	7,6 (1,0)	9,2 (1,2)	10,4 (1,4)	7,8 (1,0)	6,5 (0,9)
<b>Total</b>	<b>67,0 (9,0)</b>	<b>57,8 (7,8)</b>	<b>62,6 (8,4)</b>	<b>60,2 (8,1)</b>	<b>63,9 (8,6)</b>

Table 2. Economy. All figures in millions DKK (values in brackets are €). ARTEK funding from the Greenlandic Home Rule is included in the numbers for core funding. The large external funding in 2002 is due to late payment of work done in 2001.

BYG•DTU spends about 56% of its basic DTU funding on education; DTU's average is 40%. The very high percentage for education means that research is under-financed leading to motivation and recruitment difficulties. Thus BYG•DTU strongly recommends that the basic funding be increased in order to free resources for research.

##### Staff

<b>Staff in full time equivalents</b>	<b>2005</b>	<b>% &gt; 60 yr.</b>	<b>2006</b>	<b>% &gt; 60 yr.</b>
<b>TOTAL</b>	<b>155</b>		<b>160</b>	
<b>Faculty and research staff (grand total)</b>	<b>68</b>	<b>16</b>	<b>64</b>	<b>12</b>
<b>PhD fellows (total)</b>	<b>39</b>	<b>0</b>	<b>46</b>	<b>0</b>
<b>Technical and admin. staff (total)</b>	<b>48</b>	<b>28</b>	<b>50</b>	<b>25</b>
<b>Faculty (total)</b>	<b>42</b>	<b>32</b>	<b>46</b>	<b>23</b>
Professors	7	29	8	25
Associate professors	32	38	32	26
Assistant professors	3	0	6	0
Non-Danish faculty	4	0	10	0
Student/Faculty ratio, ("STÅ" pr. Faculty)	12		11	
<b>Research staff, externally funded (total)</b>	<b>26</b>	<b>0</b>	<b>18</b>	<b>0</b>
Research professors	1	0	0	0
Associate research professors	12	0	9	0
Assistant research professors	10	0	5	0

Postdoctoral fellows	0	0	2	0
Research assistants	3	0	2	0
Guest researchers	4	1	5	2
<b>PhD fellows (total)</b>	<b>39</b>	<b>0</b>	<b>46</b>	<b>0</b>
PhD DTU financed	6	0	9	0
PhD Externally financed	33	0	37	0

Table 3: Staff composition

The scientific staffs have since 2004 undergone a large generational change: 16 assistant, 20 associate and 3 full professors have been employed since 2004.

	2002	2003	2004	2005	2006
Number of enrolled PhD fellows	44	42	42	39	46
Number of admitted PhD fellows	8	10	7	7	16
Number of PhD graduates	4	10	10	6	5

Table 4: PhD admitted and graduated

### Technical resources

BYG•DTU's technical research infrastructure includes:

- 600 m<sup>2</sup>, 1m thick reinforced strong floor and experimental hall with associated hydraulic force equipment, workshops, and concrete casting facilities
- Advanced monitoring and testing equipment (ARAMIS, PIV, ESEM, etc.)
- Facilities for minor fire research experiments
- An outdoor area for experimental construction, building envelope, and solar energy research
- Chemical laboratories for a. o. construction materials research
- Geotechnical centrifuge, road building laboratory, geotechnical and geophysical equipment
- Low energy house (demonstration and research facility) in Greenland

BYG•DTU wishes to maintain and develop the experimental facilities at a high international level. The experimental facilities are integrated elements in the strategy for research, education, innovation and public research. This strategic decision implies that a considerable amount of staff and economic resources are allocated to maintenance and operation of the technical infrastructure. It should be noted however that the basic DTU grant does not include funds for investment and depreciation of the technical infrastructure. Thus BYG•DTU is continuously applying for external funding for new technical infrastructure and apparatus. External funding can however not be expected for maintenance, operation and renovation of the technical infrastructure. As a strategic decision BYG•DTU reinvests in IT infrastructure and maintains a state of the art pc-network based IT system linked to the Danish research net and keeps the associated technical and research software updated.

### 4.7 Strategic partners

BYG•DTU researchers are involved in a number of scientific and professional networks notably:

- RILEM: Chairman TAC and EAC
- CIB: Coordinator WG96 Architectural Management
- Fib: Arranges PhD Symposium in Civil Engineering, 2010
- NSB2008: Arranges the Nordic Symposium on Building Physics 2008
- ECTP: Member of the Danish secretariat for ECTP-Denmark
- Cold Climate HVAC 2009: Arranges conference, in Sisimiut Greenland, 2009

BYG•DTU has established collaboration with a number of international universities, notably TUM, Fakultät für Bauingenieur und Vermessungswesen and BYG•DTU, have entered into an agreement on dual degree in MSc civil engineering and on research collaboration as part of the strategic alliance between TUM and DTU.

## 5. Research profile

### 5.1 Research strategy

The Strategy 2003-8 states:

*BYG•DTU focuses its research within the areas: Building Processes, - Planning and Management, Structural Engineering, Geotechnics, Building Materials, and Building Physics and Services. The research is carried out in an international collaboration and has international research level. The international research school based at the institute educates Ph.d.-students at the highest international level.*

#### **Research goals**

- *BYG•DTU conducts research within a well-defined selection of focus areas of key importance for construction processes, buildings and structures.*
- *All focus areas achieve international research excellence and the Department is among the ten best in Europe in at least two focus areas.*
- *Holistically-oriented, interdisciplinary research is conducted through activities and projects as collaborative efforts between several of the Department's focus areas.*
- *The Department has a strong research environment which attracts Danish and foreign PhD students and guest researchers and takes part in the international guest exchange of researchers, PhD students and post-doctorates with leading foreign research environments.*
- *The Department educates 10-15 PhDs and industry-sponsored researchers annually, distributed among all its focus areas. At least half of these enter into external collaborative relationships.*

#### **Research plans**

- *Through the Department's own efforts, collaboration with other research environments and with the assistance of guest researchers, five to ten PhD courses shall be developed in the Department's fields of research. The courses shall be offered in English and shall cover basic aspects as well as cutting-edge research in advanced topics.*
- *The Department shall develop a research plan which covers specific initiatives and follow-up procedures.*
- *The focus areas' network shall be expanded nationally and internationally through collaborative projects and participation in national and EU projects, e.g. the EU's Sixth Framework Programme.*
- *Collaborative agreements shall be established with a number of parties in the building and construction industry, including government research institutes and Authorised Technological Service Institutes.*
- *The generational change at the Department shall be carried out with a view to a targeted strengthening of the research-related focus areas.*

Within the research areas (Construction Materials, Geotechnics, Structural Engineering, Building Physics, Energy and Building Services, and Planning and Management of Building Processes) the research groups have selected a number of more narrow research topics. It is the department's strategy to be broad in education and well oriented in state of the art for all our research areas, whilst we realise that excellence can only be achieved in more narrow research topics. This is reflected in the way the department organises research: The sections are responsible for maintaining a broad state of the art knowledge base within their respective research area. Within each section a number of research

groups, typically consisting of a professor, a few associate and assistant professors and some PhD students have selected a more narrow research topic where they seek to obtain international excellence.

BYG•DTU's ambition is to bring together most disciplines needed for design, implementation and operation of construction projects. We consider integration of and synergy between disciplines as very important for the future development of the construction sector, thus the department supports interdisciplinary research across research groups and sections.

BYG•DTU research wishes to contribute to the development of an innovative and research based construction sector. The EU Barcelona Agreement on a competitive economy states that 3 % of GNP shall be used for research; 1 % from public and 2 % from private funding. The Danish construction sector invests less than 1 % in total in research and innovation, Ref. /1/. In order to pursue the Barcelona goals BYG•DTU research shall inspire and collaborate with industry research. BYG•DTU researchers participate in and initiates innovative industry networks e.g. LavEByg and ECTP, and BYG•DTU conducts seminars and conferences together with industry in order to increase the innovation capacity of our sector.

## 5.2 Publication Strategy

BYG•DTU's science is subject to international peer review. BYG•DTU publishes its research in well renowned peer reviewed papers and discussed at conferences; whenever relevant WoS listed journals are preferred. Since recent years PhD-students are encouraged to publish in WoS journals and compile their thesis from journal articles. Civil engineering publishes few WoS articles compared to other scientific fields. However a recent benchmark, Ref. /2/, shows that DTU publishes more and is quoted more in civil engineering research in WoS than other respected technical universities in Europe.

Publications	2002	2003	2004	2005	2006
Publications indexed in WoS	21	23	26	43	25
Citation impact from WoS	0,90	3,57	1,65	NA	NA
Refereed publications not in WoS	6	12	11	12	16
Published conference papers	62	77	74	112	89
Monographs and books	3	1	5	7	13
Chapters in books	8	18	28	9	14
Patents granted	0	0	2	0	1

*Table 5: Publication data for BYG•DTU, from Ref. /3/. It should be noted that BYG•DTU was established in 2001, and that some articles by BYG•DTU researchers may be published under other affiliations than BYG•DTU. The bibliometric method is described in Annex 1.*

We acknowledge that some disciplines e.g. within building design and architecture and within construction management have publication traditions outside the WoS, thus, and in concert with the overall research strategy's focus on industry relevance, BYG•DTU also considers applied research reports, PhD-thesis, patents and other practice oriented output as important ways of dissemination and quality assurance for our research.

## 5.3 Funding Strategy

The funding possibilities are affected by the lack of public support for research in construction both in Denmark and the EU. In Denmark public funding for construction research is very limited; the entire public sector research capacity (DTU, Aalborg University/SBi, Technological Institute and the Schools of Architecture in Copenhagen and Århus) is evaluated at less than 375 researchers, Ref. /1/. In addition the Danish construction research policy has focused on organisational and efficiency research and

less on technological innovation, thus not favoured a technology oriented department such as BYG•DTU. The recent seventh framework programme is opening for more construction related research, possibly also because of the work by ECTP, and the Danish Ministry of Commerce has recently established a working group on research. To what extent this will influence the Danish priorities remains to be seen.

Because of the limited funding possibilities BYG•DTU is seeking to increase the public funding via lobbying through international and national working groups and networks, see section 4.7. It is not an easy task to alter the research politics in favour of construction; one reason for this is the modest private sector research in the area, and the adjacent lack of support from industry. The limited calls for construction related research has lead BYG•DTU to adopt a rather opportunistic funding strategy, thus the department submits research proposals to a wide range of donors:

- National Research Council: Various calls
- Nordic funding: E.g. NICE innovation funds
- EU: 7th FWP and Regional and Social Funds
- Ministry programmes: E.g. EUDP programme on energy efficiency in buildings
- Private research foundations: Realdania, Kuben and others
- Industry grants: Industry PhD-projects and other collaborative research projects

## **6. Section research profiles**

The research capacity, research area and examples of recent results for each section is described below. The research capacity for each staff category may be evaluated as follows: 1.0 Faculty = 0.5 man year, 1.0 research staff = 0.8 man year and, 1.0 PhD fellow = 0.8 man year.

### **6.1 Section for Construction Materials**

Faculty: 5

Research staff: 2

PhD students: 7 (4 of these externally funded)

#### **Research area**

The research area is construction materials, with the following research topics:

1. Concrete
2. Wood
3. Transport and binding

The research topics have been selected based on society relevance. Concrete and wood are by volume and economically very important construction materials, whereas the subject 'transport and binding' is central for a wide range of properties of porous construction materials in general. The number of research topics has been limited to three to ensure research groups above critical size.

As a common denominator for the research within the Construction Materials Section the focus is mainly at porous materials and their interaction with water. Also the scientific approach has general characteristics: Both experimental and theoretical research is carried out, and in particular emphasis is placed on the coupling of experimental and theoretical research. The theoretical treatment is based on the classical disciplines physics and chemistry in which thermodynamics plays an important role. This enables the understanding and development within construction materials to be structured and scientific. Central research subjects in the Section for Construction Materials concern the relationship between structure, composition and properties as well as the influence of moisture on the properties and use of construction materials.

A long time (+10 years) research goal for all research topics is to contribute to the development of more environmentally friendly, multifunctional and intelligent materials.

Also, an improved quantitative understanding enabling for example performance-based design is sought. Short and medium term research goals for the specific research areas are described below.

Target journals include:

- ACI Materials Journal,
- Cement and Concrete Research
- Holz als Roh- und Werkstoff
- Holzforschung,
- Journal of Applied Electrochemistry
- Journal of Porous Materials and Materials and Structures.
- Materials and Structures.

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Good size of research group</li> <li>• Good experimental facilities.</li> <li>• High productivity: Papers, theses (PhD, DSc), patents, know how transfer, etc.</li> <li>• High international visibility and influence: RILEM, conferences, NanoCem, PhD courses, research institutions and industry</li> <li>• Success in attracting external founding from Danish and international industry and public funds</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Need for upgrade or capacity increase of experimental equipment (e.g. thermo gravimetric analysis, water sorption analysis, X-ray absorption, calorimeter)</li> <li>• Laboratories (unstable climate rooms, storage facilities, concrete lab facilities)</li> <li>• Technical and administrative assistance (knowledge and resources)</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Improve coherence (projects and faculty research: more joint work, implement student projects in research)</li> <li>• Utilize international visibility and network for international projects (EU etc.)</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• See general SWOT, section 2 above</li> </ul>

Table 6: SWOT for the Section for Construction Materials

**Research topic: Concrete**

Research capacity: approx. 5 persons.

The research topic covers both plain concrete and reinforced concrete. The theme focuses on material properties of relevance for the manufacture and use of these materials in civil engineering structures such as houses, bridges and tunnels. The research is focused on achieving an improved and quantitative understanding of the underlying, coupled, multi-scale, chemical and physical relations. The total life cycle is considered from design over manufacturing, execution, operation, maintenance, repair to demolition and re-use; a central topic is the link between nano- and micro-scale materials properties and performance on the macro-scale. With such understanding it becomes possible to tailor materials and methods of manufacturing and execution to a specific structural performance – i.e. to carry out performance based materials design.

Examples of topics for the research in concrete include:

- Fresh and hardening cementitious materials, including early age volume changes
- Hydration and pore structure development
- Transport and fixation of matter
- Durability

Examples of recent research achievements:

- Know-how transfer of a dilatometric technique for measurement of hardening shrinkage in cementitious materials. The equipment has been sold to more than 30 universities and research laboratories around the world.
- Development of a numerical model for simulation of form-filling of self-compacting concrete
- Organization of two international conferences and three doctoral courses within the last two years.

#### Short term goals (1-5 years)

- Establish a common framework for multi-scale modelling
- Demonstrate the modelling concept in selected areas
- Experimentally test and further develop a multi-species model for transport of ions in cementitious materials
- Develop and experimentally test conceptual models for early age volume changes

#### Medium term goals (5-10 years)

- Develop and experimentally test a unified model for the ingress by diffusion of ions in a reinforced concrete structure under combined environmental and mechanical loading
- Develop and experimentally test models for rheology and aspects of manufacturing, concrete placement and curing conditions

### **Research topic: Wood Science and Technology**

Research capacity: approx. 2 persons.

Wood material research at the Section for Construction Materials concerns the material behavior of wood as a construction material. Wood is an organic material with a naturally optimized material structure. This gives wood materials some particular properties, which have to be considered when using wood as a construction material. A fundamental characteristic of wood is its relation to water. Theoretical and experimental work within the following wood science topics is included in the research:

- Wood–water interaction
- Moisture transport in wood tissue
- Hygro-mechanical phenomena of wood material
- Material rupture especially in relation to static fatigue

Examples of recent research achievements:

- Finalization of an 1 mio EUR project on modelling the effects of moisture and load history on the mechanical properties of wood.

#### Short term goals (1-5 years)

- Connecting the continuum level models of wood–water interaction to the wood molecular structure
- Develop a true multi-physical material model for wood
- Designing an accelerated test method for determining the long-term characteristics for structural wood

#### Medium term goals (5-10 years)

- Carry out fundamental research within wood material science and other man made biological composites

### **Research topic: Transport and binding**

Research capacity: approx. 3 persons.

The porosity of construction materials such as concrete, masonry and wood has significant impact on the engineering properties of these materials, since the pores provide a means of interaction between the materials and their surroundings. The research topic covers all porous materials relevant to civil engineering and covers both

the intended and the unintended transport and binding of matter in the porous material. The knowledge obtained is used for improvement of existing construction materials, for design of new construction materials as well as for the development of methods for repair and maintenance of structures. Research focuses are on porous media transport in construction materials:

- Transfers of moisture and air, and any chemicals dissolved therein
- Moisture transfer properties dependency on water content and dynamics
- Ab- and desorption isotherms for water vapor and the relation to pore structure
- Binding of matter
- Methods for repair and maintenance of existing structures containing unwanted matter
- The role of pore size distribution and geometry on the transport of matter

Examples of recent research achievements:

- Encouraging results have been obtained in removing water and salts from brick masonry in an applied electric field and to electrochemically accelerate boron ingress into wood in laboratory scale as a method for re-impregnation.

Short term goals (1-5 years):

- Implement technologies as ESEM and X-ray absorption in the characterization of porous construction materials
- Evaluate the possibilities for active salt removal from bricks and natural stone

Medium term goals (5-10 years):

- Assess the influence of pore size and pore geometry on transport of water by different driving forces (chemical, electrical, pressure)
- 3D model of pore structure based on one or more images from e.g. SEM. The model is useful for prediction of transport and binding

## **6.2 Section for Geotechnics**

Faculty: 4

Research staff: 3

PhD students: 4 (2 of these externally funded)

### **Research area**

The research area is geotechnical engineering and soil mechanics with the following research topics:

1. Geotechnics
  - Large diameter piles
  - Rock mass properties of limestone
  - Visco-plastic properties of soil and soft rock
2. Arctic Technology

The geotechnical topics were chosen as follows: The topic of large diameter piles is motivated by Danish leadership on wind turbine technology, which also yields a national focus on offshore foundation. Classification of limestone has emerged out of the recent civil works projects in the Copenhagen area, e.g. the Øresund Bridge, Copenhagen Metro and Malmö Citytunnel, where serious lack of appropriate engineering methods for determination of rock mass properties from classification was identified. Studies on viscoplastic properties have originally focused on application to the Danish oil industry, but are gradually extended to soft soil application.

The Section hosts the Centre for Arctic Technology. Arctic technology is an interdisciplinary field. The research activities within arctic technology is described in the separate section 'Research area: Arctic Technology' below.

A common denominator for the geotechnical research is the combination of laboratory testing and numerical modelling. The research group has two central testing facilities.

Firstly, a soil mechanics laboratory equipped with standard triaxial apparatuses, oedometer cells, constant rate of strain oedometer and a rock mechanics triaxial cell. Secondly, a geotechnical centrifuge for carrying out scale tests. The theoretical approach is mainly numerical, based on elasto-plastic or visco-plastic models. Development of models as well as efficient numerical implementation is part of the modelling work.

A long term (+10 years) research goal for the geotechnical research group is to contribute with

- operational models for integrated analysis of piles,
- rock mass models for design in soft, porous rock based integrated analysis of geotechnical element tests and advanced geophysical methods
- implementation of the knowledge on viscoplastic properties in standards within soil mechanics testing procedures.

Target journals include:

- Canadian Geotechnical Journal
- Computers and Geotechnics
- Geotechnical and Geological Engineering
- Geotechnical Testing Journal
- International Journal for Numerical and Analytical Methods in Geomechanics
- International Journal of Rock Mechanics and Mining Sciences
- Journal of Geotechnical and Geoenvironmental Engineering
- Rock Mechanics and Rock Engineering
- SPE Reservoir Evaluation and Engineering

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Good industry contact and research results implemented directly in industry</li> <li>• Good-will from university and department management</li> <li>• Acceptance in the Arctic as a Greenlandic university unit. Important for the funding of ARTEK</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Size of research group critically small</li> <li>• Unclear research strategy – lack of focus</li> <li>• Low publication rate (not targeted enough)</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Funds available to recruit in order to strengthen the research profile</li> <li>• Implement commercial projects in research</li> <li>• Access to experimental facilities: geotechnical centrifuge, soil mechanics laboratory, rock mechanical testing equipment</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Not enough support from laboratory technicians</li> </ul>

Table 7: SWOT for the Section Geotechnics

**Research topic: Large diameter piles**

Research capacity: 2 persons.

The research theme covers static and cyclic behaviour of large diameter piles subjected to primarily lateral load in-service. The research is focusing on experimental and numerical modelling. Scale models of piles are tested in the geotechnical centrifuge subject to variations in load patterns and soil properties. The experimental results are interpreted using either finite element models or 3D Winkler beam models. A virtual test lab based on finite elements will be developed to generate input for the p-y-curves to be implemented in large scale computer models for wind turbine design. Development of

representative finite element models for large piles requires knowledge of the stress conditions insitu – before and after installation of the pile. Depending on installation technique the soil in the vicinity of the pile may be strongly affected. The development of constitutive models that may account for complex stress-strain histories is therefore essential to a successful modelling effort. In collaboration with research topic “Visco-plastic properties of soil and soft rock” constitutive models will be developed. Furthermore, numerical modelling of such processes requires purpose-made application of advanced computational techniques such as contact mechanics, large strain modelling and discontinuity modelling. Examples of topics for the research in large diameter piles include:

- Centrifuge modelling of cyclically loaded monopiles for wind turbines
- Development of constitutive models for cyclic behaviour of soils focusing on sand
- Extension of classical Winkler models to account for cyclic effects and possibly dynamical effects
- Effect on soil properties from installation of large diameter piles – numerical/algorithmic techniques and constitutive models for large strain/discontinuous displacement field application

Examples of recent research achievements:

- Re-evaluation of basic data for p-y curves in soft clay (not yet published)

Short term goals (1-5 years)

- Bi-lateral p-y-curves for cyclically loaded piles
- Finite element based virtual test lab for generation of p-y-curves
- Numerical algorithm for analysis of installation induced stresses and strains around a large diameter pile

Medium term goals (5-10 years)

- Fully integrated installation and in-service analysis of large diameter piles
- Robust constitutive models for a wide selection of soils

Long term goals (+10 years):

- To implement operational models for integrated analysis of piles,

### **Research topic: Rock mass properties of limestone**

Research capacity: approx. 1 person.

Research on rock mass properties of limestone is focusing on the determination of classification parameters for limestone in the greater Copenhagen area and how these may be translated into rock mechanical properties useful for design of e.g. tunnels and caverns. A major concern is the up-scaling from element properties (e.g. small or medium scale triaxial tests) to rock mass properties serving as basis for design models. Here detection of fractures and joint systems plays a significant role. Likewise the inherent variation in rock quality, e.g. expressed in terms of induration degree, needs to be assessed. As of now, knowledge of these parameters has been limited prior to construction. Development of interpretation methods for and assessment of various site investigation technologies is therefore a focus area within this research topic. Recently, focus has been on the use of optical and acoustical televiewer logs, which – emerging from the oil industry – now finds its application with civil works projects. Further assessment of these techniques is planned. The rock mechanical properties of the limestone are tested in order to obtain basic input for the constitutive models. This is coordinated with research topic “Visco-plastic properties of soil and soft rock”. Focus has recently been on temperature effects on deformation rates, but will soon be extended to rate effects on strength. Examples of topics for the research area include:

- Classification of limestone using advanced borehole geophysics
- Statistical evaluation of the acoustic amplitude measurements
- Assessment of joint frequency and properties
- Temperature effects on rock mechanical properties

Examples of recent research achievements:

- A modified rock mass evaluation system for limestone applied at Citytunneln and Copenhagen district heating tunnel based on optical and acoustic televiewer logging of the borehole walls
- Together with a combination of the Hoek-Brown GSI and the Palmstrøm Jv-method we have established a safe and cost economic design method for construction of tunnels and caverns in limestone. The method is applied for the Copenhagen Ring Metro investigations

Short term goals (1-5 years)

- Refinement of classification methods for Copenhagen Limestone
- Rock mechanical model for Copenhagen Limestone

Medium term goals (5-10 years)

- Establishment of rock mass model for limestone based on classification.
- Implementation of developed methods into practice

Long term goals (+10 years):

- Rock mass models for design in soft, porous rock based integrated analysis of geotechnical element tests and advanced geophysical methods

### **Research topic: Visco-plastic properties of soil and soft rock**

Research capacity: approx. 1 person.

Research on visco-plastic properties of soil and soft rock is concerned with experimental, numerical as well as applicability aspects: The experimental part of the research is concerned with measurement techniques, with interpretation of test results in which the soil or soft rock shows visco-plastic behaviour, and with development of test methods to define the visco-plastic properties or to avoid the visco-plastic effect on the measurements. The numerical part of the research is concerned with the mathematical formulation of the visco-plastic properties, with implementation in existing material models or new models for specific applications, and with simulation of test results and various applications. In applicability aspects experimental and numerical aspects are typically combined and used to predict deformation or stress conditions in soil or soft rock related to geotechnical engineering projects. Examples of topics for the research in visco-plastic properties of soil and soft rock include:

- Effect of simultaneous consolidation and creep on interpretation of standard soil mechanics tests
- Effect of deformation rate on undrained shear strength of clay
- Development of earth pressure on walls with time
- Relation between creep and relaxation for clay
- Investigation of visco-plastic properties for lightly over-consolidated marine clay

Examples of recent research achievements:

- Initial investigations on chalk at elevated temperatures shows disagreements with the general assumptions that creep rates show monotonic increase at increasing temperatures.

Short term goals (1-5 years):

- To finalize the implementation and testing of standard triaxial test facilities
- To establish a material model for lightly over-consolidated marine clay
- To develop and implement test facilities for stress measurements in true uniaxial deformation conditions.

Medium term goals (5-10 years):

- To develop test methods applicable for plastic clays
- To fully understand and describe the relation between creep, relaxation of stress and rate dependent stress-strain relations.

- To model the interaction between soil and structural elements including the effect of visco-plastic elements.

Long term goals (+10 years):

- To implement the knowledge on visco-plastic properties in standards within soil and rock mechanics.

### **Research topic: Arctic technology**

Research capacity: 4 persons employed at Section for Geotechnics

Centre for Arctic Technology, ARTEK, plays a special role in the cooperation between Greenland and Denmark. From the business plan for ARTEK (in summary) can be read:

- *Mission:* ARTEK shall in cooperation with Greenlandic authorities and business through research, innovation, teaching, supplementary training, and cooperation contribute to sustainable development of arctic technology.
- *Main target:* ARTEK shall develop knowledge about arctic technology and distribute this through teaching, continued education and innovative activities. As a prerequisite cooperation with other DTU units (departments) will be arranged to secure a good support to Greenland and a link to relevant research activities at DTU for Greenland.
- *Research topics:* Artek research is interdisciplinary, and includes research from several sections and departments: Building and construction, environmental protection, cleaner technology, energy supply, energy savings etc

ARTEK researchers employed at the Section for Geotechnics work within:

- Permafrost in Greenland:
  - Pilot project Permafrost degradation and Infrastructural consequences in West Greenland.
  - Ongoing project: Recent and future permafrost variability, retreat and degradation in Greenland and Alaska.
- Geophysical methods employed in arctic construction
- Arctic road building
- New Greenlandic building materials (patented method)
- Handling of waste and wastewater from settlements, removal of heavy metals from fly ash from incineration plants (patented method)
- The potential for wind energy in Greenland

Examples of recent research achievements:

- The two patents – see above
- Conference proceedings from ARTEK events (international conferences arranged by ARTEK in Greenland in 2005- 2006 – 2007)
- The establishing of Greenland Innovation Centre
- The construction of test fields for the study of deterioration of airfields and roads due to climatic changes

Goals for the future:

A stronger contribution is foreseen within Arctic environment and engineering geology to support the Greenlandic development of an educational and research base for the mining and oil industry.

### **6.3 Section for Building Physics and Services**

Faculty: 6

Research staff: 7

PhD students: 9 (3 of these externally funded)

#### **Research area**

The research area is building physics, services and energy, with the following research topics:

1. Hygrothermal Building Physics
2. Building Energy Engineering
3. Technical Building Services
4. Solar Heating

The general aim of the research is to provide new knowledge and methods to develop and design whole buildings and parts of buildings with the following characteristics:

- a healthy and comfortable indoor environment
- a minimized use of energy from fossil fuels due to energy savings and use of renewable energy
- a long durability and low cost of maintenance and renovation
- an optimized life cycle cost

Target journals include:

- Applied Energy
- Applied Thermal Engineering
- Automation in Construction
- Building and Environment
- Building Simulation: An International Journal
- Energy and Buildings
- International Journal of Energy Research
- International Journal of Heat and Mass Transfer
- Journal of ASTM International
- Journal of Building Physics
- Journal of Solar Energy Engineering, Transaction of the ASME
- Solar energy
- Transport in Porous Media

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Good size and international profile of the research group</li> <li>• Good international visibility and influence: IEA, Nordic projects, PhD courses, conferences, etc.</li> <li>• International productivity: Papers, theses (PhD, DSc), patents, know how transfer, etc.</li> <li>• Success in attracting external founding from Danish and international industry and public funds</li> <li>• Good implementation of output in practice; research is very relevant for society</li> <li>• Many test facilities</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• See general SWOT, section 2 above</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Rationalising education course structure (+ integration with Indoor climate centre) may free up time for research (application, execution and publication)</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• See general SWOT, section 2 above</li> </ul>

Table 8: SWOT for the Section for Building Physics and Services

**Research topic: Hygrothermal Building Physics**

Research capacity: 2½ persons

The research on Hygrothermal Building Physics covers the mechanisms for coupled heat, air and moisture (HAM) transport in and around the thermal envelope of buildings as well as in indoor environments. The objective is to establish a basis for buildings with durable structures, buildings that are healthy to live in and require a minimum of energy. Experimental investigations are carried out, and numerical procedures developed, on heat, air and mass transport mechanisms in building materials and assemblies, and at their interfaces with external and indoor environments. The expertise is used to predict the hygrothermal performance and durability of materials and structures – both for new buildings and for renovation. The interaction between building assemblies and indoor climate is analysed, recognizing that moisture is one of the main causes of problems in the indoor climate and in building components.

Assessment of strengths: Hygrothermal building physics and its modelling and experimentation serve as a basic science in relation to some other BYG-activities: Building energy conditions, building services, indoor air quality, durability of building materials and structures. We cooperate with other of BYG's researchers on these issues and we have a strong international network among building physicist around the world.

Development areas: There is a potential to further develop our understanding of dynamic hygrothermal processes and get that represented and documented in our modelling. The full understanding of the HAM-performance of the whole building comprises an intertwined set of processes, and it is necessary to look at many different scales (from pore level in building materials to room/whole building level), and to take many different types of indoor and outdoor exposures into account.

Examples of recent research achievements:

- Development of a NORDTEST protocol for determination of moisture buffer property of building materials.
- Subtask co-leadership of an international research project on whole building heat, air and moisture response of buildings.
- Developed new experimental and numerical methods in determination of hygrothermal material-air interactions.

Challenges and opportunities for the development in the next decade: A main challenge in the near future is to recruit people in our area. We will attract candidates internationally. The integration aspect of our research renders us with some scientific challenges. We will continue working together with colleagues in our international network to combine our competences with those of researchers in complementing research areas, e.g. the indoor climate; durability and building energy areas.

The plan for research: Integrated HAM-modelling for whole buildings will be further developed and employed to:

- Predict durability/degradation of materials and building assemblies
- Estimate indoor air quality - possibly also by modelling of gaseous emissions from building materials, as well as conditions for mould growth
- Analyse and optimize the energy performance of buildings.

### **Research topic: Building Energy Engineering**

Research capacity: 5 persons

The research in building energy engineering is focused on development and integrated design of buildings with an improved energy performance. This is done by work on methods to:

- calculate performance of building elements, systems and whole buildings

- design and optimize building envelope and services in an integrated process
- develop building components and system with improved energy performance

The energy performance is linked to indoor environment and life cycle cost to evaluate general performances and perform economical optimisation in the work on developing improved elements (building envelope and glass facades as well as systems for ventilation, heating, cooling and lighting) and whole buildings.

Assessment of strengths: The research area is very relevant for the society and the construction sector as it is central to the energy saving strategies that is adopted by UN, EU and DK in order to solve the problems related to use of fossil fuels. Especially the EU Energy Performance of Buildings Directive that is implemented in the Danish building code strengthens the need for research in the field of building energy engineering. At the same time it is now realistic to perform detailed calculations of performances of building components and whole buildings and use these in work on developing improved solutions.

Development areas: The method of integrated design of buildings with respect to energy use and indoor environment is an area that has a high potential for becoming the development area in the research in building energy engineering. The knowledge on how to develop low energy buildings based on integrating new solutions may also become a development area in this field.

Examples of recent research achievements:

- A research and demonstration project on development of new domestic buildings with lower energy use resulted in documented energy savings of more than 30% at an extra construction cost of about 5%. The result was used as a basis for the new energy requirements in the Danish building code in 2006.
- A study of energy savings in existing domestic buildings in Denmark indicated that if energy savings are implemented during the next 40 years renovation then a reduction of 80% of the energy use in all the building stock is possible and with a good economy.
- Research on new slim frame window design has documented that it is possible to produce windows that averaged over the four facades in a typical domestic building will have a positive net energy gain to the house in the heating season. Commercial products based on this principle have been put on the market in 2007.

Challenges and opportunities for the development in the next decade: The challenges are to develop methods for integrated design of low energy buildings and to develop new energy saving solutions. In relation to integrated design and use of new energy saving solutions there is a need for improved simulation programs for calculating the building performances with respect to energy use and indoor environment at the different steps in the design method. There are opportunities for developing new energy saving solutions and use these in an integrated design process to make it realistic to reduce the energy use in new buildings to such a low level that the remaining energy needed can come from entirely renewable energy based energy supply systems. In this way buildings may not need energy from fossil fuels in the future.

The plan for research:

- Develop methods and calculation tools for integrated design of low energy buildings.
- Develop knowledge on new improved solutions on windows, solar shadings and low energy buildings

**Research topic: Technical Building Services**

Research capacity: 6 persons

The research in the technical building services is focused on development and design of systems that provide buildings with ventilation, heating, cooling, lighting, domestic hot and cold water, and drainage. The overall aim of the research is to create a comfortable and healthy indoor environment in buildings with a minimum use of energy. This is achieved by development of methods to:

- calculate performance of technical building services components and systems
- design and optimize technical building services in an integrated design of buildings
- develop building services components and services with an improved performance with respect to indoor environment and health as well as life cycle cost

Assessment of strengths: The research area is very relevant for the society and the construction sector as it is central to the energy saving strategies that is adopted by UN, EC and DK in order to solve the problems related to use of fossil fuels. Especially the EU Energy Performance of Buildings Directive that is implemented in the Danish building code strengthens the need for research in the field of technical building services. At the same time it is now realistic to perform detailed calculations of performances of technical building services components and systems and use these in work on developing improved solutions with respect to health, indoor environment, use of energy and life cycle cost.

Development areas: Intelligent demand controlled mechanical and passive systems with higher energy efficiency and better over-all system performance. This area is supported by development in the area of smaller and cheaper sensors. Passive ventilation systems driven by buoyancy and wind for fresh air ventilation with heat recovery and night cooling with minimal use of thermal and electric energy. Development and design of systems and components for passive and mechanical climatization of buildings including construction integrated systems (e.g. thermo active constructions) are areas with a high potential for becoming development areas for research in technical building services.

Examples of recent research achievements:

- development of dynamic numerical model for simulation of condensation and freezing/thawing in heat exchangers for comfort ventilation
- development of improved ventilation system with efficient heat recovery and efficient axial fans for single family houses in co-operation with industry partners
- knowledge transfer through project funded by the Danish Electricity Saving Trust on marketing of energy efficient ventilation systems for single family houses
- detailed two-dimensional models of heat transfer from water heated or cooled pipes in concrete floors and decks were set up and connected to the heat balance models of the rooms.

Challenges and opportunities for the development in the next decade: The challenges are to develop new types of energy saving technical building services systems. There is a need for improved models and simulation programs for calculating the building performances with respect to energy use and indoor environment for different technical building services. There are opportunities for developing new types of energy saving building services and use these in an integrated design process to reduce the energy consumption in new buildings to such a low level that the remaining energy needed can be supplied entirely from energy supply systems based entirely on renewable energy.

The plan for research:

- Develop methods and calculation tools for simulating the performance of new types of technical building services that can provide a good indoor environment with a minimum use of energy.

## **Research topic: Solar Heating**

Research capacity: 5 persons

The research is focused both on the solar heating systems and on their components. The research consists of parallel theoretical and experimental activity implemented in numerical modelling, fluid visualization, full-scale experiments and measuring programs.

All types of solar heating systems are considered in the research:

- Solar domestic hot water systems for one family and multiple family houses
- Solar heating systems for combined space heating and domestic hot water supply for one family and multiple family houses
- Solar heating plants.

Assessment of strengths: The research is important in connection with development of cost efficient solar heating systems. Today solar heating systems and wind energy systems are the most important types of renewable energy systems internationally. At present, the European solar heating market grows by more than 45% a year, and the growth is expected to continue. If Danish companies should benefit from this large solar heating market, it is required that they can offer high quality products and services. Development of such products and services must be based on detailed research.

Development areas: The cost efficiency of all types of solar heating systems can be strongly improved by development based on detailed research. For small systems the focus should be on the heat storage and on the interplay between the auxiliary energy supply system and solar collectors. For large systems the focus should be on solar collectors.

Examples of recent research achievements:

- Patent of inlet stratification device based on fabric pipes for establishment of thermal stratification in water tanks
- Development of a simulation model of solar heating systems based on a PCM material with stable super cooling for houses heated 100% by the solar heating systems
- Coordinator of European Ph.D. courses on solar heating
- 21 ISI publications in period 2004-2007

Challenges and opportunities for development in the next decade: Research on small and large solar heating systems must be carried out with the aim to develop attractive cost efficient solar heating systems of all types. Special challenges are to develop attractive solar heating systems suitable for our future energy system. Such systems are solar heating systems with seasonal heat storage covering the yearly heat demand fully and solar heating systems making use of smart control systems based on weather forecasts and smart solar tanks which can be charged both by solar collectors and by inexpensive wind energy in windy periods in such a way, that the heat demand is fully covered by solar and wind energy.

The plan for research:

- New heat and mass transfer knowledge
- New models and improved design guides for solar heating systems and components
- Advanced water heat storage including seasonal PCM (Phase Change Material) heat storage
- Interplay between auxiliary energy supply system and solar collectors and between the space heating system and the solar collectors
- Flat plate solar collectors and evacuated tubular solar collectors

## **6.4 Section for Structural Engineering.**

Faculty: 15  
PhD students: 14

### **Research area**

The research area is structural engineering, with the following research topics:

1. Design of Civil Engineering Structures.
2. Structural Performance.
3. Integrated Structural and Materials Modeling.

The overall aim of the research is to provide new and improved tools for analysis of civil engineering structures in order to allow for optimal and innovative structural design, the application of new and improved materials as well as renovation of existing structures taking a wide range of requirements into consideration including safety and sustainability throughout the whole life cycle of the structure. Numerical, experimental, and analytical methods are applied in the work. It is noted that the topics are cross-disciplinary, thus traditional structural disciplines such as design of concrete, steel and timber structures, safety of structures and structural dynamics are distributed across the themes and associated groups, as are the tool oriented disciplines including numerical analysis and experimental mechanics. It is believed that this cross-disciplinary structure addresses the society's need for dealing with problems related to the assessment of the existing, aging infrastructure (buildings, roads, bridges etc.) as well as the need to provide new innovative, sustainable construction solutions and systems.

Overall it is a short term strategic goal (2 years) that the Section is recognized as the leading Danish structural research institution and a European stronghold. Further, the strategic goals are concentrated in the following three main themes: Research focus, external funding/research volume and visibility/networking. The detailed goals are shown below:

- Consolidation of the research themes and establishment of clear, focused and coordinated research plans for these themes including identification of group members, identification of long and short term research goals, publication plans and funding plans.
- The section will play a leading role in the establishment of a Centre for Structural and Materials Testing to be the only Danish and the premier European facility for experimental engineering research related to materials and structures.
- Establishment of an increased, coordinated effort in application for external funding including applications.
- Further increase the number of PhD students as well as the number of industrial PhD projects by actively interacting with the industry and initiation of high-level dialog with leading companies.
- Increase the number of internationally announced summer schools/Ph.D. courses to 3-4. Such courses should preferably be given in international collaboration. Course topics should include: Materials modeling, Advanced load on structures, Non-linear structural analysis, Advanced structural design.
- Identify and strengthen the international – and in particular European – networks of the section, e.g. establish and/or participate in European networks preparing to approach the 7th Framework Program.
- Strengthen the seminar activity of the section and actively encourage participation from industrial partners.
- Involve PhD students actively in teaching e.g. Master's project work.

Long term strategic goals include:

- Developing concepts for new designs, products and systems to create unifying, cross-disciplinary projects, to strengthen collaboration and synergy between the section's Ph.D. students and to create research based visibility.
- Demonstrating cross-fertilization of the research activities through collaboration with other sections and research institutions

Target journals include:

- ACI Structural Journal
- ASCE Journal of Composites for Construction
- ASCE Journal of Engineering Mechanics
- ASCE Journal of Structural Engineering
- Computers and Concrete
- Earthquake Engineering and Structural Dynamics
- Engineering Fracture Mechanics
- Engineering Structures
- International Journal of Solids and Structures
- International Journal of Space Structures
- Journal of Advanced Concrete Technology
- Journal of Bridge Engineering
- Journal of Construction and Building Materials
- Journal of Materials and Structures
- Journal of Structural Control
- Journal of the International Association for Shell and Spatial Structures
- Journal of Wind Engineering
- Structural Engineering International
- Thin-Walled Structures

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Strong competences in structural analysis including numerical modelling</li> <li>• Good competences in design concepts for new products and systems</li> <li>• Access to unique laboratory facilities and the relevant competences to utilize them</li> <li>• Number of Ph.D. students and relative number of industrial Ph.D. students</li> <li>• The national and international network of the section as a whole</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Research focus and long term plans needs to be implemented</li> <li>• Visibility and dissemination must be improved in order to become a credible research partner for international partners</li> <li>• Lack of external funding apart from PhD projects</li> <li>• Output from commercial work involving physical testing utilizing laboratory facilities should be improved</li> <li>• Project management skills need upgrading</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Time seems right to position the department and section as the leading, Danish research institution in civil engineering</li> <li>• Strengthen international networks</li> <li>• Use the potential for developing concepts for new products and systems to create unifying projects and research based visibility</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Global competition from other universities and research organizations on global funding schemes</li> <li>• The section's competences and research results remain unrecognized in the academic world as well as in the professional society</li> </ul>

Table 9: SWOT for the Section for Structural Engineering

**Research topic: Design of Civil Engineering Structures**

Research capacity: 8 persons.

The research topic covers the design and modelling of optimal and innovative structures and the related engineering design philosophy and innovative concepts. The overall focus of the research group is design and analysis of load carrying lightweight structures.

Lightweight structures is a class of structures which represents optimal structural design obtained through efficiency in strength and cost by minimizing material consumption. There will be focus on design and analysis of thin-walled structures, structural connections, glass structures, cable structures, faceted shells and the loading of structures. Lightweight structures challenge all the theoretical capabilities of structural engineering using high performance materials and high tech production techniques. Currently the group encompasses the following PhD projects:

- Faceted Glass Shells.
- Pedestrian Induced Vibrations of Line-Like Structures.
- Modelling and Experimental Verification of Reinforced Concrete under Blast Load.
- Understanding and Simulating wind-induced vibrations of iced vertical cables.
- Dampers for the Vibration Control of Structural Cables.

The research group is relatively new and hence the research potential has still to be fully utilized, however it is expected that research activities will be greatly enhanced by future PhD's working within the group and hopefully by new academic/researcher positions. It is further expected that collaboration with the other groups within the section will have a positive effect.

Examples of recent research achievements:

- The research on pedestrian loading has now reached a level where it is possible to propose a codify-able approach to pedestrian loading based on probabilistic methods. (Using an earthquake engineering approach)
- A model for prediction of wind induced iced bridge hanger vibration has been developed
- The upper bound yield line method for analysis of plates has been extended to analysis of the second order post-buckling behaviour of plates
- Collaboration with the department of mathematics has been established on the subject of faceting using a curvature coordinate system
- A uni-axial shaking table and a new high capacity structural dynamic exciter has been built

Some of the current short term research themes and projects are:

- Distortion of thin walled beams.
- Development of yield-line mechanisms for local stability.
- Pedestrian induced vibration in line like structures.
- Cable vibration and damping.
- Design and vibration of cable systems.
- Modelling and design of prefabricated lightweight thin-gauge roofing elements.
- Composite lightweight roofing deck elements.
- Faceting using a curvature coordinate system.
- Conceptual design of faceted shells.
- Design of faceted glass shells.

Furthermore emphasis will be placed on national and international networking. The group will seek contacts with industry and engineering firms to perform research and assist in innovative and optimal design of lightweight structures. Through such contacts the group will disseminate knowledge and develop reliable methods, simple models and procedures for the design of lightweight structures, which incorporate modern numerical methods and utilize experimental results. With a modern view the computer performs analysis that employs the fundamental mechanics of the problem. Developments of simple structural models, which just incorporate the most important mechanics, are often very useful in practice.

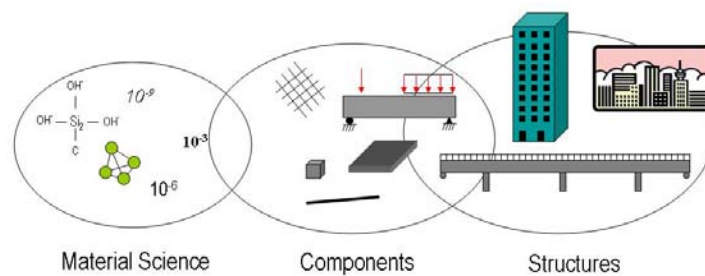
The long term goal is to consolidate the main research fields involving design of lightweight structures, conceptual design and loading of structures.

**Research topic: Structural Performance**

Research capacity: 7 persons.

In today's practice, the processes to design, build, operate and maintain products of the built environment are based on long traditions. The industry is cost-driven, project-orientated and fragmented with no dominant actor, which makes it difficult to satisfy the end-users' requirements. The exchange of design intents and project deliveries are mainly based on drawings and documents, leading to information losses between stakeholders over all phases of the lifecycle. Furthermore, traditional working methods cannot support the introduction of more advanced analyses, such as lifecycle environmental impact and lifecycle costs. The costs of designing and building in general represent only a fraction of the total lifecycle costs of a facility. The rest, ~95%, is operation and maintenance costs of which half is energy costs. Most of these lifecycle costs are committed and fixed by decisions made in the early design stage.

Reliability based assessment methods developed during the last decades together with advanced modeling and monitoring toolboxes make it possible to obtain a holistic and realistic picture of the performance of existing structures. When upgrading is needed, this will be possible by using environment friendly and efficient new materials, methods and systems, such as carbon fibre composites and systems for integrated life cycle engineering. In the following, a research program with this purpose is presented covering material science, building components and structures. It is shown schematically in Fig. 2.



*Fig.2: Assessment and upgrading of structures include methods and models from Material Science, Components and Structures.*

It should be possible to choose either a top-down or a bottom-up approach depending on the specific problem studied. However, both these approaches meet in the components area. The component area is essential for bridging material science with structures, not only from a structural point of view but also when sustainability of structures is considered. The research outlined here will be carried out in a research program, combining the efforts of competent co-workers at the department. The main research foci are:

- Numerical analysis and evaluation for rehabilitation of structures.
- Modified building materials and strengthening methods.
- Reliability.
- Structural Health monitoring.

Currently the group encompasses the following four PhD projects:

- Strengthening of Load Carrying Structures using Adhesively Bonded Composite Material.
- CFRP Retrofitting of Concrete Structures I.
- CFRP Retrofitting of Concrete Structures II.
- External strengthening of building structures with prestressed CFRP Tendons.

Examples of recent research achievements:

The long term (+10 years) goal is the development of a system/process for understanding the need for upgrading of structures. Short term goals (< 5 years) to reach this are:

- Development of modern repair and strengthening methods for concrete and metallic structures.
- Improvements of reliability based evaluation and design methods for strengthening.
- Development of systems for structural health monitoring for field structures.
- Development of durable and long life structures such as FRP (Fibre Reinforced Polymer) components.
- Fracture mechanics and numerical concepts for debonding (between substrates such as concrete and FRP).
- Force transfer between external prestressed CFRP cables and anchoring devices.

### **Research topic. Integrated Structural and Materials Modelling**

Research capacity: 10 persons.

The research group develops models and modeling approaches covering the entire life of structures and components with particular focus on reinforced concrete structures but also dealing with areas such as building components made from toughened glass. This involves a number of challenges, among others multi-physical and multi-scale modeling which combine the various physical, mechanical and chemical mechanisms, modeling of the detailed and overall geometry, development of suitable computational material models, probabilistic modeling of environmental and mechanical loads and material properties as well as the calibration of such models with experimental data and data from real structures. Currently the group encompasses the following PhD projects:

- Ultimate Strength of Wind Turbine Blade Design.
- Fracture Mechanics for Cement Paste and Mortar: Measurement and Modeling.
- Modeling of Interacting Cracks in Reinforced Concrete Structures.
- The Properties and Structural Use of Toughened Glass.
- Modeling of ECC Materials using Numerical Formulations Based on Plasticity.
- Modeling of the Ultimate Load Carrying Capacity of Reinforced Concrete Structures.

Examples of recent research achievements:

- Establishment of unique, extremely stiff bi-axial testing machine for mixed mode fracture testing of e.g. concrete
- Extensive fracture mechanics based research on testing and analysis of fibre reinforced concrete (FRC) and FRC structures have resulted in a series of RILEM recommendations and recently also a 'Nordtest' fracture mechanics test.
- Development and implementation of efficient Extended Finite Element Method (XFEM) formulation for cohesive crack propagation
- Development of a multi-scale, fracture mechanical based modelling approach for cementitious overlays
- Development of a multi scale, fracture mechanical based constitutive modelling approach for high performance cementitious composites
- Demonstration of reinforcement principles for glass beams

The primary, very long term (+10 years) goal is the development of a numerical model (framework) which enables service life simulation for reinforced concrete structures covering aspects of production, construction and in-service life. This is envisioned to take place in collaboration with the Section for Building Materials and a wide range of external collaborating partners in short term projects. Eventually an impact on design guidelines is expected.

Short term (1-5 years) projects are defined which either directly support the long term research goal or which support the long term goal indirectly by dealing with and solving similar problems with similar type of analysis. E.g. analysis of toughened glass components requires solving for the eigenstresses due to the manufacturing and toughening process; an analysis which bears many similarities to the analysis for eigenstresses in concrete structures due to the hardening process. Short term projects involve:

- Computational fracture mechanics for reinforced concrete structures (XFEM, rebar-concrete interaction, interface fracture mechanics).
- Experimental fracture mechanics (Crack detection, mixed mode).
- Transport properties in cracked reinforced concrete structures.
- Modeling of electro-chemical processes in reinforced concrete structures including corrosion.
- Modeling of deterioration processes in reinforced concrete structures.
- Modeling of eigenstresses due to hardening (concrete) and toughening (glass).
- Analysis of glued connections.
- Probabilistic framework for environmental loads on structures.

## **6.5 Section for Planning and Management of Building Processes**

Faculty: 13

Research staff: 7

PhD students: 3 (all externally funded)

### **Research area**

The research area is planning and management of building processes including building design and fire engineering, with the following research topics:

1. Urban Management
2. Design Management
3. Construction Management
4. Facilities Management
5. Fire Safety Engineering

The section has organised its research activities to reflect the life cycle of a typical building. This cycle begins with urban planning and passes through the phases of design management and construction management to realise the constructed works; this is followed by the facilities management phase. Urban Management is concerned with quality of life and infrastructure decisions. Design management focuses on the development of the client brief, conceptual design and detailed design and the interface with construction activities. Construction management is concerned with the realisation of the building, from the interface with design through various stages of production, construction and assembly to a completed building. Facilities management represents the period during which the building is used, adapted, modified and eventually disassembled, returning to urban management and the start of another cycle. Fire Safety Engineering is a more specialised research focus area, however, associated to this section as it represents a strongly prioritised parameter in the design process. Crosscutting themes underpinning the section's research activities encompass integration, innovation, information and communication technologies, and sustainability.

We have used the internationally recognised term 'management' as the common cyclical denominator for the majority of the research areas. This term, as well as the crosscutting themes, is generic to the majority of the section's research activities. It may, however, be interpreted in slightly different ways by each research topic, reflecting the special focus and contextual premises of the topic and the aims and objectives of specific research projects.

Research work is largely multi-disciplinary, which reflects the wide professional background and research interests of the section. The section places high importance on

its relationship with the main stakeholders of the built environment – authorities and institutions, users, industry and other external target groups. A current and long-time goal is to make a perceptible contribution to the value of built products and processes in society and in projects. A broad range of tools is used to disseminate knowledge, such as books, chapters in books and articles in professional/industry journals, conference presentations and research articles in international journals. Research work is concerned with national and international construction sectors. The main quantitative research goals are twofold: that every member of the section should produce one refereed publication per year as a minimum and that the section produces two PhDs each year.

Target journals:

- Architectural Engineering and Design Management
- Building Research and Information
- Construction Management and Economics
- Design Studies
- Engineering Construction & Architectural Management
- Environment and Planning and Facilities
- Facilities and Nordic Journal of Surveying
- Fire Safety Journal
- International Journal of Project Management
- Journal of Construction Research
- Journal of Urban Technology
- Real Estate Research
- Urban Studies

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• Consistent and socially viable resource base on section level</li> <li>• Cross-disciplinary competencies on a basis of technical knowledge and understanding</li> <li>• Holistic and life-cycle oriented approach to research themes</li> <li>• High adaptability to changing research agendas among stakeholders</li> <li>• Favourable interaction and dissemination platform through the section's two (post graduate) master-educations</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Large individual variation in core-competencies and preferences imply sparse and critical resource allocation on research project level</li> <li>• Dissemination priority towards industrial partners and users imply lacking attention to high profile academic publication</li> <li>• Weak tradition among building sector actors for involving actively in research</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• Increasing demand for the section's research results in the construction industry. Easy access to better branding of the project portfolio and research activities</li> <li>• Integrated focus on products and processes as an adequate basis for interaction with technology oriented research groups at BYG•DTU</li> <li>• The section's research profile is well compatible with and/or at the cutting edge compared to the international research community</li> <li>• Potential synergy effects within generic management research areas in</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Loss of synergy with technology oriented research at DTU and loss of visibility in the construction sector after the coming departmental reorganisation at DTU</li> </ul>

connection with departmental reorganisation at DTU	
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Table 10: SWOT for the Section of Planning and Management of Building Processes

### Research topic: Urban Management

Research capacity: 3 persons.

Urban quality is decisive for the quality of life, social networks and economic growth. Especially for a creative business life, development of informal networks and the ability to attract a well qualified working force. The Harbour Bath in central Copenhagen is an excellent example on how transition of the technical infrastructure creates unique urban quality. The research focuses on achieving an improved understanding of how cities can be managed as complex technological systems to ensure the development of well functioning, technologically advanced, cities. Three interdependent sub-themes have been identified:

- Management of technical infrastructure: development of methods and tools that ensures that the integrated complex of technical infrastructure and buildings is safe, flexible and resource efficient. Integrated planning and management, demand side management, security of supply, efficiency and new technology in buildings are central concepts in this sub-theme. Facilities management is seen as one of the management disciplines that could contribute to a resource efficient management of buildings and cities. Simple models of integrated systems are developed.
- New forms of collaboration in urban development: analysis of different forms of collaboration between public and private partners in urban development and urban regeneration, Public-Private-Partnerships, appreciative inquiry and other forms of collaboration. The technical infrastructure's role in creating urban quality and value for the end-users will be studied, as well as how use and maintenance is incorporated in the urban development projects
- Innovation and development of competences in complex technological systems: analysis of the interplay between institutional innovation and technological innovation in relation to urban development and transition of infrastructure. Innovation in complex technological systems is not an activity that merely takes place in a laboratory; it is the result of interplay between a number of different actors. A special attention is given to the role of intermediary actors.

Examples of recent research achievements:

- A very useful result has been the identification of the practioner's most important reasons for not using the hundreds of decision support and evaluation tools concerning urban sustainability that have been developed during the last decade (part of the result of the PETUS project)
- The Intermediaries project has advanced our understanding of the multiple ways social housing estates acts as intermediaries in relation to innovation of sustainable building technologies.

Short term goals (1 – 5 years):

- Exploring the international and international state of the art in research in urban management
- Strengthening the networks with the building sector
- Advancing the development of innovation theories in relation to sustainable urban development
- Participating in development of a national urban management centre

Medium term goals (5 – 10 years):

- Developing integrated models of urban development

- Advancing the triple bottom line decision making methods and models, including the economic dimension of urban quality and the link between technical infrastructure and urban quality

Long term goals (+10 years):

- The long term goal is to develop methods and models supporting strategic decisions in urban development, including the technical infrastructure – and actually used by the decision makers.

### **Research topic: Design Management**

Research capacity: 3 persons.

Design management is growing in importance in design and construction, both in practice and as an academic subject. In 1992 the CIB working group W096 Architectural Management was formed to bring together and promote research in architectural design management. More recently design management has become a topical theme of international conferences and peer-reviewed journals. It has been recognised for a long time that the decisions made in the early design phases are crucial for developing value and minimising waste. These decisions also affect the way in which a building is realised (safely and efficiently) and how it performs in use. Thus, the interface between design and construction activities is an important area for this research group. Our focus is on the development of an integrated design management model and associated conceptual frameworks under the four interdependent research foci:

- Value management
- Communication and partnering
- Lean design management
- Constructability, health and wellbeing

Examples of recent research achievements:

- The research activities within effective design communication and value creation (lean design) have had a significant power of penetration in the CIB research community and among prestigious publishers. The group was awarded best paper at the CIB World Building Congress 2007.
- As an element of the efforts within partnering research a process evaluation tool has been developed (PPI Partnering Performance Indicator). This innovative management tool is currently in use on 5-10 ongoing building projects.

Short term goals (1-5 years)

- Short term goals relate to the completion and dissemination of current research projects, which address issues concerned with strategic partnering and value management. The results will add to the theoretical and practical development of the design management field.
- Application and development of value management theory, via collaboration with industry, into a conceptual integrated design management model.

Medium term goals (5-10 years)

- The medium term goal is to develop a common framework for integrated design management that is applicable to the Danish context. This model will be grounded in the section's earlier work and will subsequently be tested via application in industry. The model will incorporate elements of the section's four research themes.
- Associated with this will be new externally funded research projects that explore discrete elements of the integrated design management model. Target areas are the development of strategic partnering, lean design management theory, and constructability.

Long term goals (+10 years)

- The long term goal is to develop the design management field through applied research, interaction with industry and international research networks. This is central to the Section's philosophy of close collaboration with industry.

### **Research topic: Construction Management**

Research capacity: 5

In the international research community construction management covers a rather broad scope of themes, from choice of methods, machinery and resource allocation on site to construction economics and strategic issues on firm and sector level. Thus CM is worldwide considered an important area of research and development and indeed identified as a crucial key to understanding and improving poor performance indicators in building processes.

As part of the sector's and its enterprises' response to development problems a number of new management concepts have been sought implemented, lean construction and partnering being the most well known. Although management concepts show promising results, their more precise impact continues to be unclear. Also, there is an increasing perception that within a future knowledge economy industry will be dependent of close cooperation with research institutions in order to spur on mission-oriented research and innovation, but also to assure education of the future knowledge workers.

In order to support these developments the section's CM approach has gradually and persistently enlarged the research paradigm from a narrow focus on production engineering (anlægsteknik) to a more modern industrial production paradigm. Within this paradigm collaboration in value chains, production technologies, logistics, production planning and new forms of organization and cooperation, which enhanced the bonds and links between the production's elements come into focus. This development runs parallel to production research within manufacturing and service under the headlines of operations strategy and management. Obviously, this scope implies connections and symbiotic fields with the other research areas of the section as well as in the department, with other departments and with other research institutions. The use of ICT, innovation processes and integration are especially prevalent topics.

Examples of recent research achievements:

- The research focus on building defects and failures has proved to be of great interest to the public authorities as well as to building companies. As a result the project portfolio has increased with the aim of developing new best practise competencies.
- The CM research has been able to break the ice in relation to contractors' hesitating attitudes towards investing in research: industrial PhD students is now accepted by major contractors.

Short term goals (1-5 years):

- Contributions to ICT (implementation) processes in construction after the completion of the national digital construction programme.
- Development of understanding and methods for a new quality paradigm for building production, based on business excellence and other approaches to failures and quality problems in production.
- Contributions to improved handling of knowledge in production processes; workforce and technologies, using supply chain management, governance and network theories.
- To provide research based inputs to new approaches and methods in reducing occupational accidents within building production.

Medium-term (5-10 years):

- To establish a common framework for building processes in a project and production perspective
- To use this framework in development of research on failures, quality, new technologies, organisations and management concepts
- To demonstrate successful integration and cooperation with other research areas in the section and beyond, in particular in relation to research on production and project management, ICT and innovation perspectives in value chains.

#### Long-term (+10)

- To provide a solid theoretical basis for understanding building production processes, management and organisation. This multidisciplinary theoretical understanding would allow for a holistic conceptualisation of creation of value, transformation of matter, flow, learning and social interaction between people, materials and technology.
- To deliver conspicuous contributions to better productivity, effectiveness and innovation processes in construction.

### **Research topic: Facilities Management**

Research capacity is at the moment approx. 2 persons, but the capacity will be increased considerable with the establishment of the Realdania financed research centre on FM early 2008.

FM is a new field of research in Denmark and the research environment is still at an early stage of development. The creation of such an environment is the main challenge at this point in time. In our neighbouring countries research in this field has been established for several years and centres for FM research exist in most other countries in Northern Europe. The international research infrastructure with networks, conferences and journals – although a highly recognized journal is lacking - has been established although the research field still must be said to be fairly immature. However, there are possibilities for fruitful internal collaboration and the demand for research and education on FM in Denmark is emerging strongly. The new research centre at DTU is expected to be a breakthrough for FM research in Denmark.

In the section the definition of FM is interpreted as encompassing processes related to several levels from a single building to the societal level. FM is generally a concept that describes a number of aspects concerning management in relation to the built environment: Real estate strategies, portfolio management, life cycles, building appraisal, adaptability, briefing, user involvement, space management, working conditions, sustainability, CAFM, operation and maintenance.

- Environmentally friendly building operation in housing developments under different forms of ownership.
- Facilities Management Best Practice – case studies from Nordic countries.
- ICT methods for dynamic building operation.
- Usability of workplaces with a case study based on a post occupancy evaluation of DR Byen. Part of international project in collaboration between CIB 111 and EuroFM.

Examples of recent research achievements:

- The research group has been assigned to the chairmanship of Research Network Group i EuroFM from 1. January 2007 and chairmanship of organizing committee for EuroFM's research symposium in Manchester June 2008
- Arranged international workshop in April 2007 as part of research project on Usability of workplaces
- External funding to establish a new 5 year research centre has been achieved

The aim of the research in FM is to establish and consolidate FM as a field of research using our current strong fields of research and international collaboration as a basis for the development. The FM research theme has three strategic goals: The first is to develop a multidisciplinary theoretical framework for understanding contents and dynamics in Facilities Management, drawing on managerial, organisational and environmental perspectives. The second strategic goal is to establish closer relations to FM-practitioners, especially in Denmark. A third strategic goal is to get a central position in the international FM-research establishment.

The new research centre will create opportunities to get closer towards fulfilling the first goal. Concerning the second goal the relations to FM-practitioners have been increased considerably by employing a researcher with practical experience and a strong network in the Danish FM profession and the relations have been strengthened further by involving practitioners in developing the research programme for the new research centre. A major step in relation to the third goal has been the election of a researcher from the section as board member of EuroFM and chairman of EuroFM's Research Network Group. The decision to establish a new position as professor in FM at DTU will be another major step.

### **Research topic: Fire Safety Engineering**

Research capacity: 4 persons

The research area consists mainly of two parts: a structural part and a non-structural part. The structural part deals with test methods, calculation methods and design data for assessment of load bearing capacities of structures of concrete, steel and wood for the load case of fire and a methodology for implementation of structural design in a performance-based fire safety design. The non-structural part deals with fire models, fire chemistry, fire dynamics, combustion models, CFD calculation for fire safety and the application of this for risk assessment in a performance-based fire safety design of buildings. This part also provides data and fire scenarios used by the structural part. The research of the group constitutes a basis for a scientific development on the area, where the results are applied by the industry often even prior to publication. The group communicates its results by means of papers, conference contributions, reports, programs, and through education. The research of the group constitutes the scientific basis for both teaching activities and for a major part of the development on fire safety in Danish consultant companies, where it is regarded as a subject for advanced research.

Examples of recent research achievements:

- A new test method for explosive spalling of fire-exposed concrete has been developed, and it has been verified to be easy to apply and to give reliable results.
- A basis for design of load-bearing structures for fully developed fires have been established on request of the Danish building industry and approved by the ministry, and research has been made in order to find data for fire exposures and material properties to be used.

Short term goals (0-5 years)

- Data and methods for general implementation of a performance-based structural fire safety design.
- Flame spread on materials and surfaces.
- Self-ignition of storages
- Atrium smoke management
- Fire load in car parks.
- Design of fire exposed concrete beams and slabs for moment, shear, and anchorage.
- Increase of reliability of CFD as a tool for fire safety design

#### Medium term goals (5-10 years)

- Design methods for any common structure of any concrete at any time of any fire.
- Ignition and flame spread of new building materials
- Evacuation in a Performance-Based Design and Fire models for this.
- Toxicology as a critical condition for evacuation. Data and methods for evaluation
- Fire safety of fireworks. The problem and its solution.

#### Long term (+10 years)

- Data and methods for any aspect of fire exposed concrete structures.
- Theoretical solution of the problem of explosive spalling of concrete structures.
- Explosion and Terror Safety
- Data and methods for performance-based structural fire safety design including new test methods for fully developed fires and explosions.
- Quantify and address the uncertainties and unknowns in the data, tools and methodologies for assessing fire scenarios

## 7. References

- /1/ Danish Enterprise and Construction Authority: Facts on construction research and knowledge dissemination in Denmark today. Draft report in Danish. Sep. 2007
- /2/ Internal DTU benchmark with a number of Technical Universities in EU and US.
- /3/ ORBIT, DTU's research database: [orbit.dtu.dk/app](http://orbit.dtu.dk/app) and data provided by DTU Analysis & Research Promotion Center (D'ARC):  
<http://www.dtu.dk/English/darc.aspx>
- /4/ Data provided by DTU Analysis & Research Promotion Center (D'ARC):  
<http://www.dtu.dk/English/darc.aspx>

#### Annexes:

- A.1 Quality criteria**
- A.2 Background data**
- A.3 Strategy 2003-08**
- A.4 Development plan 2008-11 (UMV 2008-11, in Danish)**
- A.5 Annual reports 2004, -05, and -06**

## **A.1 Quality criteria**

The following quality criteria are applied in the self evaluation report.

### *Basic Research*

Basic research projects are initiated by the department or in collaboration with research oriented industry. Projects are typically defined within long term research goals and divided into short term projects with PhD students or Post. Docs. The quality criteria applied to basic research projects are:

- The project is of high international scientific level.
- The project generates new basic, generic knowledge.
- The project includes research education.
- The project attracts external funding and competent and relevant personnel.
- The project work forms a basis for research based teaching.

### *Development projects*

Development projects should be based on the demands from the society and industry, and are typically short term projects. The quality criteria applied to such projects include:

- The project is carried out in close collaboration with relevant industry.
- The project attracts or is based on external funding.
- The project attracts people with the relevant practical knowledge.
- The project generates novel products/systems/processes that may be patented.

### *Dissemination*

The following quality criteria are applied:

- Publication in peer-reviewed international journals (On average 1-2 pr. man year).
- Publication in popular technical magazines in Denmark and internationally.
- Participation in international and national conferences. (On average 1-2 conference paper pr. man year).
- Key-note presentations at national and international conferences.
- External courses for the industry in various areas.
- Visibility in the public media.
- Networking
- Networking shall be carried out in three levels, internally at DTU, externally with other research organizations and externally with partners in industry.

## **A.2 Background data**

### **Staff, research, and finances**

The following tables show the staff composition, student/faculty ratio, publication statistics and budget numbers.

### **WoS publications**

The following tables show scientific journal publications with peer review registered for 2005 and 2006 by Web of Science (Thomson Scientific). The publication overview is made based on the following search profile: "BYG-DTU is affiliation"

It should be noted that BYG•DTU has undergone a major generational change during the last couple of years, thus the search is not representative for the present staff composition.

It should be noted that the sum of publications from the sections may exceed the total BYG•DTU publications. This is because the same publication may appear in two different sections; when authors from different sections have contributed to the publication.

**Technical University of Denmark  
Department of Civil Engineering**

<b>Staff ( in Full Time Equivalents)</b>	<b>2005</b>	<b>% over 60 years</b>		<b>2006</b>	<b>% over 60 years</b>
<b>Faculty and research staff (grand total)</b>	<b>68</b>	<b>16</b>		<b>64</b>	<b>12</b>
Faculty (total)	42	32		46	23
Professors	7	29		8	25
Professors with special assignments (MSO)	0			0	0
Associate professors	32	38		32	26
Assistant professors	3	0		6	0
Non-Danish faculty	4	0		10	0
Student/Faculty ration, (STÅ/Faculty)	12			11	
Research staff, externally funded (total)	26	0		18	0
Research professors	1	0		0	0
Associate research professors	12	0		9	0
Assistant research professors	10	0		5	0
Postdoctoral fellows	0	0		2	0
Research assistants	3	0		2	0
Research fellows	0	0		0	0
Guest researchers, excl. PhD-fellows	4	1		5	2
Technical and administrative personnel: total	48	28		50	25
<b>PhD fellows (total):</b>	<b>39</b>	<b>0</b>		<b>46</b>	<b>0</b>
PhD fellows	6	0		9	0
Industrial PhD fellows;	33	0		37	0
<b>PhD enrolled</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>
Number of enrolled PhD fellows (all types)	44	42	42	39	46
Number of admitted PhD fellows (all types)	8	10	7	7	16
Numer of PhD graduates (all types)	4	10	10	6	5
<b>Publications</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>
Publications indexed in WoS	21	23	26	43	25
Citation impact	0,90	3,57	1,65	NA	NA
Refereed scientific articles not in WoS	6	12	11	12	16
Conference paper in proc., books or journals	62	77	74	112	89
Monographs, books	3	1	5	7	13
Chapters in books	8	18	28	9	14
Patents granted	0	0	2	0	1
Spin-outs based on patents from depart.	0	0	0	0	0
<b>Economy and research funding</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>
Core funding (from DTU)	38,2 (5,1)	37,8 (5,1)	38,7 (5,2)	41,0 (5,5)	45,6 (6,1)
External research grants	21,2 (2,9)	10,8 (1,5)	13,5 (1,8)	11,4 (1,5)	11,8 (1,6)
Contracts and funding from private sources	7,6 (1,0)	9,2 (1,2)	10,4 (1,4)	7,8 (1,0)	6,5 (0,9)
<b>Total</b>	<b>67,0 (9,0)</b>	<b>57,8 (7,8)</b>	<b>62,6 (8,4)</b>	<b>60,2 (8,1)</b>	<b>63,9 (8,6)</b>
All figures in millions DDK (Euro)					

BYG•DTU, 138 WoS-publikationer 2002-2006*						Section				
Record nr.	Forfattere	Titel	Tidsskrift	Udgivelsesår	Startside	Physics and services	Geotechnics	Planning and management	Structural Engrg.	Construction materials
1	Ottosen, LM; Villumsen, A	High Cu and Cd pollution in sediments from Sisimiut, Greenland	ENVIRONMENTAL CHEMISTRY LETTERS	2006	195		GEO			BMA
2	Jensen, PE; Ottosen, LM; Ferreira, C; Villumsen, A	Kinetics of electrodiolytic extraction of Pb and soil cations from a	JOURNAL OF HAZARDOUS MATERIALS	2006	493		GEO			BMA
3	Jensen, FM; Falzon, BG; Ankersen, J; Stang, H	Structural testing and numerical simulation of a 34 m composite	COMPOSITE STRUCTURES	2006	52				BK	
4	Fischer, G; Li, VC	Effect of fiber reinforcement on the response of structural memb	ENGINEERING FRACTURE MECHANICS	2007	258				BK	
5	Pedersen, AJ; Ottosen, LM	Elemental analysis of ash residue from combustion of CCA treat	CHEMOSPHERE	2006	110					BMA
6	Furbo, S; Knudsen, S	Improved design of mantle tanks for small low flow SDHW syste	INTERNATIONAL JOURNAL OF ENERGY	2006	955	BFI				
7	Ingeman-Nielsen, T; Baumgartner, F	CR1Dmod: A Matlab program to model 1D complex resistivity ef	COMPUTERS & GEOSCIENCES	2006	1411		GEO			
8	Ottosen, LM; Lepkova, K; Kubal, M	Comparison of electrodiolytic removal of Cu from spiked kaolinite	JOURNAL OF HAZARDOUS MATERIALS	2006	113					BMA
9	Thygesen, LG; Bilde-Sorensen, JB; Hoffmeyer, P	Visualisation of dislocations in hemp fibres: A comparison betwe	INDUSTRIAL CROPS AND PRODUCTS	2006	181					BMA
10	Schmidt, JE; Christensen, N; Batstone, DJ; Trably, E; Lyber	Safe recycling of sewage sludge on agricultural land-biowaste	PROCESS SAFETY AND ENVIRONMENTAL	2006	253					
11	Dammann, S; Elle, M	Environmental indicators: establishing a common language for g	BUILDING RESEARCH AND INFORMATION	2006	387			PLB		
12	Jiang, J; Winther-Jensen, B; Kjaer, EM	Characterization of plasma-polymerized 4-vinyl pyridine with silv	MACROMOLECULAR SYMPOSIA	2006	84					
13	Ottosen, LM; Arevalo, E; Stichnothe, H; Calmano, W	Ferric flocks to remove Zn and Cu from dockyard wastewater	ENVIRONMENTAL CHEMISTRY LETTERS	2006	164					BMA
14	Christensen, IV; Pedersen, AJ; Ottosen, LM; Ribeiro, AB	Electrodiolytic remediation of CCA-treated waste wood in a 2 m	SCIENCE OF THE TOTAL ENVIRONMENT	2006	45					BMA
15	Kjeldsen, AM; Flatt, RJ; Bergstrom, L	Relating the molecular structure of comb-type superplasticizers t	CEMENT AND CONCRETE RESEARCH	2006	1231					BMA
16	Laarz, E; Kauppi, A; Andersson, KM; Kjeldsen, AM; Bergstr	Dispersing multi-component and unstable powders in aqueous n	JOURNAL OF THE AMERICAN CERAMIC	2006	1847					BMA
17	Tommerup, H; Svendsen, S	Energy savings in Danish residential building stock	ENERGY AND BUILDINGS	2006	618	BFI				
18	Norgard, JS	Consumer efficiency in conflict with GDP growth	ECOLOGICAL ECONOMICS	2006	15			PLB		
19	Ottosen, LM; Lima, AT; Pedersen, AJ; Ribeiro, AB	Electrodiolytic extraction of Cu, Pb and Cl from municipal solid w	JOURNAL OF CHEMICAL TECHNOLOGY	2006	553					BMA
20	Jensen, PE; Ottosen, LM; Pedersen, AJ	Speciation of Pb in industrially polluted soils	WATER AIR AND SOIL POLLUTION	2006	359		GEO			BMA
21	Nystroem, GM; Pedersen, AJ; Ottosen, LM; Villumsen, A	The use of desorbing agents in electrodiolytic remediation of har	SCIENCE OF THE TOTAL ENVIRONMENT	2006	25		GEO			BMA
22	Boggild, CE; Forsberg, R; Reeh, N	Meltwater retention in a transect across the Greenland ice sheet	ANNALS OF GLACIOLOGY, VOL 40, 2005	2005	169					
23	Rojo, A; Hansen, HK; Ottosen, LM	Electrodiolytic remediation of copper mine tailings: Comparing di	MINERALS ENGINEERING	2006	500					BMA
24	Hertz, KD	Quenched reinforcement exposed to fire	MAGAZINE OF CONCRETE RESEARCH	2006	43			PLB		
25	Nordin, H; Taljsten, B	Concrete beams strengthened with prestressed near surface mo	JOURNAL OF COMPOSITES FOR CONSTRUCTION	2006	60				BK	
26	Furbo, S; Andersen, E; Thur, A; Shah, LJ; Andersen, KD	Performance improvement by discharge from different levels in s	SOLAR ENERGY	2005	431	BFI				
27	Jensen, AP	Limit analysis of gusset plates in steel single-member welded co	JOURNAL OF CONSTRUCTIONAL STEEL	2006	144				BK	
28	Christensen, IV; Ottosen, LM; Melcher, E; Schmitt, U	Determination of the distribution of copper and chromium in part	WOOD RESEARCH	2005	11					BMA
29	Koch, C; Bendixen, M	Multiple perspectives on organizing: projects between tyranny ar	BUILDING RESEARCH AND INFORMATION	2005	536			PLB		
30	Hertz, KD	Concrete strength for fire safety design	MAGAZINE OF CONCRETE RESEARCH	2005	445			PLB		
31	Walter, R; Ostergaard, L; Olesen, JF; Stang, H	Wedge splitting test for a steel-concrete interface	ENGINEERING FRACTURE MECHANICS	2005	2565				BK	
32	Schultz, JM; Jensen, KI; Kristiansen, FH	Super insulating aerogel glazing	SOLAR ENERGY MATERIALS AND SCIENCE	2005	275	BFI				
33	Nystroem, GM; Ottosen, LM; Villumsen, A	Acidification of harbor sediment and removal of heavy metals ind	SEPARATION SCIENCE AND TECHNOLOGY	2005	2245		GEO			BMA
34	Hejll, A; Taljsten, B; Motavalli, M	Large scale hybrid FRP composite girders for use in bridge struc	COMPOSITES PART B-ENGINEERING	2005	573				BK	
35	Hansen, HK; Yianatos, JB; Ottosen, LM	Speciation and leachability of copper in mine tailings from porph	CHEMOSPHERE	2005	1497					BMA
36	Shah, LJ; Furbo, S	Modeling shadows on evacuated tubular collectors with cylindric	JOURNAL OF SOLAR ENERGY ENGINEERING	2005	333	BFI				

37	Ferreira, U; Ribeiro, A; Ottosen, L	Effect of major constituents of MSW fly ash during electrodi	SEPARATION SCIENCE AND TECHN	2005	2007						BMA
38	Hertz, KD; Sorensen, LS	Test method for spalling of fire exposed concrete	FIRE SAFETY JOURNAL	2005	466				PLB		
39	Batstone, DJ; Hernandez, JLA; Schmidt, JE	Hydraulics of laboratory and full-scale upflow anaerobic sludge	BIOTECHNOLOGY AND BIOENGINEE	2005	387						
40	Lura, P; Jensen, OM	On the measurement of free deformation of early age cement pa	CEMENT & CONCRETE COMPOSITE	2005	854						BMA
41	Pedersen, AJ; Ottosen, LM; Villumsen, A	Electrodialytic removal of heavy metals from municipal solid was	JOURNAL OF HAZARDOUS MATERIA	2005	103						BMA
42	Moreira, EE; Ribeiro, AB; Mateus, EP; Mexia, JT; Ottosen, L	Regression modeling of electrodi	WOOD SCIENCE AND TECHNOLOGY	2005	291						BMA
43	Shah, LJ; Andersen, E; Furbo, S	Theoretical and experimental investigations of inlet stratifiers for	APPLIED THERMAL ENGINEERING	2005	2086	BFI					
44	Wognum, PM; Krabbendam, JJ; Buhl, H; Ma, X; Kenett, R	Improving enterprise system support - a case-based approach	ADVANCED ENGINEERING INFORMA	2004	241						
45	Thygesen, LG; Ander, P	Quantification of dislocations in spruce pulp and hemp fibres usi	NORDIC PULP & PAPER RESEARCH	2005	64						
46	Nystroem, GM; Ottosen, LM; Villumsen, A	Electrodialytic removal of Cu, Zn, Pb, and Cd from harbor sedim	ENVIRONMENTAL SCIENCE & TECHN	2005	2906			GEO			BMA
47	Ottosen, LM; Pedersen, AJ; Christensen, IV	Characterization of residues from thermal treatment of treated w	WOOD SCIENCE AND TECHNOLOGY	2005	87						BMA
48	Ottosen, LM; Pedersen, AJ; Ribeiro, AB; Hansen, HK	Case study on the strategy and application of enhancement solu	ENGINEERING GEOLOGY	2005	317						BMA
49	Pedersen, AJ; Kristensen, IV; Ottosen, LM; Ribeiro, AB; Vill	Electrodialytic remediation of CCA-treated waste wood in pilot sc	ENGINEERING GEOLOGY	2005	331						BMA
50	Ferreira, C; Jensen, P; Ottosen, L; Ribeiro, A	Removal of selected heavy metals from MSW fly ash by the elec	ENGINEERING GEOLOGY	2005	339						BMA
51	Nystrom, GM; Ottosen, LM; Villumsen, A	Test of experimental set-ups for electrodi	ENGINEERING GEOLOGY	2005	349			GEO			BMA
52	Furbo, S; Vejen, NK; Shah, LJ	Thermal performance of a large low flow solar heating system w	JOURNAL OF SOLAR ENERGY ENGIN	2005	15	BFI					
53	Thygesen, LG; Hoffmeyer, P	Image analysis for the quantification of dislocations in hemp fibre	INDUSTRIAL CROPS AND PRODUCT	2005	173						BMA
54	Laugesen, JL	Density functional calculations of elastic properties of portlandite	CEMENT AND CONCRETE RESEARC	2005	199						
55	Holck, O; Rosenfeld, JLJ	Estimation of exposure to sunlight of the liner under a tiled roof	SOLAR ENERGY	2005	199	BFI					
56	Furbo, S; Andersen, E; Knudsen, S; Vejen, NK; Shah, LJ	Smart solar tanks for small solar domestic hot water systems	SOLAR ENERGY	2005	269	BFI					
57	Knudsen, S; Morrison, GL; Behnia, M; Furbo, S	Analysis of the flow structure and heat transfer in a vertical man	SOLAR ENERGY	2005	281	BFI					
58	Jordan, U; Furbo, S	Thermal stratification in small solar domestic storage tanks caus	SOLAR ENERGY	2005	291	BFI					
59	Nielsen, EP; Herfort, D; Geiker, MR	Phase equilibria of hydrated Portland cement	CEMENT AND CONCRETE RESEARC	2005	109						BMA
60	Nielsen, EP; Herfort, D; Geiker, MR	Binding of chloride and alkalis in Portland cement systems	CEMENT AND CONCRETE RESEARC	2005	117						BMA
61	Nielsen, TR	Simple tool to evaluate energy demand and indoor environment	SOLAR ENERGY	2005	73	BFI					
62	Krabbenhof, K; Damkilde, L; Krabbenhof, S	Ultimate limit state design of sheet pile walls by finite elements a	COMPUTERS & STRUCTURES	2005	383					BK	
63	Hansen, HK; Rojo, A; Ottosen, LM	Electrodialytic remediation of copper mine tailings	JOURNAL OF HAZARDOUS MATERIA	2005	179						BMA
64	Krabbenhof, K; Damkilde, L	Double porosity models for the description of water infiltration in	WOOD SCIENCE AND TECHNOLOGY	2004	641					BK	
65	Jensen, KI; Schultz, JM; Kristiansen, FH	Development of windows based on highly insulating aerogel glaz	JOURNAL OF NON-CRYSTALLINE SO	2004	351	BFI					
66	Krabbenhof, K; Damkilde, L	A model for non-Fickian moisture transfer in wood	MATERIALS AND STRUCTURES	2004	615					BK	
67	Weitzmann, P; Kragh, J; Roots, P; Svendsen, S	Modelling floor heating systems using a validated two-dimension	BUILDING AND ENVIRONMENT	2005	153	BFI					
68	Richter, A; Koch, C	In defence of Schein's perspective on organizational culture	SAFETY SCIENCE	2004	981				PLB		
69	Thomsen, KE; Schultz, JM; Poel, B	Measured performance of 12 demonstration projects - IEA Task	ENERGY AND BUILDINGS	2005	111						
70	Hertz, KD	Reinforcement data for fire safety design	MAGAZINE OF CONCRETE RESEARC	2004	453				PLB		
71	Kamp, A; Hagedorn-Rasmussen, P	Diversity management in a Danish context: Towards a multicultu	ECONOMIC AND INDUSTRIAL DEMOC	2004	525				PLB		
72	Felby, C; Thygesen, LG; Sanadi, A; Barsberg, S	Native lignin for bonding of fiber boards - evaluation of bonding r	INDUSTRIAL CROPS AND PRODUCT	2004	181						BMA
73	Krabbenhof, K; Hoffmeyer, P; Bechgaard, CG; Damkilde, L	Finite element analysis of boron diffusion in wooden poles	WOOD AND FIBER SCIENCE	2004	573					BK	
74	Koch, C	Innovation networking between stability and political dynamics	TECHNOVATION	2004	729				PLB		
75	Arenson, LU; Johansen, MM; Springman, SM	Effects of volumetric ice content and strain rate on shear strengt	PERMAFROST AND PERIGLACIAL PR	2004	261						
76	Vejen, NK; Furbo, S; Shah, LJ	Development of 12.5 m(2) solar collector panel for solar heating	SOLAR ENERGY MATERIALS AND SC	2004	205	BFI					
77	Richter, A; Koch, C	Integration, differentiation and ambiguity in safety cultures	SAFETY SCIENCE	2004	703				PLB		
78	West, BN; Emmitt, S	Functional design? An analysis of new speculative house plans	DESIGN STUDIES	2004	275				PLB		
79	Hansen, HK; Ottosen, LM; Villumsen, A	Electrodialytic removal of cadmium from straw combustion fly as	JOURNAL OF CHEMICAL TECHNOLO	2004	789			GEO			BMA
80	Kovler, K; Lange, DA; Stang, H	Early age concrete - properties and performance	CEMENT & CONCRETE COMPOSITE	2004	413					BK	
81	Ostergaard, L; Lange, D; Stang, H	Early-age stress-crack opening relationships for high performanc	CEMENT & CONCRETE COMPOSITE	2004	563					BK	
82	Shah, LJ; Furbo, S	Vertical evacuated tubular-collectors utilizing solar radiation from	APPLIED ENERGY	2004	371	BFI					
83	Andersen, E; Shah, LJ; Furbo, S	Thermal performance of Danish solar combi systems in practice	JOURNAL OF SOLAR ENERGY ENGIN	2004	744						
84	Nielsen, LF	On the influence of crack closure on strength estimates of wood	HOLZ ALS ROH-UND WERKSTOFF	2004	81						

85	Knudsen, S; Furbo, S	Thermal stratification in vertical mantle heat-exchangers with ap	APPLIED ENERGY	2004	257	BFI				
86	Velizarova, E; Ribeiro, AB; Mateus, E; Ottosen, LM	Effect of different extracting solutions on the electro-dialytic reme	JOURNAL OF HAZARDOUS MATERIA	2004	103					BMA
87	Reeh, N; Christensen, EL; Mayer, C; Olesen, OB	Tidal bending of glaciers: a linear viscoelastic approach	ANNALS OF GLACIOLOGY, VOL 37	2003	83					
88	Reeh, N	Holocene climate and fjord glaciations in Northeast Greenland: i	SEDIMENTARY GEOLOGY	2004	333					
89	Geiker, MR; Brandl, M; Thrane, LN; Bager, DH; Wallevik, O	Reply to the discussion by M. Mouret and M. Cyr of the paper "C	CEMENT AND CONCRETE RESEARC	2003	1905					BMA
90	Jakobsen, MR; Fritt-Rasmussen, J; Nielsen, S; Ottosen, LM	Electrodialytic removal of cadmium from wastewater sludge	JOURNAL OF HAZARDOUS MATERIA	2004	127					BMA
91	Reeh, N; Mohr, JJ; Madsen, SN; Oerter, H; Gundestrup, NS	Three-dimensional surface velocities of Storstrommen glacier, G	JOURNAL OF GLACIOLOGY	2003	201					
92	Illum, K; Meyer, NI	Joint implementation: methodology and policy considerations	ENERGY POLICY	2004	1013				PLB	
93	Holck, O; Svendsen, S; Brunold, S; Frei, U; Kohl, M; Heck, M	Solar collector design with respect to moisture problems	SOLAR ENERGY	2003	269	BFI				
94	Shah, LJ; Furbo, S	Entrance effects in solar storage tanks	SOLAR ENERGY	2003	337	BFI				
95	Pedersen, MU; Clorius, CO; Damkilde, L; Hoffmeyer, P	A simple size effect model for tension perpendicular to the grain	WOOD SCIENCE AND TECHNOLOGY	2003	125				BK	BMA
96	Furbo, S; Shah, LJ	Thermal advantages for solar heating systems with a glass cover	SOLAR ENERGY	2003	513	BFI				
97	Kines, P; Mikkelsen, KL	Effects of firm size on risks and reporting of elevation fall injury in	JOURNAL OF OCCUPATIONAL AND E	2003	1074				PLB	
98	Kines, P	Case studies of occupational falls from heights: Cognition and be	JOURNAL OF SAFETY RESEARCH	2003	263				PLB	
99	Pedersen, AJ	Characterization and electro-dialytic treatment of wood combustio	BIOMASS & BIOENERGY	2003	447					BMA
100	Christoffersen, P; Tulaczyk, S	Thermodynamics of basal freeze-on: predicting basal and subgl	ANNALS OF GLACIOLOGY, VOL 36	2003	233					
101	Pedersen, AJ; Ottosen, LM; Villumsen, A	Electrodialytic removal of heavy metals from different fly ashes -	JOURNAL OF HAZARDOUS MATERIA	2003	65		GEO			BMA
102	Hansen, HK; Kristensen, IV; Ottosen, LM; Villumsen, A	Electroosmotic dewatering of porous materials - Experiences wit	JOURNAL OF CHEMICAL ENGINEERIN	2003	689		GEO			BMA
103	Nystrom, GM; Ottosen, LM; Villumsen, A	The use of sequential extraction to evaluate the remediation pote	JOURNAL DE PHYSIQUE IV	2003	975		GEO			BMA
104	Ottosen, LM; Pedersen, AJ; Kristensen, IV; Ribeiro, AB	Removal of arsenic from toxic ash after combustion of impregna	JOURNAL DE PHYSIQUE IV	2003	993					BMA
105	Pedersen, AJ; Gardner, KH	Characterization of municipal solid waste incineration fly ash bef	JOURNAL-DE-PHYSIQUE IV	2003	1029					
106	Thygesen, LG; Blennow, A; Engelsen, SB	The effects of amylose and starch phosphate on starch gel retro	STARCH-STARKE	2003	241					BMA
107	Madsen, B; Lilholt, H	Physical and mechanical properties of unidirectional plant fibre c	COMPOSITES SCIENCE AND TECHN	2003	1265					
108	Christoffersen, P; Tulaczyk, S	Response of subglacial sediments to basal freeze-on - 1. Theory	JOURNAL OF GEOPHYSICAL RESEAR	2003						
109	Christoffersen, P; Tulaczyk, S	Signature of palaeo-ice-stream stagnation: till consolidation indu	BOREAS	2003	114					
110	Ottosen, LM; Kristensen, IV; Pedersen, AJ; Hansen, HK; Vill	Electrodialytic removal of heavy metals from different solid waste	SEPARATION SCIENCE AND TECHN	2003	1269					BMA
111	Hertz, KD	Limits of spalling of fire-exposed concrete	FIRE SAFETY JOURNAL	2003	103				PLB	
112	Meyer, NI	European schemes for promoting renewables in liberalised mark	ENERGY POLICY	2003	665				PLB	
113	Meyer, NI; Koefoed, AL	Danish energy reform: policy implications for renewables	ENERGY POLICY	2003	597				PLB	
114	Krabbenhoft, K; Damkilde, L	A general non-linear optimization algorithm for lower bound limit	INTERNATIONAL JOURNAL FOR NUM	2003	165					BK
115	Krabbenhoft, K; Damkilde, L	Lower bound limit analysis of slabs with nonlinear yield criteria	COMPUTERS & STRUCTURES	2002	2043					BK
116	Nielsen, EP; Geiker, MR	Chloride diffusion in partially saturated cementitious material	CEMENT AND CONCRETE RESEARC	2003	133					BMA
117	Tanaka, T; Yoshimura, T; Gimsing, NJ; Mizuta, Y; Kang, WH	A study on improving the design of hybrid stress-ribbon bridges	JOURNAL OF WIND ENGINEERING AN	2002	1995					BK
118	Reeh, N; Mohr, JJ; Krabill, WB; Thomas, R; Oerter, H; Gund	Glacier specific ablation rate derived by remote sensing measure	GEOPHYSICAL RESEARCH LETTERS	2002						
119	Duer, K; Svendsen, S; Mogensen, MM; Laustsen, JB	Energy labelling of glazings and windows in Denmark: Calculate	SOLAR ENERGY	2002	23	BFI				
120	Knudsen, S	Consumers' influence on the thermal performance of small SDH	SOLAR ENERGY	2002	33	BFI				
121	Pedersen, PJ	Evaluation of assisting agents for electro-dialytic removal of Cd, P	JOURNAL OF HAZARDOUS MATERIA	2002	185					
122	Geiker, MR; Brandl, M; Thrane, LN; Bager, DH; Wallevik, A	The effect of measuring procedure on the apparent rheological p	CEMENT AND CONCRETE RESEARC	2002	1791					BMA
123	Velizarova, E; Ribeiro, AB; Ottosen, LM	A comparative study on Cu, Cr and As removal from CCA-treate	JOURNAL OF HAZARDOUS MATERIA	2002	147					BMA
124	Geiker, MR; Brandl, M; Thrane, LN; Nielsen, LF	On the effect of coarse aggregate fraction and shape on the rhe	CEMENT CONCRETE AND AGGREGA	2002	3					BMA
125	Kines, P	Construction workers' falls through roofs: Fatal versus serious in	JOURNAL OF SAFETY RESEARCH	2002	195				PLB	
126	Velizarova, EG; Ribeiro, A; Mateus, EP; Ottosen, LM	Electrodialytic removal of Cu and Cr from soil and wood contami	ABSTRACTS OF PAPERS OF THE AM	2002	U616					BMA
127	Pedersen, AJ	Electrochemical treatment of wood combustion fly ash for the re	ABSTRACTS OF PAPERS OF THE AM	2002	U625					BMA
128	Kristensen, IV; Ottosen, LM; Ribeiro, A; Villumsen, A	Electrodialytic remediation of CCA-impregnated waste wood.	ABSTRACTS OF PAPERS OF THE AM	2002	U625					BMA
129	Heller, AJ	Heat-load modelling for large systems	APPLIED ENERGY	2002	371	BFI				
130	Ottosen, LM; Eriksson, T; Hansen, HK; Ribeiro, AB	Effects from different types of construction refuse in the soil on e	JOURNAL OF HAZARDOUS MATERIA	2002	205					BMA
131	Baumgartner, F; Munk, J; Jezek, KC; Gogineni, S	On reconciling ground-based with spaceborne normalized radar	IEEE TRANSACTIONS ON GEOSCIEN	2002	494					
132	Guldbrandsen, T	Uncertainty contributions from mismatch in microwave measure	IEE PROCEEDINGS-MICROWAVES AN	2001	393					

133	Krenk, S; Nielsen, SRK	Vibrations of a shallow cable with a viscous damper	PROCEEDINGS OF THE ROYAL SOCI	2002	339				BK	
134	Kines, P	Occupational injury risk assessment using injury severity odds ra	HUMAN AND ECOLOGICAL RISK ASS	2001	1929			PLB		
135	Christiansen, MB; Nielsen, MP	Plane stress tension stiffening effects in reinforced concrete	MAGAZINE OF CONCRETE RESEARC	2001	357				BK	
136	Geiker, MR; Laugesen, P	On the effect of laboratory conditioning and freeze/thaw exposur	CEMENT AND CONCRETE RESEARC	2001	1831					BMA
137	Ostergaard, L; Lange, DA; Altoubat, SA; Stang, H	Tensile basic creep of early-age concrete under constant load	CEMENT AND CONCRETE RESEARC	2001	1895				BK	
138	Krenk, S	Unified formulation of radiation conditions for the wave equation	INTERNATIONAL JOURNAL FOR NUM	2002	275					

# STRATEGY

Department of Civil Engineering  
(BYG•DTU)

March 2003

This Strategy Note has been prepared as a collaborative effort between the Dean of Research, the Deans of Education and the Department.

The Note has been approved by the management team at DTU in March 2003.

The ambition of the Department of Civil Engineering at the Technical University of Denmark (BYG•DTU) is to be a nationally and internationally recognised university department which, through its activities in education, research and innovation, contributes to the technical development of the building and construction industry and the associated commercial and industrial development process. The strategy presented here has been developed in close collaboration with DTU's overall strategy for the achievement of these goals, specially aimed at the period 2003-2008.

The strategy describes the principal goals and the tools for achieving them. As a result of continuously changing conditions, the tools described here will have to be continuously adjusted throughout the period to suit changes in conditions as well as the results achieved.

**The goals comprising BYG•DTU's strategy are:**

- **Mission**, i.e. the Department's raison d'être.
- **Vision**, i.e. the Department's desired future.
- **Strategic goals**, i.e. the Department's goals for the six-year planning period.

**The instrument included in BYG•DTU's strategy is:**

- **The strategy plan**, i.e. the academic profile and tools which shall be used to realise the vision.

## **MISSION**

As a university department with activities in the areas of teaching, research and innovation, BYG•DTU should contribute to knowledge, advancement, commercial progress and sustainability in the field of civil engineering.

- The Department's programmes should produce highly qualified graduates at the Bachelor of Science in engineering (BSc) and Civil Engineer (MSc) levels for the Danish building and construction industry, and it should provide students with the opportunity to prepare themselves for a career in research.
- The Department's research should contribute to the continued growth of the building and construction industry, both nationally and internationally, and
- The Department should contribute to innovation and renewal in the Danish building and construction industry through active dialogue.

Through these activities, values are created for the students, society in general and the building and construction industry in particular.

## **VISION**

In 2008, BYG•DTU is recognised as one of Europe's leading civil engineering university departments in education and in at least two central fields of research. The Department is the preferred collaborative partner for the Danish building and construction industry in research and development and is recognised as a supplier of graduates with the best qualifications.

- The Department's education offers coherent programmes of study in broad application-oriented aspects as well as more specialised subjects.
- The Department's research is centred on a limited number of focus areas where visibility is achieved at an international/European level.
- The Department has an extensive collaborative relationship with the Danish building and construction industry and contributes substantially to its innovation and renewal through continuous collaborations as well as through the solution of specific problems.

## **STRATEGIC GOALS**

### **Education**

- BYG•DTU is recognised for providing relevant, future-oriented MSc (engineering) programmes, the solid academic foundation of which can provide a basis for life-long learning.
- The Department contributes visibly to all categories of education: BSc (engineering), MSc (engineering), Master and continuing education programmes.
- The Department has a simple academic structure geared towards imparting a comprehensive understanding of construction processes, buildings and structures as well as towards training specialists with a view to development work and research.
- The Department's course selection is closely coordinated with courses at DTU's other departments which provide teaching of high relevance to the field of civil engineering.
- The Department's courses use state-of-the-art IT tools and attach great importance to project work and synthesis.
- The Department's courses of study and course structure provide for international student exchange.
- The Department ensures topicality and contact with the business and industry community in the teaching of practice-oriented subjects.

### **Research**

- BYG•DTU conducts research within a well-defined selection of focus areas of key importance for construction processes, buildings and structures.
- All focus areas achieve international research excellence and the Department is among the ten best in Europe in at least two focus areas.
- Holistically-oriented, interdisciplinary research is conducted through activities and projects as collaborative efforts between several of the Department's focus areas.
- The Department has a strong research environment which attracts Danish and foreign PhD students and guest researchers and takes part in the international guest exchange of researchers, PhD students and post-doctorates with leading foreign research environments.
- The Department educates 10-15 PhDs and industry-sponsored researchers annually, distributed among all its focus areas. At least half of these enter into external collaborative relationships.

## **Innovation**

- Within its focus areas, BYG•DTU is the preferred collaborative partner in Denmark for the undertaking of commissioned research in collaborative projects, industrial research projects and research and innovation consortiums.
- The Department has state-of-the-art experimental facilities and expertise at its disposal. These facilities and expertise make up a substantial portion of the Department's activities in the area of innovation.
- The Department permanently houses a number of innovative companies, the activities of which form part of the Department's life in the areas of both research and teaching.

## **Personnel and finance**

- BYG•DTU's personnel policy supports education, research and innovation by attracting talented workers to all staff groups and continuously developing their qualifications.
- The Department generates external funding for research in accordance with DTU's targets through participation in national and international research programmes as well as through collaborative projects and commissioned research.

## **STRATEGY PLAN**

BYG•DTU is a university department. This strategy plan is, therefore, based on the premise that each staff member will display personal initiative within the framework of the plan and that the Department will support this.

### **Education**

- BYG•DTU shall perform an audit of its course selection for the purpose of rationalisation and creating clearly defined programmes of study based on comprehensiveness and academic progression.
- Regular seminars shall be established with external users and graduates of the Department for the purpose of evaluation and continuous renewal of the programmes.
- The Department's research shall be made visible in teaching, and special project activities linked to the research shall be offered.
- Coherent use of state-of-the-art IT tools for the planning, design and analysis of buildings and structures shall be introduced into the teaching activities.
- Experimental demonstrations and trials shall be incorporated into the teaching activities.
- Small, independent projects and continuous evaluation throughout the course shall be included in the teaching activities.
- Teaching activities shall be organised with a view to making it possible to take at least two semesters in English at the end of a programme of study.
- Teaching collaborations shall be established with other departments on common subjects such as mechanics, hydraulic engineering, road building and geology as well as management and product modelling.
- The opportunities shall be investigated for entering into binding collaborative agreements with other Northern European universities on common course material and the exchange of teachers.
- In practice-oriented subjects, teaching activities shall draw on external associate professors and student projects shall be carried out, to the extent possible, with external collaboration.
- The Department shall head the establishment of a BSc (engineering) programme with special focus on the architectural aspects of structure design – “architectural engineering”.
- The Department will offer flexible courses in central subjects, e.g. construction management, building maintenance and fire technology, which provide for external participation as well as continuing education, e.g. in the form of Master programmes.

## **Research**

In the area of research, the Department's strategy plan includes a clear identification of several key action areas, a description of the action and a number of common initiatives.

- BYG•DTU's research shall be organised within a limited number of central focus areas:
  - o Structural engineering
  - o Geotechnology
  - o Building materials
  - o Construction processes, planning and management
  - o Building physics and installations
- Through the Department's own efforts, collaboration with other research environments and with the assistance of guest researchers, five to ten PhD courses shall be developed in the Department's fields of research. The courses shall be offered in English and shall cover basic aspects as well as cutting-edge research in advanced topics.
- The Department shall develop a research plan which covers specific initiatives and follow-up procedures.
- The focus areas' network shall be expanded nationally and internationally through collaborative projects and participation in national and EU projects, e.g. the EU's Sixth Framework Programme.
- Collaborative agreements shall be established with a number of parties in the building and construction industry, including government research institutes and Authorised Technological Service Institutes.
- The generational change at the Department shall be carried out with a view to a targeted strengthening of the research-related focus areas.

### ***Structural engineering***

The load-bearing structure is an essential part of buildings and is the dominating aspect in civil engineering projects such as bridges, towers, harbours, etc. This focus area covers the overall design of the structure and particular design aspects including demonstration of strength, durability, etc. with regard to the loads and effects on the structure from, e.g. climate, wear and breakdown processes. Innovative structure design involves substantial research-related challenges in, among other things, the use of new materials and new structural elements. Moreover, there is a need for improved methods of experimental determination and modelling of use and failure characteristics of structures, as well as their durability.

This focus area shall concentrate its research on the optimal design of building structures with regard to both use and failure conditions, utilising the latest models and methods of calculation. International research collaboration shall be expanded and this focus area shall participate in innovative Danish construction projects.

- In the field of structural engineering, at least two PhD courses shall be established, e.g. in structural design and concrete structures.
- At least two PhDs/industry-sponsored researchers shall be trained annually with external participation in at least half of the projects.

- An active effort shall be made to implement a generational change in the focus area to create a well-defined future-oriented research profile.
- In connection with the generational change, emphasis shall be laid on the development of research-related collaborative relationships with the building and construction industry as well as the establishment/continuation of international collaborative relationships.

### ***Geotechnology***

Geotechnology includes determination and modelling of the properties of soil and rock types as well as the design and dimensioning of foundations and structures such as roads, tunnels, dams, docks, etc. An essential reorientation of the field is taking place internationally under the influence of advances in experimental technologies and improved material models. This process is expected to lead to demands for improved descriptions of the modes of action of geotechnical structures, especially under conditions of use.

This focus area shall concentrate its research on the experimental description of soil and rock types, the development of models for their behaviour and the implementation of these models in the latest numerical computing tools. International research collaboration shall be expanded and the area shall be included in development-oriented Danish building and civil engineering projects.

- A gathering and upgrading of the experimental facilities shall be carried out with combined internal and external funding.
- At least one general PhD course shall be developed in the field of geotechnology.
- The existing external collaborative relationships shall be strengthened in the field of geotechnical foundations.
- At least two PhDs/industry-sponsored researchers shall be trained annually, with external participation in at least half of the projects.
- An active effort shall be made to strengthen staffing in the focus area, especially in the interaction between the experimental determination of material properties and the modelling of these properties or the design of geotechnical structures.

### ***Building materials***

The ability of structures to meet the requirements of their function is determined by a combination of structural design, choice of materials and execution and maintenance. It is important for the building and construction industry to be able to describe the strength and deformation properties, durability, aging and breakdown of the construction materials. Essential construction materials, such as concrete, masonry and timber, are porous, and their pore structure and ability to bind moisture are decisive for mechanical properties, such as rigidity and strength, for durability and for fire-resistance properties. These matters are crucial to the function and cost of any construction project and there is a need for an active research effort in, among other things, the relation between the structure and the properties of the materials, and the development of improved materials.

Research in this focus area shall primarily include experimental descriptions of porous building materials such as concrete, masonry and timber and the development of models for their structure, properties and function. International research collaboration shall be expanded and the focus area shall contribute to the Danish development of new building materials.

- A renovation and upgrading of the experimental facilities shall be carried out with combined internal and external funding.
- The activities in the areas of durability and maintenance shall be expanded and combined with facilities management.
- The existing PhD courses shall be consolidated and expanded with courses of a more general nature, e.g. in material physics or material mechanics in international collaboration with, among others, the Swiss Federal Institute of Technology, in Zurich, and Delft University of Technology.
- At least three PhDs/industry-sponsored researchers shall be trained annually.

### ***Construction processes, planning and management***

The construction process, from planning to design to implementation, has a significant influence on the total technical-financial result. Furthermore, the building and construction industry is characterised by a dependency on the interaction between many players in changing combinations. Construction processes and planning are identified as key areas for making the Danish building and construction industry more efficient. Some of the key components are improved product models, the reorganisation of processes with a view to improved information and material flow and facilities management with the use of modern IT tools.

Research in the area shall focus on construction processes and organisation as well as their planning and management. Emphasis shall be laid on innovation in construction processes, e.g. through new working processes, and the development of process models and forms of management. Another contribution shall be the development of logistics and product modelling. Improved external research collaboration shall be developed and the focus area shall be included in the organisation and planning of major Danish building and construction projects as well as pilot projects.

- A formalised collaboration shall be entered into with the Department of Manufacturing Engineering and Management on innovation, project management and product modelling.
- A network shall be formed with the building and construction industry in the area of construction management and processes, preferably in collaboration with Danish Building and Urban Research.
- A collaborative relationship shall be developed in facilities management with Lund Institute of Technology and Chalmers University of Technology.
- Two PhD courses shall be developed, possibly in collaboration with the Department of Manufacturing Engineering and Management and/or with external partners.

- At least two PhDs/industry-sponsored researchers shall be trained annually.

### ***Building physics and installations***

Because of the users' demand for functionality and economy and society's demand for energy conservation and environmental improvements, buildings have to be energy efficient, durable and have a healthy indoor climate. A holistic approach to the building envelope and installations is the basis for creating buildings with a healthy indoor climate and low energy consumption. This subject area deals with the interaction between the building envelope and installations, and intelligent methods of controlling them. It is a central aspect in both the design and operation of buildings as well as in the development of construction products and system solutions.

The area's main focus shall be on the integrated design of building envelopes and installations and their control with a view to ensuring optimal operations with regard to energy and climate conditions. In this context, it is necessary to establish detailed knowledge of the physical conditions that obtain in the building. As a basis for this, targeted research shall be conducted into the establishment and experimental verification of models for the coupled energy and mass flows which take place in structures and installations.

- Activities shall be initiated in the control and regulation of building installations with a view to developing "intelligent buildings".
- External funding of this focus area shall be ensured through participation in international research programmes, e.g. the EU's Sixth Framework Programme and the Nordic Energy Research Programme.
- Two PhD courses shall be developed in international collaboration.
- At least two PhDs/industry-sponsored researchers shall be trained annually.

### **Centre for Arctic Technology – ARTEK**

The Arctic perspective in teaching and research in the field of civil engineering is the responsibility of the Centre for Arctic Technology. The Centre provides BSc (engineering) and continuing education programmes in the field of Arctic technology, partly in Greenland and partly at DTU. The Centre also offers classes in Arctic technology in the MSc (engineering) study programme. The Centre conducts research activities, including training PhD students, in the field of civil engineering in the Arctic regions, which is the Centre's core area.

- ARTEK shall expand its role as a provider of technology and innovation, having regard for the special social and environmental conditions of the Arctic regions.
- International contacts shall be established with Arctic research and teaching environments in Scandinavia, Russia, Canada and the USA with a view to entering into collaborative agreements and exchange programmes for students and academic staff.

## **Innovation**

### ***BYG-test***

An internal project unit shall be established in the Department for experimental activities under the name BYG-test. This unit shall take on experimental assignments in the form of commissioned jobs and collaborative projects.

- BYG-test shall focus on projects with a high content of advanced experimental techniques and through its own profits contribute to maintaining advanced experimental facilities and expertise in the Department.
- BYG-test shall enter into collaborative agreements with similar players in the field of testing, such as Danish Building and Urban Research, the Danish Technological Institute, the FORCE Institute, the Risø National Laboratory, GEO (the Danish Geotechnical Institute) and the Danish Institute of Fire and Security Technology.
- BYG-test shall collaborate as required with innovative companies which have offices and laboratory facilities at the Department.

### **Staff and finances**

- It shall be ensured that BYG•DTU acts as a coherent university department with the academic fellowship that is natural for such a unit.
- The Department shall consciously work to further staff qualifications and experience bases with instruments such as sabbaticals and foreign exchange.
- At the start of the period, the Department shall prepare a comprehensive plan for the need for competency development and the means required for this development.
- The annual staff appraisal interviews shall relate directly to the Department's strategy for teaching, research and innovation, and shall identify the needs for competency development, e.g. in the form of continuing education.
- The Department shall develop a plan for the coming generational change. This plan shall include: active recruiting, simultaneous appointments to several positions in the same focus area, special start-up funding for the establishment of research initiatives and sponsored research positions.
- The generational change shall be furthered through the establishment of a senior policy for the Department's staff and, where possible, through early appointments to positions.

## ANNEX: RESOURCES

Distribution of number of employees - 2002

	Professors	Assoc. professors	Assis. professors	Research assistants	PhDs	T&As
Ordinarily funded	7	44	3	4	17	52
Externally funded	0	8	7	9	13	2

Department of Civil Engineering (BYG•DTU)  
Technical University of Denmark  
Brovej, Building 118  
DK-2800 Kgs. Lyngby

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## BYG•DTU UdviklingsMål og Virkemidler 2008-2011

### 1. Institutprofil og strategi

#### 1.1 Faglige profil og strategi

BYG•DTU er et universitetsinstitut inden for byggeri og anlæg (Civil Engineering).

Instituttets **mission** er undervisning, forskning, innovation og myndighedsbetjening. Instituttet bidrager gennem byggeteknisk vidensudvikling til social og kommerciel værdiskabelse.

Instituttets **vision** er at blive et af Europas førende byggetekniske institutter og en foretrukken samarbejdspartner for virksomheder og myndigheder nationalt såvel som internationalt.

Instituttets strategi for 2003-8 findes på [www.byg.dtu.dk](http://www.byg.dtu.dk). De strategiske mål fra 2003 vil være nået med udgangen af 2007.

Denne UMV for 2008-10 er første skridt i udvikling af en ny strategisk plan. UMV-en beskriver særlige igangværende og nye større initiativer, og den beskriver derfor ikke resultater eller videreførelse af almindelige institutaktiviteter.

Der er ved udarbejdelsen af UMV ikke taget stilling til de organisationstilpasninger der vil ske i grænsefladerne til øvrige institutter som følge af fusionsprocessen. Instituttet imødeser at der vil ske justeringer i forhold til det nye IPL og det nye MEK.

#### 1.2 Strategiske udviklingsområder

Instituttet har siden etableringen i 2001 gennemført en række aktiviteter inden for prioriterede udviklingsområder. Hvert udviklingsområde etablerer en ny platform på vejen til realiseringen af visionen:

##### 2001-03: Rammer og resurser

*Handlinger:* Fusion af institutter. Etablering af basis- og projektorganisation og centraliserede administrative, regnskabs- og IT-systemer. Udpegning af institut-, sektions-, forsknings- og studieledere. Implementering af DTUs ledelsesmodel: UMV, handlingsplan, årsrapport. Vedtagelse af Strategi 2003-08.

*Resultater:* En velfungerende organisation og en fælles identitet.

### **2003-06: Generationssskifte**

*Handlinger:* Økonomisk betinget stabsreduktion efterfulgt af et stort generationsskifte. Ansættelse af 4 professorer, 11 lektorer, 8 adjunkter og 10 TAP har skabt et nyt institut.

*Resultater:* En VIP-gruppe med bedre aldersfordeling, international baggrund, et stort forskningspotentiale og meget stærk erhvervsbaggrund herunder flere med erfaring med myndighedsbetjening. En TAP-gruppe som svarer til instituttets tekniske og administrative mål.

### **2004-07: National positionering**

*Handlinger:* Etablering af nye industrikontakter og udpegning af advisory board. Afholdelse af aftagerseminarer. Netværk med Realdania, Kuben og andre fonde. Masteruddannelserne i brand og byggeledelse. ARTEK. Mere end 30 eksterne lektorer. Etablering af forskerskolen IRS@BYG. To industrinetværk: LavEbyg, C-Prosam. NanoByg. Ledelse af Dansk Facilities Management Netværk. I 2007: B150 arrangementer.

*Resultater:* Forbedret eksternt image. BYG•DTU har fået status som den danske bygge- og anlægssektors foretrukne forskningspartner. Kraftig vækst i indgåede erhvervs- og samfinansierede phd-kontrakter, otte kontrakter alene i 2006.

### **2001-08: Uddannelsesrevision**

*Handlinger:* Etablering af uddannelserne Arktisk Teknologi i 2001 og Architectural Engineering i 2002. Revision af studieplaner i dialog med aftagere og øvrige uddannelser i Danmark og EU. Implementering af Bologna-deklarationen. Kandidatuddannelse på engelsk. I 2007-8: Indføre CDIO. Indgå uddannelsesaftale med Faculty of Civil Engineering and Geodesy, TUM. Etablere kandidatuddannelse i Architectural Engineering.

*Resultater:* Velstrukturerede uddannelser med klare kompetenceprofiler gennem koordinerede anbefalede studieforløb. Stigende rekruttering både af danske og udenlandske studerende. Anerkendelse af uddannelsernes kvalitet hos aftagere.

### **2007-10: Innovation**

*Handlinger:* Etablere en BYG-innovationsenhed i IPU. Danne nationalt center for mekanisk konstruktions- og materialeprøvning med Risø, MEK, AU, FORCE. Ansætte leder af BYG•innovation gennem IPU. Aktiv markedsføring af instituttets innovationsressourcer.

*Resultater:* Øget omsætning i innovationsaktiviteter, bedre incitament for VIP for innovationsaktiviteter, medfinansiering af forskningsinfrastruktur.

### **2008-11: Forskningskvalitet**

*Handlinger:* Forskningsevaluering i 2007. Fokus på forskningskvalitet gennem styrket forskningsledelse. Reviderede forskningsplaner som led i udarbejdelse af ny strategi. Opprioritering og opkvalificering af ansøgningsarbejdet. Forskningsevaluering i 2011.

*Resultater:* Flere og bedre artikler. Større prestige. Bedre grundlag for uddannelse, innovation og myndighedsopgaver.

### **2009-12: International positionering**

*Handlinger:* Udnytte stigende forskningsproduktion som platform for international positionering. Aktiv ledelsesdeltagelse i RILEM, CIB og andre internationale organisationer. Øget udveksling af videnskabelig stab med prestigeinstitutter. Aktiv markedsføring af kandidatuddannelserne.

*Resultater:* Godt internationalt image. Påvirke de internationale forskningsprioriteringer. 25% udenlandske kandidatstuderende og tilsvarende udveksling af danske studerende.

## 2009-12: Myndighedsopgaver

*Handlinger:* Etablere kontakter hos myndigheder med henblik på den situation som forventes at opstå i takt med at sektorforskningen konkurrenceudsættes. Identificere myndighedsopgaver i EU regi.

*Resultater:* En væsentlig andel af myndighedsopgaverne varetages af BYG•DTU fra 2012.

### 1.3 Kvalitetssikring

#### Uddannelse

Der holdes et undervisningsseminar hver 12.-18. måned med deltagelse af censorer og aftagervirksomheder, det næste afholdes den 29. august 2007.

Undervisningen benchmarkes gennem deltagelse i eksterne nationale og internationale netværk f.eks. Netværkerne 'Byggeri og Anlæg', CDIO-organisationen og EUCEET.

#### Forskning

Forskningslederne sikrer, at forskning som hidtil er dokumenteret i rapporter og konferencebidrag fremover publiceres i prestigetidsskrifter. Projektbudgetterne skal tage højde herfor.

#### Administrative processer

Instituttet identificerer de vigtigste lokale arbejdsprocesser og udarbejder standard procedurer som dokumenteres i instituttets medarbejderhåndbog på Portalen.

#### Laboratorie- og værkstedprocedurer

Det er ikke resurseøkonomisk at opretholde en certificeret kalibrering på alle instrumenter hele tiden, derfor vil en systematisk og resurseøkonomisk kvalitetsplan blive udviklet af instituttets laboratorieudvalg.

### 1.4 Intern kommunikation og inddragelse

Til opfølgning og forankring af BYG•DTUs strategi benytter instituttet DTUs rullende årsplan. Årsplanen indgår løbende i ledelsens kommunikation med medarbejderne. Kommunikationen understøttes af den årlige MUS med hver enkelt medarbejder, af sektionsmøder ca. en gang om måneden, morgenmadsmøder for hele instituttet en gang om måneden, og et årligt UVM-seminar for en bredere kreds af ledende medarbejdere.

I 2007 har instituttet iværksat en proces for revision af strategien som udløber i 2008:

Januar	• Søhus-seminar for VIP, som start på processen
Marts-april	• Fremtidsværksted faciliteret af Fremforsk, udarbejdelse af fremtidsscenerier for rammebetingelserne for de kommende 10-20 år.
April-maj	• Sektionsbaseret dialog om UVM2008-11
Maj-juli	• Selvevaluering af forskningen
Oktober-november	• Ekstern forskningsevaluering ved peer-review panel
Januar 08	• Strategiseminar for alle medarbejdere
Maj 08	• Ny strategi og UVM 2009-12

## 2. Personaleressourcer og personalepolitik

### 2.1 Organisation

BYG•DTUs basisorganisation er opdelt i sektioner efter de faglige fokusområder. Instituttets aktiviteter gennemføres i projekter, som kan gå på tværs af sektioner, institutter og virksomheder.

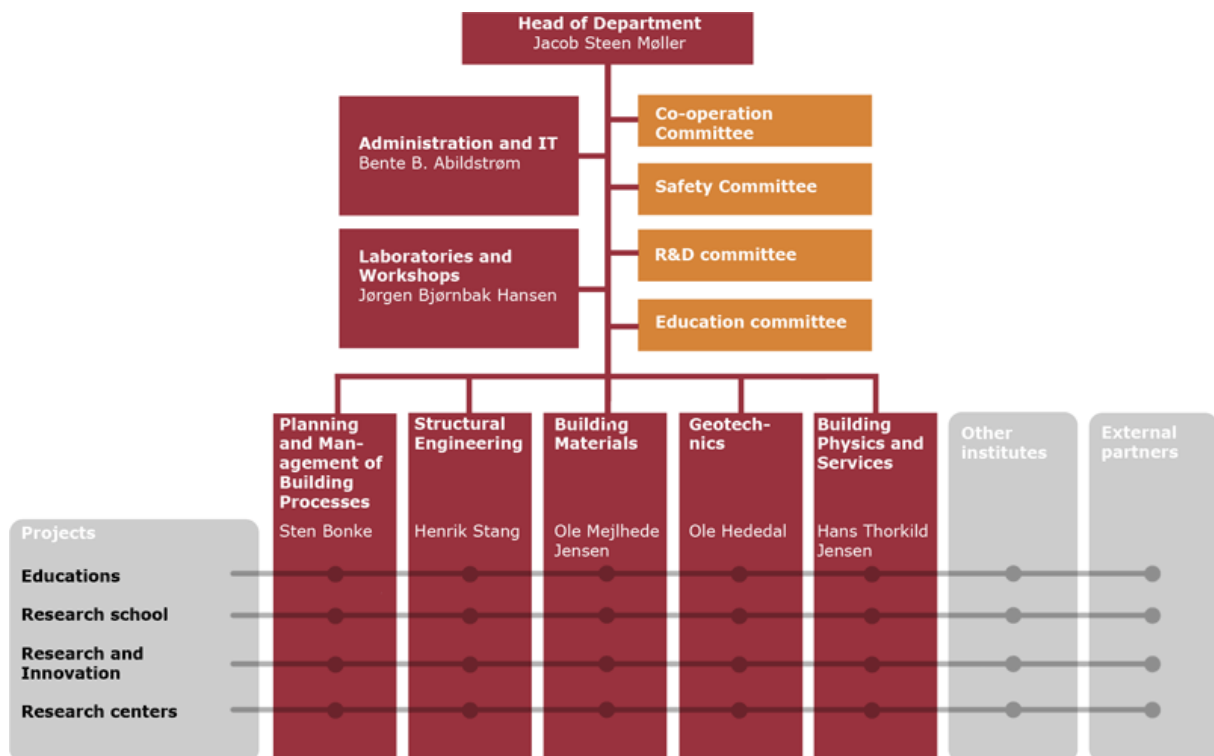
#### Basisorganisation

Sektioner og afdelinger varetager medarbejderudvikling og kompetenceudvikling og råder over de tekniske resurser.

Samarbejdsspørgsmål behandles i samarbejdsudvalget. Sikkerhedsarbejdet koordineres og udføres af sikkerhedsudvalget.

Koordination af forskning, innovation og myndighedsbehandling sker gennem instituttets forsknings- og innovationsudvalg som består af udpegede forskningsledere og institutdirektør

Koordination og evaluering af uddannelserne sker gennem instituttets studienævn, hvor det tilstræbes at studielederne enten er medlem eller deltager ved invitation.



Figur 1: BYG•DTU Organisation

## Projektorganisation

BYG•DTU organiserer sine aktiviteter i projekter. Tværgående koordination af projekter på tværs af institutter og samarbejde med parter uden for DTU finder sted i forsknings- og innovationscentre.

Eksisterende centre:

- ARTEK, Center for arktisk teknologi, Arne Villumsen
- C•PROSAM, Centre for Protective Structures and Materials, Benjamin Riisgaard
- IRS@BYG, International Research School for Civil Engineering at BYG•DTU, Stephen Emmitt
- LavEByg, Højteknologisk netværk vedrørende integrerede lavenergiløsninger på bygningsområdet, Svend Svendsen

Planlagte centre:

- BYG•innovation gennem IPU (etableret i 2007), lederstilling opslås gennem IPU.
- Realdania center for Facilities Management (forprojekt afsluttes i 2007), Per Anker Jensen
- Nationalt center for mekanisk prøvning med MEK, Risø, AU, mfl. (under etablering), Henrik Stang
- Ekstremlastlaboratorium (på idestadie i 2007), Kristian Hertz

Instituttet vil styrke projektledelse og -administration gennem uddannelse af projektledere og indførelse af IT-støttede projektledelsesværktøjer i takt med at DTUs generelle systemer udvikles.

## 2.2 Leder- og medarbejderudvikling

Fra foråret 2006 er DTUs reviderede MUS koncept fuldt indarbejdet. Instituttet fastholder og videreudvikler kompetenceudviklingsaktiviteterne gennem:

- Pædagogisk udvikling gennem UDtU
- DTUs kursusudbud
- Specielle BYG•DTU-kurser, f.eks.
  - scientific writing
  - engelsk for VIP og TAP
  - teambuilding
- SCKK støttet kompetenceudvikling om kvalitetsudvikling i UFI-processer
- Mini-MTU i 2007, evt. opfølgning i 2010.

Senere i perioden vil instituttet udvikle midler og incitamentter til at øge den internationale udveksling af VIP for at styrke den internationale positionering.

Senere i perioden vil instituttet undersøge hvilke nye kompetencer som kræves for at indgå aktivt i konkurrencen om myndighedsopgaver.

## 2.3 Generelle HR Data

Instituttet er ved at afslutte et omfattende generationsskifte. Der er indregnet en stigning i antallet af professorer som svarer til antallet af større forskningstemaer med forskningsledelse.

På grund af den generelle stigning i midler til forskeruddannelse og stigende interesse i industrien for erhvervs-phd-ordningen regnes med en stigning i antallet af phd-studerende.

Instituttet benytter eksterne undervisere (eksterne lektorer, formålsansatte VIP) i stort omfang. Den samlede mængde indkøb af undervisningsassistance forventes ikke at stige, idet det er vigtigt, at undervisningen forankres hos faculty.

### **Udvikling i medarbejderprofil**

#### Sektionen for Byggematerialer:

Forskningstemaet 'transport og binding' søges forstærket med ansættelse af VIP. TAP kompetencen inden for elektron-mikroskopi skal udvikles yderligere i forbindelse med indfasning af nyt Environmental Scanning Elektron Microscope, ESEM.

#### Sektionen for Geoteknik:

Gennem rekruttering af to yngre VIP i 2007 vil geoteknikgruppens generationsskifte stort set være på plads, dog vil endnu en lektor fratræde inden for perioden. Faglig profil for en ny VIP vurderes under hensyn til gruppens samlede profil, herunder behovet for fornyelse inden for bjergartsmekanik.

Vejbygningsområdet skal integreres i BYGs fagprofil. I begyndelsen af perioden ansættes en gæsteprofessor for at definere en mekanisk baseret forsknings- og undervisningsplan. Udmøntningen af planen forventes at kræve en eller flere VIP samt et passende antal phd-studerende og en laborant.

Udviklingen af medarbejderstaben ved ARTEK er primært styret af undervisningsbehov og eksternt finansierede projektaktiviteter.

#### Sektionen for Planlægning og Ledelse af Byggeprocesser:

Gennem de aktuelle stillingsopslag inden for projektering styrkes instituttets kompetencer i bygningsdesign, projektering og digitalt byggeri.

Et professoropslag i construction management skal inkorporere en faglig indsats inden for ny IKT på byggepladser i den forskning og undervisning, som vedrører nye produktionskoncepter, organisationsformer og innovationsprocesser i byggeriet.

På byledelsesområdet skal et planlagt generationsskifte styrke forskning og metodeudvikling i operationelle ledelsesaspekter, ligesom der her er behov for phd-tilgang.

Endelig vil den forventede etablering af et forskningscenter for Facilities Management med støtte fra Realdania indebære oprettelse af flere nye stillinger, bl.a. phd-studerende og formålsansatte VIP. Det vil tidligt i perioden blive aktuelt at tage stilling til et professoropslag som faglig løftestang på FM-området.

#### Sektionen for Bygningsfysik og Installationer

I perioden skal nyansættelser primært sikre forskningsplanens mål og undervisningen inden for forskningstemaerne bygningsenergiteknik og installationsteknik, herunder numeriske beregningsmetoder og CFD.

#### Sektionen for Bygningskonstruktioner:

Til området konstruktionsdesign skal rekrutteres VIP med evne til syntese og design af komplekse konstruktioner under hensyntagen til materialevalg og last. Særlig vægt vil blive lagt på rekruttering af kompetencer inden for design af konstruktioner udført i metaller og lignende materialer.

Til området konstruktioners ydeevne vil blive lagt vægt på kompetencer inden for plasticitetsteoretisk baseret design. I forbindelse med den planlagte styrkelse af konstruktionsområdet skal i særlig grad rekrutteres med henblik på numeriske metoder til understøtning af forskning og undervisning på alle sektionens områder.

Rekruttering med henblik på undervisningen/forskning i Architectural Engineering videreføres med udgangspunkt i aktuelle VIP-ansættelser.

#### Afdelingen for Forsøgshal og Værksteder

Som følge af generationsskifte er der for nyligt sket en styrkelse af elektronik-, måle – og forsøgsteknikkompetencen. Kompetenceudvikling vil fortsætte gennem efteruddannelse i kvalitetssikring, styreteknik, forsøgs- og måleteknik, sprogkurser, teambuilding mv.

#### Afdelingen for Administration og IT

Detaljeret planlægning af personaleudviklingen beror på DTUs indførelse af nye administrative systemer og strategiske omlægning af området i forbindelse med fusionen.

### **3 Andre ressourcer**

#### **3.1 Partnerskaber**

##### **Eksterne samarbejdspartnere**

BYG•DTU indgår i en række forpligtende samarbejder med danske og internationale parter. I nedenstående liste gives eksempler på de vigtigste. I perioden vil instituttet prioritere de internationale universitetskontakter med den målsætning, at alle større forskningsgrupper indgår i mindst et strategisk internationalt forskningssamarbejde.

##### **Netværk og faglige organisationer**

<b>Samarbejdspartner</b>	<b>Samarbejdets art og begrundelse</b>
CiB. Intl. Council for Res. and Innov. in Construction	Professor Stephen Emmitt er joint co-ordinator for CiB's working group W96: "Architectural Management" med TU-Delft
Kassel University, TU-Graz, Lund University, University of Lleida mfl.	Samarbejde om phd-uddannelse inden for solvarmeområdet. BYG•DTU koordinerer phd-kurserne ved de europæiske universiteter
LavEByg: Højteknologisk netværk vedr. Integrerede lavenergiløsninger på bygningsområdet	BYG•DTU leder netværket i et samarbejde med MEK-ICIEE (Indeklimacentret), SBI, AAU, TI samt 99 byggevareproducenter, rådgivende ingeniører, byggefirmaer, kommuner og styrelser. <a href="http://www.dtu.dk/centre/LavE.aspx">http://www.dtu.dk/centre/LavE.aspx</a>
NanoCem	Europæisk netværk med 30 partnere inden for cement og beton mhp. forståelse på nano- og mikroniveau. Understøttes af Marie Curie Research Training Network. <a href="http://www.nanocem.org">www.nanocem.org</a>
RILEM. International forskningsorganisation for materialer og konstruktioner	Professor Ole Mejlhede Jensen er formand for Technical Activities Committee og er formand for Educational Activities Committee. Vigtigt samarbejde om phd-kurser inden for betonmaterialeområdet.

## Universiteter og undervisningsinstitutioner

Samarbejdspartner	Samarbejdets art og begrundelse
Bygge- og anlægsskolen i Sisimiut	ARTEK har adgang til skolens faciliteter og samarbejder med skolen om undervisningen.
CBS: Realdania center for ledelse i byggeri	Forskning og forskeruddannelse inden for svigt i byggeriet og "tværorganisatorisk samarbejde i byggeriet"
KU Leuven	Samarbejde med Europas førende miljø i bygningsfysik.
London City University	Samarbejde om brandteknisk forskning og undervisning og konstruktionsmonitoring med fiberoptik. Bl.a. gives et fælles msc/phd kursus i Structures for Hazards i UK.
Luleå Tekniska Universitet	Samarbejde om beton- og trækonstruktioner, kompositter og måleteknik. Fastholder prof. B.Täljstens kontakter.
TUM	Facultät für Bauingenieur- und Vermessungswesen: Forsknings- og undervisningssamarbejde etableret i 2007
University of Alaska	Arktisk teknologi. Permafrostprojekt støttet af US-NSF.
University of California	Projektsamarbejde om avancerede materialer (kompositter) og måleteknik. USA's førende i komposit- og betonkonstruktioner.
University of Michigan	DTU æresdoktor Victor Li leder det førende amerikanske forskningsmiljø i konstruktioner i fiberbeton. Fælles phd, udveksling af VIP, phd-kurser. <a href="http://www.engineeredcomposites.com">www.engineeredcomposites.com</a>
University of Salford	Forskning i byggeprocessens materialestrømme. Universitetet er en central partner inden for lean construction. EU FP7 ansøgning om 'Agile Holistic Production Systems' med afsæt i projektproduktion inden for byggeri og skibsværfter.
Purdue University	Projektsamarbejde udbygges inden for integreret levetidsprojektering (konstruktion-materiale-belastning). Fælles phd og udveksling af VIP.
Syracuse University	Samarbejde om modeludvikling inden for koblet luft, fugt og varmetransport sammen med Indeklimacentret.

## Virksomheder

Samarbejdspartner	Samarbejdets art og begrundelse
Cement och Betonginstitutet (S)	Betonforskning. Fastholder prof. B.Täljstens kontakter.
Dansk Brand- og Sikringsteknisk Institut	Udover et fagligt samarbejde kan BYG•DTU anvende instituttets fuldt udstyrede brandlaboratorium til kostpris. Evt. samarbejde om ekstremlastlaboratorium
Danske byggevareproducenter	Samarbejde om forskning med f.eks. Rockwool, Danfoss, Velux, Aalborg Portland og Icopal. Løbende innovationsprojekter udbygges med forskerskoleaktiviteter.
Danske udførende firmaer	- undervisning (eksterne lektorer, praktik og eksamensprojekter), forskning og forskeruddannelse med f.eks. NCC, MTH og Pihl. - samarbejde med Dansk Byggeri om bl.a. Det Digitale Byggeri
Danske rådgivende firmaer	- Samarbejde om undervisning (eksterne lektorer, praktik og eksamensprojekter), forskning og forskeruddannelse med f.eks. COWI, GEO, FORCE, RAMBØLL, NIRAS og B&K. - Dialog med FRI
Danske byg- og driftsherrer	Samarbejde om forskning, uddannelse og innovation i relation til facilities management. BYG•DTU koordinerer dansk netværk om forskning i FM
Fraunhofer-Institut für Bauphysik IBP	Samarbejdsaftale mellem Fraunhofer, ICIEE(MEK) og BYG•DTU om fælles (EU-) forskningsprojekter.
NORUT Teknologi AS, (N)	Teknologisk institut for betonteknologi og numeriske metoder. NORUT er medlem af styregruppen for forskerskolen IRS@BYG

SBi	- Fælles sekretariat for ECTP-Danmark - Phd-projekter hvor SBi er industripartner. - Medlem af styregruppe for forskerskolen IRS@BYG
SINTEF (N)	Samarbejde om oliespild i arktis.
Teknologisk Institut	- Beton, TI's Betoncenter indgår i NanoCem. - Phd-projekter hvor TI er industripartner - Energieffektiv ventilation - Forskning i IT i byggeriets processer - Facilities management - Fælles sekretariat for ECTP-Danmark.

### Myndigheder

Samarbejdspartner	Samarbejdets art og begrundelse
EBST, Erhvervs- og Byggestyrelsen	Projektsamarbejde om fejl og mangler, Det Digitale Byggeri, udvikling af nye kontrakt- og samarbejdsformer mv.
Energistyrelsen	Løbende samarbejde om energihandlingsplan og energibesparelser i byggeriet
Grønlands Hjemmestyre	Omfattende rådgivning om uddannelse, forskning og innovation gennem ARTEK

### DTU-samarbejde

BYG•DTU samarbejder med en række institutter og enheder:

- MEK: Samarbejde med ICIEE indeklimatecenteret skal udbygges med formaliseret koordination af rekruttering, forskning og undervisning
- MEK: Samarbejde om undervisning i bærende konstruktioner skal revurderes
- MEK: Samarbejdet om instrumentindkøb og drift videreføres i nyt center for mekanisk prøvning
- MEK: Der er behov for en styrkelse af vandbygningsområdet som led i kandidatuddannelsen i 'Soil and Water Mechanics'
- IPL: Samarbejdsfladen med det nye institut skal afklares. Uanset den nye skilleflade vil instituttet udvikle det strategiske samarbejde med IPL om forskning og undervisning
- Risø: Samarbejde om etablering af center for mekanisk prøvning
- CTT: Undervisningen i vejbygning skal revideres i samarbejde med CTT
- Ørsted•DTU: Undervisning i bygningsakustik og belysning skal revurderes. Begge områder har central betydning for fremtidens byggeri
- CAS: Vi samtaler om nærmere samarbejde om udvikling af Campus Service ved at udnytte instituttets kompetencer inden for bl.a. facilities management og bygningsenergi. CAS varetager driften af lavenergihuset i Sisimiut
- Nano•DTU: Koordinering af nanoforskningen
- Energi•DTU: Koordination af energiforskningen
- Materialer•DTU: Koordination af materialeforskningen, hvis et sådant netværk etableres

## 3.2 IT

### Hardware

BYG•DTU har standardiseret IT-driften baseret på pc-teknologi for hele instituttet, svarende til state of the art i byggesektoren. Gennemsnitslevetiden for en pc til instituttets ansatte er 3,5 år, hvorefter den genbruges som målecomputer eller studentercomputer.

Alle medarbejdere med dokumenteret behov får adgang til instituttets netværk via internet (VPN) og tilbydes elektronisk kalender (PDA).

Det lokale behov for regnekapacitet er støt stigende i takt med udviklingen af numeriske metoder, instituttet investerer løbende i øget regnekraft i eget regnecenter. Instituttet vil løbende holde øje med de muligheder som etableres af DTU, og hvor det er muligt benytte fælles resurser i stedet for at opbygge egen regnekapacitet.

På Architectural Engineering indgår anvendelse af studenter-laptops som en integreret del af undervisningen, på baggrund af disse erfaringer ønsker instituttet at udvikle en ny struktur for databaser, projektcomputere etc. idet instituttet forventes at alle bygningsuddannelserne vil blive baseret på studenter-laptops inden 2011. Instituttet anbefaler en central diskussion af denne vision og de økonomiske konsekvenser heraf.

### **Software**

Langt den overvejende del af den software, der anvendes i byggesektoren og på BYG•DTU er lavet til Microsoft Windows, derfor anvendes MS-windows som standardiseret systemplatform. I forbindelse med etablering af regnecenteret baseret på parallelprocessering anvendes den for opgaverne optimale platform.

Fra januar 2007 skal alle større byggeprojekter med staten som bygherre gennemføres digitalt (se <http://www.detdigitalebyggeri.dk/>). På samme måde skal uddannelserne benytte en IKT baseret undervisningsform. Instituttet ønsker, at integrationen af IKT i undervisningen er visionær i forhold til arbejdsformerne og teknologien som anvendes i byggesektoren. Det indebærer, at anvendelse af personlige web-baserede IKT værktøjer (via laptops) vil blive integrerede elementer i den pædagogiske metode på alle uddannelserne. Instituttet er derfor i gang med at etablere et BIM-eksperimentarium (BIM: Building Information Modelling) som bliver omdrejningspunkt for en satsning inden for digitalt byggeri.

Instituttet ønsker ikke at udvikle egne IT-systemer til administration eller projektledelse men deltager gerne i samarbejde om DTUs centrale systemudvikling.

### **IT-sikkerhed**

BYG•DTU vil i et tæt samarbejde med DTUs centrale IT-service sikre, at instituttet lever op til DTUs fortolkning af DS 484. Det vil løbende blive vurderet, om der er lokale forhold som kræver en skærpelse i forhold til de centrale krav. Den lokale IT-sikkerhedsorganisation reviderer løbende instituttets overordnede IT-beredskabsplanen og den underliggende dokumentation.

## **3.3 Laboratorieudstyr**

Instituttets samlede instrument- og laboratorieudstysaktiver har en anslået nyværdi på 95 Mkr med et fornyelsesbehov på ca. 6 Mkr/år. Sådanne investeringer kan ikke rummes inden for rammebevillingen, hvorfor instituttet søger fondsdækning til indkøb af apparatur og arbejder for at øge instrumentleje og dækningsbidrag fra eksternt finansierede aktiviteter. Det har f.eks. været muligt med eksterne midler at udvide instituttets eksperimentelle faciliteter på det dynamiske område med bl.a. Danmarks største fuldskala konstruktionsbelastningsenhed. Med nylige indkøb af avanceret måleudstyr har BYG•DTUs forsøgshal fået et kvalitativt løft som bringer den på højt internationalt niveau.

Følgende umiddelbare fornyelsesbehov er identificeret:

- opgradering af eksisterende belastningsudstyr med digital styring.
- instituttets klimakamre er forældede og skal fornyes
- laser- og videobaseret baseret deformationsmåleudstyr
- opgradering af geoteknisk prøveudstyr
- fælles ansøgning med Risø om anskaffelse af røntgentomografiudstyr.

- IT og sensorudstyr til hybridmodellering (integreret numerisk og fysisk modellering)

I 2007 etableres et nationalt center for mekanisk prøvning med Henrik Stang som videnskabelig leder. Centeret vil koordinere indkøb og resurseudnyttelse for BYG•DTU, Risø og MEK og indgå samarbejde om fælles resurseudnyttelse med FORCE, AU og industrien. Centerets mål er at konsolidere den internationale position og bringe den nationale forskningsinfrastruktur inden for området på allerhøjeste europæiske niveau.

Instituttet har udarbejdet forslag til et Ekstremlastlaboratorium (DTUs hvidbog). Realiseringsmulighederne forventes afklaret i 2008 i forbindelse med FISTs udbud af midler til national forskningsinfrastruktur.

### **3.4 Lokaler**

Der er behov for et markant kvalitetsløft af instituttets arealer i bygning 118, 119, 117, 115 og 204. Samtidig trænger bygning 116 meget stærkt til renovering. Bygning 117 blev i sin helhed overført til BYG•DTU i 2006. Der udestår aftaler med CAS om nødvendig istandsættelse og bygningsforandring i 117. På kort sigt ønskes etableret en dør i bygning 116s nordfacade og en renovering af indgang og receptionsareal i bygning 118 som kan binde bygning 118 og 116 sammen.

De fysiske rammer skal fremover rumme et stærkt stigende antal studenterprojekter fordi vi er gået væk fra midtvejsprojekter (5-6 studerende pr. projekt) og over til bachelorprojekter (1-2 studerende pr. projekt).

## **4 Uddannelse, forskning og innovation**

### **4.1 Undervisning og uddannelse**

Instituttet vil sikre, at uddannelserne får et øget internationalt islæt, ved f.eks. at studielederne udarbejder studieforløb med et semester ved udvalgte udenlandske universiteter og ved at iværksætte en international rekrutteringskampagne i samarbejde med vicedekanen for internationalt samarbejde. I 2007 indgår instituttet en aftale med TUM, Fakultät für Bauingenieur- und Vermessungswesen om uddannelse og forskning.

Undervisningen på en række kurser skal fremover være projekt- og procesorienterede for at fremme den selvstændige indlæring og for at fremtidssikre den studerendes uddannelse. Der inddrages både eksperimentelt arbejde og numeriske værktøjer i undervisningen på en række kurser, og der udvikles et Virtuelt Laboratorium baseret på undervisningsvideoer.

#### **Civil Engineering (kandidatuddannelsen)**

Rammerne for kandidatuddannelsen i Civil Engineering (bygningsretningen) blev lagt fast i 2006. Uddannelsen vil fremover indeholde fire anbefalede specialiseringer:

- Building Structures
- Building Services
- Soil and Water Mechanics
- Urban and Construction Management

Specialiseringerne og anbefalede studieforløb er udarbejdet i samarbejde med MEK, M&R, Ørsted•DTU og CTT.

### **Architectural Engineering (ny kandidatuddannelse)**

BYG•DTU ønsker at etablere en kandidatuddannelse i Architectural Engineering i lighed med uddannelserne på førende udenlandske tekniske universiteter. Baggrunden herfor er dels instituttets ønske om at højne ambitionsniveauet i uddannelsen, dels opfordringer fra erhvervskontakter som påpeger, at uddannelsens sigte svarer til en kandidatuddannelse, dels DTU's strategiske målsætning om at være en "graduate school" og dels de studerendes relativt stærke gymnasiebaggrund og affinitet for at studere videre. I forbindelse med etableringen af AE kandidatuddannelsen er det vigtigt at der etableres kontakter til førende AE miljøer i udlandet med henblik på studenter- og facultyudveksling.

Indtil den ny kandidatuddannelse er på plads skal der skabes en uddannelsesmæssig ramme inden for den eksisterende kandidatuddannelse for de – relativt mange – studerende som ønsker at fortsætte på en AE overbygning.

Det er forbundet med et øget resursebehov at etablere en ny kandidatuddannelse. Instituttet vil derfor udarbejde en forretningsplan for udvikling og drift af uddannelsen til drøftelse med direktionen med henblik på at finde de nødvendige resurser.

### **Byggeteknologi (civilbachelor)**

BYG•DTU har i 2005 formuleret fire anbefalede civilbachelorforløb i byggeteknologi:

- Bygningskonstruktion og materialer
- Bygningsfunktion med vægten på bygningsfysik og -installationer,
- Anlægskonstruktioner med vægten på geoteknik, strømningsmekanik og konstruktioner,
- Infrastruktur med vægten på byplanlægning, vejbygning og trafikteknik.

### **Architectural Engineering (diplom)**

I forbindelse med studieplansrevisionen som led i indførelse af CDIO ønsker instituttet at styrke de studerendes akademiske træning og faglige baggrund for at læse videre på den planlagte kandidatuddannelse. Instituttet vil undersøge om der kan opnås fordele ved at højne adgangskravene så de svarer til civil-uddannelsen og gennemføre samlæsning med enkelte civil-kurser.

### **Bygningsingeniør (diplom)**

Studieplanen revideres i forbindelse med indførelsen af CDIO.

### **Arktisk Teknologi (diplom)**

Ved tilmeldingsfristens udløb i år var der 12 grønlandske ansøgere til starten i august 2007, hertil skal lægges eventuelle danske ansøgere. Der pågår et studieplansarbejde i forbindelse med CDIO. Fra optaget 2007 er indført to profiler inden for Arktisk Teknologi: Bygge & Anlæg og Miljø & Planlægning. Studielederen har efter ønske herom fra grønlandsk side foreslået oprettelsen af endnu en profil i relation til geologi, råstofudvinding og minedrift. Instituttet påpeger, at denne mulighed for miljøspecialisering stiller krav til uddannelsen i Danmark som skal honoreres af andre institutter.

### **Rekrutteringsaktiviteter**

BYG•DTU vedligeholder en aktiv hjemmeside, deltager i Åbent Hus, udbyder Ny Viden (22 Ny Viden arrangementer i 2006), og bidrager til DYNAMO. I 2007 gennemføres en international essaykonkurrence i forbindelse med B150 arrangementerne med invitation til studerende på 65 udenlandske universiteter. Ad hoc deltages i Forskningens døgn, VIP stiller op til interviews og phd-ere deltager i møder på gymnasier, men generelt vurderer instituttet, at kvalitetsundervisning og et godt studiemiljø er de væsentligste faktorer for rekrutteringen.

Som led i instituttets indsats for international positionering indgår rekruttering af top-studerende fra udvalgte universiteter til kandidat og phd-uddannelse.

Instituttet anbefaler at diplom-B optaget reduceres f.eks. til en klasse pr. år i lighed med diplom-AE. Det vil styrke uddannelsens profil som en krævende DTU uddannelse med særlige kvaliteter. Instituttet vil sikre, at nedgangen i STÅ opvejes af øget produktion på kandidatuddannelsen i Civil Engineering ved at øge den internationale rekruttering. Allerede i april 2007 godkendte instituttet 17 ud af 25 internationale ansøgninger om optagelse på kandidatoverbygningen i Civil Engineering. Yderligere vil en ny kandidatuddannelse i Architectural Engineering øge rekrutteringen til DTU.

## 4.2 Forskning

### Forskningsbeskrivelse

For fokusområderne gælder, at forskningen i de kommende år styrkes gennem deltagelse i internationale forskningsprogrammer, styrkelse af eksisterende og etablering af nye internationale forskningsnetværk, rekruttering af phd-studerende både nationalt og internationalt samt etablering af flere phd-kurser i forskerskoleregi. Der vil ske en styrkelse af det internationale samarbejde gennem øget antal besøg af gæstprofessorer og post doc.

#### Sektionen for Byggematerialer

Forskningen er struktureret i tre temaer:

- Beton
- Træ
- Stoftransport og -binding

Fælles for alle tre forskningsområder vil forskningen være præget af både en eksperimentel og en teoretisk tilgang. Den teoretiske behandling vil være baseret på de klassiske discipliner fysik, termodynamik, mekanik og kemi. Det høje internationale niveau søges fastholdt både i kvantitet og kvalitet for alle tre forskningsområder. Centrale fælles forskningsemner vedrører sammenhængen mellem struktur, sammensætning og egenskaber, samt fugtens indflydelse på byggematerialers egenskaber og anvendelse.

Forskningen i beton omfatter både armeret og uarmeret beton og er orienteret mod materialeegenskaber af relevans for betons anvendelse i konstruktioner. Der fokuseres på opnåelse af forøget forståelse og kvantificering af de koblede multiskala kemisk, fysiske og mekaniske relationer som har betydning for hele livscyklusen af konstruktioner. Forskningen er orienteret mod generalisering af struktur-egenskabssammenhænge; centrale emner er frisk betons flydeegenskaber, hydratisering og strukturdannelse, svind og behov for efterbehandling og armeringskorrosion.

Forskningen i træmaterialer vedrører træets opførelse som et konstruktionsmateriale. I særlig grad forskes inden for følgende områder: Interaktionen mellem træ og vand er et forskningsområde af stor betydning, da det fører til fundamental viden om træ som et naturligt, biologisk materiale. Et andet forskningsfokus er forståelse af konstruktionsmaterialets træets opførelse under naturlig fugtvariation. Effekten af samtidig last- og fugtpåvirkning har unik stor betydning for træmaterialer og påvirker anvendelsen og sikkerheden af trækonstruktioner. Dette motiverer forskning i hygromekaniske fænomener for træmaterialer.

Forskningen i stoftransport og -binding vedrører alle porøse, byggerrelevante materialer. Forskningstemaet er fokuseret på både tilsigtet og utilsigtet transport og binding af stoffer i det porøse materiale. Eksempler på forskningsfokus er: adsorption/desorption af

fugt, transport af salte ind i eller mod overfladen af materialet samt indflydelsen af geometri og overfladeegenskaber. Disse fænomener og egenskaber kan have stor betydning både ved design af byggematerialer og ved udvikling af nye og forbedrede metoder til reparation og vedligeholdelse af eksisterende bygninger.

#### Sektionen for Geoteknik

Sektionen har ansvaret for geoteknik og tilgrænsende fagområder, derudover har sektionens medarbejdere ved Center for Arktisk Teknologi (ARTEK) det overordnede ansvar for udvikling og koordinering af forskningen i arktisk teknologi på DTU.

Sektionens byggetekniske forskning er struktureret i tre temaer:

- Geoteknik
- Geofysiske undersøgelsesmetoder til bygge- og geotekniske anvendelser
- Vejbygning

Det overordnede sigte er at etablere en sammenhængende forståelse for de geologiske og geotekniske forholds betydning for bygge- og anlægskonstruktioners virkemåde. Forskningen tager udgangspunkt i fastlæggelsen af parametre til mekaniske modeller som anvendes ved dimensionering af konstruktioner som f.eks. tunneller, broer og veje.

Forskningen i geoteknik konsolideres omkring to overordnede temaer: store pæle og rateeffekter for jord og porøse bjergarter. Modeldannelsen i forbindelse med store pæle omfatter bl.a. installationseffekter samt konsekvensen af cykliske belastninger. Temaet understøttes numerisk via udvikling af robuste algoritmer som tager højde for brud- og deformationsegenskaber lokalt på punktniveau og globalt for det samlede jordlegeme. Eksperimentelt undersøges pælenes opførsel ved modelforsøg i den geotekniske centrifuge. Forskning i rateeffekter i jord og porøse bjergarter vil fortsætte i planperioden. Fokus har hidtil ligget på deformationsproblematikken, men vil i planperioden drejes over i retning af brudproblematikken. Modeldannelsen vil understøttes af omfattende eksperimentelt arbejde i gruppens nyrenoverede laboratoriefaciliteter.

Forskningen i geofysik og vejbygning tager primært afsæt i arktiske anvendelser inden for bl.a. dimensionering og tilstandsvurdering af veje samt permafrostproblematikker. Der arbejdes med udvikling af matematiske værktøjer til tolkning af måledata og fastlæggelse af korrelationer til parametre som indgår i mekaniske modeller. Modeludviklingen understøttes via eksperimentelt arbejde, som foregår såvel i laboratorier som i felten (specielt i Grønland). I 2007 er instituttets laboratoriefaciliteter inden for vejbygning og geofysik styrket. I begyndelsen af planperioden skal potentialet af disse investeringer udmøntes, bl.a. gennem en strukturering af forskningsindsatsen inden for vejbygning, jf. afs. 2.3.

#### Sektionen for Planlægning og Ledelse af Byggeprocesser

Forskningen er struktureret i fem temaer:

- Urban Management
- Design Management
- Construction Management
- Facilities Management
- Brandsikkerhed

Sektionens fokusområder repræsenterer en samlet faglig platform for byggeprocessens ledelses- og planlægningsniveauer. Den er ramme for forskningsaktiviteter, som sigter mod syntese og innovation på tværs af aktørroller og institutionelle barrierer. Den strategiske udfordring er at udnytte denne position til at fremme tværgående forskning i byggeprocessens systemiske sammenhænge. De statslige og erhvervsmæssige tiltag inden for Det Digitale Byggeri, lean, leverancekæder, strategisk partnering, OPP,

energioptimering og bæredygtighed mv. afføder alle i vidt omfang forsknings- og udviklingsbehov, som kan understøtte sådanne forandringsprogrammers implementering i byggeriets særlige teknologi- og markedsdomæner. Sektionens forskningsaktiviteter skal derfor bidrage til opbygning af nye management-kompetencer, som kan operere med nye teknologi- og procesforståelser i hyppigt ændrede kombinationer, herunder også med videninput fra nye produktteknologier og brancheområder.

Forskningen inden for Urban Management har i planperioden til formål at udvikle den ingeniørmæssige state-of the-art forståelse inden for feltet. I profileringen af BYGs tilgang og position vil der i danske og internationale projekter blive arbejdet med koblingen mellem bygningen, dens brugere og det infrastrukturelle system, den indgår i, samt de strategiske beslutninger, der bliver truffet af byernes ledelse i forbindelse med de teknologiske omstillingsprocesser. Endvidere vil der blive forsket i brugerdrevet innovation på by-niveau mhp. en afdækning af de rammer, som byledelse sætter for innovationsprocessen.

Forskningsplanen inden for design management omfatter metodeudvikling og optimering i projektering, herunder værdiledelse, kommunikation og partnering, lean design samt bygbarhed og arbejdsmiljø. Forskningen gennemføres med internationale partnere i CIB og i samarbejde med CBS samt rådgivere og bygherrer. Et par erhvervs-phd er under opstart. Forskning og innovation på designområdet vil endvidere få et forstærket fokus på en udbygning af den 3D objektorienterede arbejdsmetode, der er introduceret gennem Det Digitale Byggeri, og som er en del af Building Information Modelling konceptet, BIM. Områder med særlig fokus udover modellering i relation til byggeprocesforløbet er simulerings- og analyseprocesser, herunder en yderligere specifikation af relevante byggeobjekttyper og –egenskaber samt koblingen fra 3D modeller til projektdokumentation. Nye samarbejdsformer og typer af projektaftaler tages ligeledes op. Der vil i perioden blive opbygget et BIM Laboratorium, hvor de forskellige modelkoncepter, arbejdsprocesser, standarder og værktøjer bliver afprøvet i et konkret miljø. I første omgang for at opgradere undervisningen inden for feltet, men på længere sigt vil laboratoriet også omfatte innovative forskningsprojekter.

Det klassiske fag anlægsteknik er i dag opdelt i to emner: Byggeledelse og udførelsesteknik. Byggeledelse indgår i fokusområdet Construction Management og er genstanden for det foreslåede professorat. Det omfatter bl.a. ledelse af byggeproduktionen, byggepladsens organisering, innovationsprocesser i byggeprocessen, projektledelse og økonomi. Udførelsesteknik og metoder bliver nu integreret i de byggetekniske fagdiscipliner, således at f.eks. tunnelbyggeri læres i faget geoteknik, og betonudstøbning indgår i konstruktions- og materialekurser. Denne integration af design og udførelse er en central forudsætning for bedre bygbarhed og imødekommer et stærkt ønske fra Advisory Board. Forskning og innovation inden for byggeproduktion vil i øvrigt fokusere på værdiskabelse gennem organisering og anvendelse af viden, kvalitetsindsatser (forebyggelse af svigt) og samarbejde med kunder og brugere. Hertil kommer en fortsat prioritering af forebyggelse af arbejdsulykker. Periodens forskning skal derfor støtte udviklingen og anvendelsen af nye ledelseskoncepter, procesorienteret IKT-anvendelse, nye organisationsformer samt andre typer af teknologier og materialer. Udviklingen af innovationsprocesser og overvindelse af barrierer er et særligt fokus.

Inden for Facilities Management vil fokus ligge på etablering af det planlagte Realdania finansierede forskningscenter. Til den igangværende afklaringsfase har Realdania bevilget et forprojekt, som omfatter bl.a. en tematisk profilering af centret under overskriften 'forskning i rum for mennesker, bygninger med brugsværdi og ejendomme som faciliteter'. Konkret arbejdes med etablering af projekter om organisationsmodeller for FM, innovation i FM leverancekæder, merværdi af FM, FM og energiforbrug, identifikation af brugerbehov, workplace management, drift og byggeprojekt, markedet for FM samt driftspartnerskaber. Der lægges vægt på opbygning af internationale forskningsrelationer og inddragelse af centrale

aftagerparter, ligesom det er af stor betydning at forøge den løbende projektportefølje og faglige konsolidering af dette nye forskningsområde, bl.a. ved tilgang af phd-studerende. Herunder vil der skulle iværksættes planlægning af et professorat inden for FM.

Fokusområdet brandsikkerhed er nu organiseret som en forskningsgruppe med egen forskningsledelse. Brandsikkerhed indgår med stigende betydning i projektering og profileres som et selvstændigt kompetencefelt hos myndigheder, bygherrer og rådgivere (jf. den store søgning til BYG•DTUs efteruddannelsesmaster inden for området). Forskningsplanen omfatter metoder og data til projektering med funktionsbaserede brandkrav, designmetoder for konstruktioner påvirket af fuldt udviklede brande, brandmodeller, bl.a. CFD-modeller og selvantændelse. Laboratoriefaciliteter til forskningen er under implementering i bygning 204, ligesom der vil blive arbejdet videre med den fremlagte plan for etablering af et nationalt ekstremtlast laboratorium til fuldskala afprøvning (jf. omtale andetsteds).

### Sektionen for Bygningsfysik og Installationer

Forskningen er struktureret i fire forskningstemaer:

- Hygrotermisk bygningsfysik
- Bygningsenergiteknik
- Bygningsinstallationer
- Solvarme

Det overordnede sigte er at tilvejebringe viden og værktøjer, der danner grundlag for udvikling og projektering af energirigtige, holdbare bygninger med godt indeklima. Fælles for sektionens forskningstemaer er, at der sættes på en fornyelse af de teoretiske og eksperimentelle metoder bl.a. ved øget anvendelse af CFD, PIV og FEM.

Forskningen i hygrotermisk bygningsfysik fokuserer på modeldannelse og eksperimentelle undersøgelser af de koblede varme-, fugt- og luftstrømninger i bygninger. Nye modeller omfatter FEM analyse af de koblede transportfænomener i flere dimensioner, samt kontrolvolumenmetoder, der omfatter hele spektret fra materialeniveau, over sammensatte konstruktioner til bygninger i deres helhed med indendørs rum og forbindelsen til udeklimaet. I perioden vil forskningsaktiviteter blive igangsat inden for:

- modellering af flerdimensional koblet fugt-, luft- og varmetransport i klimaskærmskonstruktioner.
- Lavenergibyggeri, bygningsfysiske forhold og indeklima i Grønland.
- Inventarets betydning for de hygrotermiske forhold i rum
- Modellering af fugttransport under indvirkning af dynamisk sorption og hysteresis og ikke-isoterme forhold (påtænkes med BM-sektionen)

Forskningen i bygningsenergiteknik er orienteret mod metoder til integreret design og optimering samt produktudvikling af lavenergibygninger med fokus på samlet behandling af bygningernes generelle indeklimaforhold, bruttoenergiforbrug og totaløkonomi. Forskningen skal styrkes med opbygningen af modeller og programmer til beregning af energimæssige egenskaber af komponenter og hele bygninger. Disse modeller udgør det fælles grundlag for udviklingen af lavenergiløsninger på bygningsområdet. I perioden vil forskningsaktiviteter blive igangsat inden for:

- Multifunktionelle glasfacader, der kombinerer funktionerne: varmeisolering, solafskærmning, dagslysregulering og ventilation.
- Detaljeret dynamisk beregning af belysningsforhold i rum med kombination af dagslys og elbesparende belysningsanlæg.
- Nye typer vinduer med stærkt forbedrede egenskaber mht. energi og levetid baseret på integration af punkterfrie ruder i smalle ramme/karmkonstruktioner af kompositmaterialer.
- Metoder til anvendelse af løsningsrum (mulige løsninger) i integreret design af bygninger med fokus på indeklima, energiforbrug og økonomi

- Metoder til vidtgående energirenovering af eksisterende bygninger

Forskningen i installationer styrkes ved opbygning af detaljerede dynamiske simuleringsmodeller af anlæg til ventilering samt opvarmning og køling af bygninger herunder nye typer ventilationsløsninger, fx passiv ventilation med varmegenvinding. Der fokuseres på beregningsmodeller af nye typer energirigtige og intelligente installationer, der fysisk eller funktionsmæssigt er integreret i bygningens konstruktioner og klimaskærm. I perioden vil forskningsaktiviteter blive igangsat inden for:

- Detaljeret dynamisk modellering af installationer til opvarmning, ventilation og køling
- Energibesparende ventilations-, varme- og kølesystemer til forskellige klimaforhold.
- Lavenergifyjrnvarmeløsninger til lavenergihuse
- Detaljerede beregningsmodeller for bygningers indeklima og energiforbrug til brug ved design og drift af bygninger, idet der tages hensyn til aktuelle vejr- og brugsforhold.

Forskningen i solenergi vil øge indsigten i energi- og massestrømmene i solvarmeanlæg med fokus på evakuerede glasrørssolfangere, plane solfangere og avancerede varmelagre. Desuden fokuseres på samspillet mellem solfangere og eksisterende energianlæg og på undersøgelser af hvor store energibesparelser der opnås ved anvendelse af solvarmeanlæg. I perioden vil forskningsaktiviteter blive igangsat inden for:

- Solvarmeanlæg der benytter avancerede intelligente varmelagre, herunder sæsonlagre, som muliggør en høj effektivitet både for solfangerne og de(t) eksisterende energianlæg.
- Avancerede varmelagre med nyudviklede og patenterede stofindløbsrør, der forøger temperaturlagdeling i varmelageret og ydelsen af solvarmeanlæg.
- Solvarme i Grønland. Blandt andet vil solvarmeanlæg med vakuumsolfangere, der udnytter solstråling fra alle retninger blive undersøgt.
- Solvarmeanlægs samspil med andre energikilder i fremtidens energisystem. Eksempelvis intelligente solvarme-/elvarmeanlæg med styresystemer baseret på vejrudsigter.

#### Sektionen for Bygningskonstruktioner

Forskningen er struktureret i tre forskningstemaer:

- Design af bygningskonstruktioner
- Bærende konstruktioners ydeevne og monitorering
- Integreret konstruktions- og materialemodellering

Det overordnede sigte er at tilvejebringe forbedrede værktøjer til analyse af bærende konstruktioner for derigennem at åbne for nye muligheder for optimal og innovativ konstruktionsdesign, anvendelse af nye eller forbedrede materialer og renovering af eksisterende konstruktioner under hensyntagen til en bred vifte af kravspecifikationer, herunder bæredygtighed i hele konstruktionens livscyklus. Der benyttes numeriske, eksperimentelle og analytiske metoder.

Design af bygningskonstruktioner omfatter modellering, beregning og design af optimale og innovative konstruktioner og den hertil relaterede designfilosofi inklusive lastbeskrivelse og sikkerhedsfilosofi. Gruppens fokus er opførsel og konceptuelt design af lastbærende letvægtskonstruktioner. Letvægtskonstruktioner omfatter konstruktioner, hvor ydeevnen er optimeret i forhold til vægt og materialeforbrug. I denne forbindelse er der specielt fokus på opførsel og design af tyndvæggede konstruktioner, forbindelser og konstruktionssamlinger, innovative glaskonstruktioner, kabelkonstruktioner samt skaller og membraner. Endvidere har beskrivelsen af konstruktionslaster og dynamisk opførsel

gruppens særlige bevågenhed ligesom anvendelsen af nye materialer med høj ydeevne, f.eks. kompositter, spiller en betydelig rolle ved udvikling af letvægtskonstruktioner.

Bærende konstruktioners ydeevne og monitorering: Overvågning, vedligeholdelse og reparation af samfundets infrastruktur har stor økonomisk betydning for bygherrer, myndigheder og samfundet som helhed. Gruppens forskningsområde omfatter studier af konstruktioners ydeevne og bæredygtighed som funktion af materialevalg, konstruktionsudformning og belastning. Der fokuseres specielt på reparation, forstærkning og opgradering af eksisterende konstruktioner og bæredygtigheden af disse tiltag. Forskningen baseres på et samspil mellem laboratorieeksperimenter og numerisk modellering. Sandsynlighedsteoretiske analyseværktøjer udvikles og anvendes i forskningen. Endvidere udvikles og anvendes avancerede metoder og sensorer til tilstandsvurdering og konstruktionsovervågning. Metoder til tolkning af resultater fra disse aktiviteter udgør ligeledes et forskningsemne, ligesom det er vigtigt at generere velstrukturerede databaser med oplysninger om forskellige konstruktioners langtidsopførsel, og hvordan forskellige typer reparationer fungerer. Sådanne databaser vil få stor betydning ved udvikling af nye bæredygtige konstruktioner samt vedligeholdelses- og reparationsstrategier.

Integreret konstruktions- og materialemodellering: Pålidelige levetidsmodeller er en forudsætning for, at bæredygtigheden af vedligeholdelsesstrategier, reparationer og forstærkninger af konstruktioner kan vurderes. Gruppen udvikler levetidsmodeller med særlig fokus på levetidsmodeller for armerede betonkonstruktioner. Dette involverer en lang række udfordringer bl.a. multi-fysik- og multi-skalamodellering, som kombinerer de forskellige fysiske, mekaniske og kemiske nedbrydningsmekanismer, modellering af den aktuelle geometri, både overordnet og detaljeret, udvikling af detaljerede materialemodeller, sandsynlighedsteoretisk modellering af klimamæssige og mekaniske belastninger og materialeegenskaber samt kalibrering af levetidsmodeller mod data fra virkelige konstruktioner. Gruppen fokuserer i de kommende år specielt på modellering af og samspillet mellem revnedannelse, ion- og væsketransport og armeringskorrosion. Det langsigtede mål er udvikling af en generel numerisk baseret levetidssimulator for betonkonstruktioner.

#### International Research School in Civil Engineering at BYG•DTU

Forskerskolen (Educational Programme) samarbejder med RILEM (International Union of Laboratories and Experts in Construction Materials Systems and Structures) om markedsføring af phd-sommerskoler. I perioden planlægges:

- Styrkelse af ledelse og selvevaluering af forskerskolen
- Etablering af predocs til fastholdelse af særligt dygtige kandidater
- Etablering af seks nye phd-kurser (sommerskoler), i internationalt samarbejde med de akademiske partnere nævnt i afsnit 3.1.
- Der iværksættes yderligere tiltag til at styrke integrationen af de studerende i skolen og forbedre phd-miljøet (fælles seminarer og ph.d.-kurser, sociale arrangementer, koordinerede udlandsrejser mm.).

#### **Benchmarking**

BYG•DTU ønsker at sammenligne sig med de bedste byggeteknologiske institutter på verdensplan. Tabellen identificerer mulige sammenligningspartnere i alfabetisk rækkefølge.

<b>Universitet / forskningsinstitution</b>	<b>Institut / center / afdeling ved fornævnte</b>	<b>Forskningsområder</b>
Chalmers Tekniske Högskola	- Building Service Engrg. - Building Physics - Built Environment - Civil and Environmental	-Bygningsinstallationer -Bygningsfysik -Urban management -Design og construction

	Engineering - Constr. Service Mgmt.	management -Facilities management
EPF-Lausanne	Laboratory of Construction Materials	Byggematerialer
ETH-Zürich/EMPA,	Department of Civil Engineering	-Bærende konstruktioner -Geoteknik -Byggematerialer
KU Leuven (Katolieke Universiteit Leuven)	Labo Bouwfysica	Bygningsfysik
Loughborough University	Department of Civil & Building Engineering.	Architectural Engineering
Lunds Tekniska Högskola	-Energi + ByggnadsDesign -Brandteknik	-Solvarme -Brand
TU Delft (Technische Universiteit Delft)	Faculty of Civil Engineering and Geoscience	-Bærende konstruktioner -Geoteknik
TUM	-Fakultät für Bauingenieur- und Vermessungswesen -Fakultät für Architektur	-Byggematerialer -Bærende konstruktioner -Architectural Engineering
University of Reading	School of Construction Management and Engineering	Design og construction management

Instituttet vil sammen med Forskningsdekanen gennemføre en forskningsevaluering i 2007 og 2011 med henblik på at dokumentere om strategiens mål er nået: "Instituttets fokusområder har international forskningshøjde, og instituttet er blandt de bedste i Europa inden for mindst to fokusområder".

### Strategiske ansøgninger

BYG•DTU søger at øge efterspørgslen efter byggeforskning bl.a. gennem Dansk Teknologiplatform for Byggeriet, se [www.ectp-danmark.dk](http://www.ectp-danmark.dk) og European Construction Technology Platform, se [www.ectp.org](http://www.ectp.org). Det ser ud til, at arbejdet til en vis grad bærer frugt da f.eks. Regeringens Energi-handlingsplan åbner for bygningsenergiforskning. Det Strategiske Forskningsråds fokusområder åbner visse muligheder for byggeforskning og EUs 7. rammeprogram indeholder byggeforskning som emne. BYG•DTU vil målrette ansøgninger mod:

Finansieringskilde	Emner
FIST (forskningsrådene)	En række forsknings- og apparaturansøgninger vil blive udarbejdet. I 2007 ansøges bl.a. om bevilling til nationalt center for mekanisk prøvning og midler til IRS@BYG
Sektorforskningskasser f.eks.: Erhvervs og Byggestyrelsen Energistyrelsen ELFOR PSO EFP	Specielt inden for bygningsenergi og byggeledelse og -planlægning er der muligheder for at etablere samarbejdsprojekter. LavEByg netværket benyttes som platform for udarbejdelse af ansøgninger.
RealDania	Instituttet arbejder for at blive vært for et Realdania center for Facilities Management. Instituttet deltager i en ledende rolle i initiativet NanoBYG.
Andre private fonde f.eks.: -Villum Kann Rasmussen Fonden -Knud Højgaard's Fond	Der søges løbende private fonde om forskningsprojekter og apparaturbevillinger.

-Boligfonden Kuben -Danielsens Fond -Johan Heinrich Hoffmann og Hustrus Mindefond	
EU 7. rammeprogram	BYG•DTU indgår i forskningsnetværk med ECTP-partnere i Europa. Specielt vil vi benytte vores medlemskab af Nanet og NanoCem som platform for ansøgninger inden for byggematerialeområdet. I 2007 søges bl.a. om projekter inden for områderne 'Cultural Heritage', 'Nanosciences, Nanotechnologies Materials and new Production Technologies' og 'People'.

### 4.3 Innovation, herunder efteruddannelsesaktiviteter

Den vigtigste innovation sker i samarbejdsprojekter med industripartnere. Institutet vil yderligere styrke indsatsen på dette område.

#### Patenter og opfindelser

Byggeriets struktur og tradition gør, at produktorienteret innovation f.eks. i form af patentering kun sker i begrænset omfang. Institutet forventer dog løbende at have en til to opfindelser i pipelinen. I 2007 er bevilget proof of concept midler til to opfindelser.

#### IPU enhed til BYG•innovation

Der gennemføres en styrkelse af organisationen af BYG•innovation gennem den netop etablerede IPU enhed for byggeri med henblik på en konsolidering og øgning af omsætningen af rekvireret avanceret prøvning, forskning og udvikling.

#### Innovation i Grønland

Instituttets innovationsarbejde i det arktiske udvikles i takt med det Grønlandske Hjemmestyres satsning på innovationsaktiviteter. ARTEK organiserer disse aktiviteter. Arne Villumsen er direktør for Grønlands Innovationscenter hvortil Hjemmestyret gav 7,0 Mkr i 2007 til etablering og en driftsbevilling på 1,0 Mkr pr. år.

#### Efteruddannelsesaktiviteter:

BYG•DTU gennemfører en række efteruddannelsesaktiviteter, eksempler på aktiviteter som indgår tidligt i planperioden:

- De eksisterende masteruddannelser i Brandteknik (50 deltagere i 2006) og Ledelse af byggeri (23 deltagere i 2006) videreføres og konsolideres.
- Samarbejde med DKBI (Dansk Konstruktions- og BetonInstitut) videreføres inden for efteruddannelsesområdet, bl.a. om fleksibel masteruddannelse.
- Institutet har sammen med Dansk Byggeri engageret sig i udrednings- og udviklingsarbejde inden for byggeriets kompetenceudvikling, specielt inden for Det Digitale Byggeri.

### 4.4 Myndighedsopgaver

BYG•DTU udfører allerede i dag en række myndighedsopgaver. F.eks. har Institutet for nylig medvirket ved udmøntningen af bygningsreglementets afsnit om brand og indgået i samarbejde med Energistyrelsen i forarbejdet til regeringens energiplan.

Instituttet vil øge synligheden af sine særlige forudsætninger og kompetencer overfor myndighedsopgaver og etablere kontakter hos myndigheder med henblik på at kunne

udnytte den situation som forventes at opstå i takt med at sektorforskningen konkurrenceudsættes. Instituttet vil yderligere sammen med Afdelingen for Myndighedsbetjening identificere myndighedsopgaver i EU regi.

I 2008 vil instituttet udarbejde en strategi for myndighedsbetjeningen med udgangspunkt i håndbogen fra Afdelingen for Myndighedsbetjening. Der er oplagte områder hvor BYG•DTU besidder kompetencer som er unikke i dansk sammenhæng (f.eks. i forbindelse med den godkendte statikerordning, brandteknik og energibesparelser) som kan bringes endnu mere i spil i forbindelse med myndighedsbetjening.

## **5 Samspil med omverden**

### **Ekstern kommunikation**

Instituttet har siden 2004 udgivet en ekstern årsberetning og vedligeholder en attraktiv hjemmeside. Instituttet tilstræber at bidrage med en artikel til hver udgave af DTUs profilmagasin DYNAMO.

Med henblik på at øge forskningen og innovationsperspektivet i byggeriet vil instituttet arbejde for en mere aktiv forskningspolitik hos FRI, Dansk Byggeri og hos de store aftagervirksomheder med henblik på at øge midlerne til forskning inden for instituttets område.

### **Offentlig debat**

BYG•DTU indgår i den offentlige debat inden for instituttets fagområde. Siden april 2006 er registreret ca. 55 presseklip. Der var særlig mange citater om DR-byen, energirigtigt byggeri og om brokollapset i Nordjylland, men også emner som samarbejdet med TUM, arbejdsmiljø i byggeriet, Nanoteknologi, brandteknik, bygningsingeniøruddannelserne og konstruktiv bygningsbeskyttelse (terrorsikring) indgår.

### **ATV**

Medarbejdere som er medlem af ATV:

- Forskningsleder Niels Foged
- Professor Ole Mejlhede Jensen
- Instituddirektør Jacob Steen Møller
- Professor Henrik Stang
- Professor Arne Villumsen

Instituddirektør Jacob Steen Møller er medlem af styregruppen for ATV projektet Fremtidens Byggeerhverv. Professor Henrik Stang blev i 2007 medlem af ATVs erhvervsforskerudvalg.

### **Alumnenetværket**

BYG•DTU bidrager til at facilitere alumnernes aktiviteter, men mener grundlæggende, at alumnenetværkets aktiviteter skal drives af alumnerne selv.

## 6 Økonomiske forhold

### Rammebevillingen

Rammebevillingen i denne UMV er reguleret med 2,5 % i 2008 og derefter fastholdt, det antages yderligere, at særbevillingerne, som i 2006 blev givet til uddannelsen arktisk teknologi fastholdes gennem hele planperioden.

Rammebevillingen dækker undervisningen og facultys aktiviteter inden for forskning og innovation. Undervisningsbelastning udgør (2006) 58 % af rammebevillingen, hvor gennemsnittet for DTU er 44 %. Der findes ikke nogen norm for undervisningens andel af rammebevillingen, idet tildelingen af rammen foretages af direktionen efter en samlet vurdering og prioritering mellem alle DTUs aktiviteter.

BYG•DTU vurderer, at det ikke vil være muligt at leve op til DTUs visioner for forskning, innovation og myndighedsopgaver uden en øgning af basismidlerne til forskning.

Det er et kritisk problem, at nyansatte forskere overbelastes med undervisning. Tid til fri forskning er den allervigtigste forudsætning for at kunne rekruttere og fastholde de rigtige personer. Der er derfor et tvingende behov for at aflaste faculty, så der bliver tid til forskning og innovation.

Konkrete tiltag som anbefales finansieret særskilt ved tidsbegrænsede bidrag fra RSO:

- 0,6 Mkr i 2007/8 til frikøb af VIP i forbindelse med implementering af CDIO
- 0,9 Mkr i 2007/8 til udvikling af kandidatuddannelsen i Architectural Engineering
- 0,6 Mkr i 2008 til ekstraordinær investering i IT hardware og software samt ekspertbistand til eksperimentarium for det digitale byggeri
- 3,0 Mkr. over tre år til apparaturfornyelse og renovering af klimakamre
- 0,6 Mkr i 2008-11 for stigningen i internationale optag på kandidatuddannelsen

Tiltag som anbefales finansieret ved varige løft af rammen.

- Midler til generel øgning af forskningsandelen af rammebevillingen, dette er i særlig grad vigtigt i forbindelse med fratræden af en række diplomlærere.
- Det store antal studerende medfører stærkt stigende driftsomkostninger til udstyr og materialer og et stigende træk på TAP-t. Der søges om 0,7 Mkr/år til tekniske undervisningsfaciliteter, herunder IT udstyr til læring i digitalt byggeri og driftsmidler til den forsøgstunge undervisning
- Kompensation for studieledelse. Instituttet bidrager med fem studieledere svarende til en ekstra uddannelsesbelastning på en til to fuldtidsstillinger
- Bevilling til kandidatuddannelsen i Architectural Engineering fra 2009

Instituttet planlægger ikke at øge den disponible formue, da en strategisk opsparring ikke anses for relevant med den store undervisningsbyrde in mente. Dette vil øge instituttets sårbarhed overfor risikoprojekter, hvorfor opmærksomheden på projektstyring vil blive skærpet yderligere.

### Eksterne projektmidler

Eksterne projektmidler inkl. rekvireret arbejde og ph.d.-projekter udgjorde i 2006 ca. 33 % af den samlede omsætning. De fleste midler kommer fra danske og udenlandske forskningsprogrammer og fra danske fonde. Instituttet har løbende en håndfuld mindre myndighedsopgaver i form af ad hoc aftaler med SBI, Dansk Standard, TI og rådgivende ingeniører. Dertil kommer større opgaver for Grønlands Hjemmestyre.

Det er vanskeligt at vurdere om der vil ske en øgning eller reduktion i mulighederne for at tiltrække eksterne midler til forskning inden for byggeriet. I denne UMV antages en

mindre stigning i den eksterne finansiering. Det kendetegner de eksterne fonde og forskningsprogrammer, at de i stadig stigende omfang reducerer tildelingen af overhead, hvilket øger kravene til instituttets medfinansiering.

Private samarbejdspartnere og fonde åbner kun i ganske få tilfælde mulighed for forudbetalinger. Instituttet har fra 2007 skærpet opmærksomhed på at sende faktura så tidligt som kontrakterne tillader. Instituttet vurderer ikke det vil være muligt at mindske likviditetsbindingen yderligere.

Der er ikke i den nuværende projektportefølje identificeret særligt risikobehæftede projekter.

### **Økonomistyring**

Der er stigende behov for udvikling af værktøjer til styring og opgørelse af instituttets resurser anvendt til undervisning, forskning og andre aktiviteter. Instituttet anbefaler, at DTU etablerer et professionelt time-sagsstyringssystem omfattende alle kontogrupper til støtte for projektledelsen.

## **7 Opsamling af de vigtigste strategiske projekter**

Den vigtigste udfordring for BYG•DTU er at videreudvikle en stærk international forskningsprofil i tråd med instituttets strategi samtidig med den meget store undervisningsbelastning. De vigtigste strategiske udviklingsprojekter i punktform:

- Fokus på forskningskvalitet og produktion gennem styrket forskningsledelse, forskningsevaluering i 2007, international stabsudveksling, sabatticals mv.
- Oprette en kandidatuddannelse i Architectural Engineering
- Udvikle BYG-innovationsenhed i IPU og etablere et nationalt center for mekanisk konstruktions- og materialeprøvning med Risø og MEK
- Styrket international positionering bl.a. igennem deltagelse i FP7 projekter, andre internationale netværk og gennem samarbejdet omkring udvikling af ph.d. kurser.

## 2.3 - Generelle HR Data

Videnskabeligt Personale (Årsværk)	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Chefer, forsknings- og programchefer						
Professor/Forskningsprofessor	8	7	8	9	9	10
Professor MSO/Forskningsprofessor MSO			1	1	1	1
Docenter	3	1	2	2	2	2
Forskningsspecialister						
Seniorrådgiver						
Lektor/Seniorforsker	38	44	44	43	44	44
Adjunkt/Forsker	11	10	12	16	16	16
Projektseniorforsker						
Projektforskere/Post.Doc.	2	1				
Forskningsassistent	2	4	3	3	3	3
Kandidatstipendiat						
Øvrige VIP						
<b>I alt</b>	<b>64</b>	<b>67</b>	<b>70</b>	<b>74</b>	<b>75</b>	<b>76</b>

Ph.d. studerende	26	29	31	33	35	35
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Teknisk Administrativt Personale (TAP)	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Ledere/konsulenter						
Akademikere (fagl. og adm.)	12	12	12	12	12	12
Kontomedarb.	13	13	13	13	13	13
Teknikere	20	21	21	21	21	21
Elever/lærlinge/studentemedhj.	1	1	1	1	1	1
Midlertidigt ansatte						
Personer i soc. ordning	5	5	5	5	5	5
<b>I alt</b>	<b>51</b>	<b>52</b>	<b>52</b>	<b>52</b>	<b>52</b>	<b>52</b>

Eksterne lektorer, undervisningsassistenter, hjælpelærere (i antal)	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Eksterne lektorer	34	30	30	30	30	30
Undervisningsassistenter	94	94	94	94	94	94
Hjælpelærere	54	54	54	54	54	54
<b>I alt</b>	<b>182</b>	<b>178</b>	<b>178</b>	<b>178</b>	<b>178</b>	<b>178</b>

Institut i alt (ekskl. eksterne lektorer mv.)	141	148	153	159	162	163
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## 4.1 Undervisning og uddannelse

Undervisning og uddannelse	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011	
STÅ – totalt	517	520	520	520	520	520	
STÅ pr. VIP	11.8	11.1	10.6	10.6	10.6	10.6	Pr. faculty
STÅ pr. mio. kr. (ud fra instituttets varige økonomiske ramme)	11.3	11.3	11.0	11.0	11.0	11.0	
Antal deltagere på specialkurser	233	140	140	140	140	140	
Antal afsluttede midtvejsprojekter (civilingeniøruddannelsen)	33	50	50	50	50	50	Bachelorprojekter, ikke midtvejsprojekter
Antal afsluttede eksamensprojekter på civilingeniøruddannelsen	85	80	80	80	80	80	
Antal afsluttede eksamensprojekter på diplomingeniøruddannelsen	130	120	120	120	120	120	
Antal afsluttede eksamensprojekter i samarbejde med andre institutter (hvor STÅ - praktik	1	3	2	2	2	2	
	59	35	50	50	50	50	

Erhvervsbaserede uddannelsesprojekter	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011	
Antal diplom-, bachelor-, kandidat- projekter afviklet i samarbejde med erhvervslivet	9	10	12	15	15	15	2006: Defineret ved registreret medvejleder fra firma. Definition uklar.

## 4.2 Forskning

Forskningsresultater	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011	Noter
<b>Publikationer m. referee og citationer</b>							
Scientific articles with referee in ISI-indexed journals	30	45	50	55	60	60	
Scientific articles with referee	15	15	15	15	15	15	
Contributions to conference proceedings (with referee)	91	90	80	80	80	80	
Monografier	13	10	10	10	10	10	Definition?
Bidrag til bøger	14	10	10	10	10	10	
Citationer 2002-2006 for publikationer indekseret i 02-06	208	220	240	260	280	300	
Citationer 2006 for publikationer indekseret i 02-06	98	100	110	120	130	140	
<b>Videnskabelige afhandlinger</b>							
Doktorafhandlinger (fra instituttet)	0	0	1	0	0	1	
<b>Publikationer uden referee</b>							
Scientific publications, articles and conference contributions with no peer-	44	45	40	35	30	30	Scientific publication vs. report?
Popular contributions (incl. TV, radio, news papers)	55	55	55	55	55	55	Defineret ved presseklip
<b>Scientific reports</b>							
Scientific reports	33	40	40	40	40	40	Scientific publication vs. report?
<b>Anden publikation (herunder elektronisk)</b>							Emnet er ikke veldefineret

Andre forskningsrelaterede aktiviteter	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011	
Antal af faste VIP som har haft ophold ved andre forskningsinstitutioner	7	3	4	5	5	5	Minimum 1 måneds ophold.
Antal gæsteforskere som har haft ophold ved instituttet	11	5	6	7	7	7	Minimum 1 måneds ophold.
Antal inviterede bidrag v. internationale konferencer	15	15	15	15	15	15	
Antal int. konferencer / sommerskoler, hvor instituttet er (med)arrangør	11	10	10	10	10	10	Konferencer som BYG-DTU har arrangeret eller været med i f.eks. scientific committee
Antal gange hvor instituttets VIP har medvirket i officielle evalueringer af andre	1	2	3	3	4	5	
Antal gange hvor VIP har deltaget i andre institutioners bedømmelsesudvalg for	10	10	10	10	10	10	
Antal gange hvor VIP har deltaget i bedømmelsesudvalg v. VIP-	9	10	10	10	10	10	
Andet (art kan angives i selve UVM'en)							

Forskerskoler, antal studerende fra instituttet	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Navn: <i>Skriv navnet på forskerskolen her</i>						
<a href="mailto:IRS@BYG">IRS@BYG</a>	42	45	50	55	55	55
Navn:						
Navn:						

Ph.d.-kurser	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal dedikerede ph.d. kurser på instituttet - i enheder af 5 ECTS-point	3	5	7	8	9	9

Antal ph.d. projekter i samarbejde med virksomheder	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
	13	15	18	21	24	27

Dette er måske for lavt sat? Lidt udefineret, hvad der ligger i "samarbejde med virksomheder"

### 4.3 Innovation, herunder efteruddannelsesaktiviteter

Kommercialiserbar Intellectual Property	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal af kommercialiserbare patenter fra instituttet	1	1	0	1	0	1
Omfang af salgs- og licensindtægter fra patenter udviklet på instituttet, angivet i 1000 kr.	0	150	100	0	0	0
Omfang af slags- og licensindtægter fra software udviklet på instituttet, angivet i 1000 kr.	0	0	0	0	0	0

Ikke fra patent, men fra know-how

Forskningsnær rådgivningsvirk-somhed og innovation i eksisterende virksomheder	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal af projekter indgået som samarbejdsaftaler med industrien eller under ordning om indtægtsdækket virksomhed	60	65	70	70	70	70
Antal aftaler og kontrakter indgået med GTS institutter i forbindelse med teknologioverførsel	7	7	7	7	7	7
Omsætning i de to ovenstående kategorier, angivet i 1000 kr.	3716	4000	4000	4000	4000	4000
Omsætning i de IPU-enheder, der samarbejder med instituttet, angivet i 1000 kr.	0	750	2000	3000	4000	5000

Omsætning i 2006 kun for projekter startet i 2006

Virksomhedsopstart	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal virksomheder startet med udgangspunkt i know-how fra instituttet						
Aktivitetsniveauet i virksomhedskuvøser på instituttet, målt i omsætning og angivet i 1000 kr.						

Omsætning i 3H og Damptech ikke oplyst

Virksomhedsnetværk	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal virksomheder tilknyttet instituttets virksomhedsnetværk og -klubber	109	100	100	100	100	100

LavEByg og C-PROSAM

Efteruddannelsesaktiviteter	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal kursister ved instituttets efteruddannelsesaktiviteter (ekskl. aktiviteter under deltidsuddannelse)	2	0	0	0	0	0
Antal STA optjent ved instituttets efteruddannelsesaktiviteter (kun deltidsuddannelse)	14	19	19	19	19	19

## 4.4 Myndighedsbetjening

Personalemæssige ressourcer	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal VIP-årsværk i alt tilknyttet aftaler om myndighedsbetjening	1	1	1.5	3	5	5
Antal TAP- årsværk i alt tilknyttet aftaler om myndighedsbetjening	0.2	0.2	0.2	0.5	1	2

Økonomi	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Eksterne indtægter fra myndighedsbetjening i alt (1,000 kr)	600	600	900	1800	2400	2400
- heraf eksterne indtægter fra internationale bevillingsgivere (1,000 kr)	0	0	0	0	0	0
Procentvis andel af instituttets samlede omsætning (inkl. basisfinansiering), der vedrører myndighedsbetjeningsopgaver	1.00	1.00	1.00	2.00	2.00	2.00

Beløbet for 2006 indgår i samarbejdskontrakter ovenfor

Kontrakter/aftaler	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Antal kontrakter/aftaler som instituttet har indgået om myndighedsbetjeningsopgaver*)	5	5	5	7	9	9
Antal internationale kontrakter/aftaler på myndighedsbetjeningsområdet	0	0	0	0	0	0
Antal myndigheder som instituttet har indgået kontrakter/aftaler med om myndighedsbetjeningsopgaver	3	3	3	3	3	3

Guestimates

Kompetenceopbygning og organisation	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Har instituttet udpeget en ansvarlig for området, i fald ansvaret delegeres fra direktøren (ja/nej)			ja			
Har instituttet udarbejdet en strategi**) for myndighedsbetjeningsområdet (ja/nej)			ja			
Har instituttet sat sig ind i Håndbogen***) gennem evaluering i forhold til mindst ét konkret eksempel (ja/nej)			ja			

\*) Aftaler, hvor instituttet er underleverandør i forhold til et andet kontraherende institut, tæller med

\*\*) Strategien foreslås opbygges efter en læst udviklet af Afd. For Myndighedsbetjening. Denne omfatter bl.a.: kvantitative omsætnings- og kontraktmål, markedsføringsforhold, salgsforhold, samarbejdspartnere og konkurrenter, kommunikation.

\*\*\*) Afd. For Myndighedsbetjening udgiver primo 2008 en Håndbog for Myndighedsbetjening. Håndbogen ligger elektronisk og opdateres løbende med best-practise

## 6. - Økonomisk ramme

(Mio.kr.)	Faktisk 2006	Budget 2007	Budget 2008	Budget 2009	Budget 2010	Budget 2011
Varig økonomisk ramme	45603	46103	48256	48256	48256	48256
Forventede <b>eksterne</b> indtægter, samlet	28772	24728	25428	27453	27853	29433

Samlede eksterne indtægter omfatter UK 90, UK 95, Artek samt Masteruddannelserne

# UMV for 2008 - 2011 BYG•DTU

UNDERKONTO  
INSTITUT  
BASISÅR

Alle UK  
11 (BYG)  
2007

	Regnskab 2006	Budget 2007	Prognose efter 1. Kvarter 2007
<b>Indtægter:</b>			
Variig økonomisk ramme	45.603	46.103	46.103
Anlægsbevillinger	0	0	0
Øvrige bevillinger	2.738	6.017	6.353
Eksterne midler til forskning	17.162	18.000	18.000
Andre indtægter	11.938	6.944	7.444
Interne overførselsindtægter	2.001	1.917	1.720
DTU finans. Ph.d. og elever	4.123	4.452	4.452
<b>Indtægter i alt</b>	<b>87.689</b>	<b>83.433</b>	<b>84.072</b>

<b>Omkostninger:</b>			
Løn	63.021	64.913	65.900
Rejse & repræsentation	3.770	4.306	4.055
Energi	53	120	60
Konsulentydelse	1.160	1.850	1.800
Øvrige varer og tjenester	13.120	7.088	7.700
Leje, rep. og vedl.	932	562	700
Skatter og afgifter	17	150	20
Omkostninger ved lukning af projekter	0	0	0
Afskrivninger	0	0	0
Finansielle omkostninger, netto	5	0	0
Driftsomkostninger	19.057	14.076	14.335
Anlægsinvesteringer	3.188	350	350
Interne overførsler	4.176	4.192	3.995
<b>Omkostninger i alt</b>	<b>89.441</b>	<b>83.531</b>	<b>84.560</b>

<b>Driftsresultat</b>	<b>-1.752</b>	<b>-98</b>	<b>-508</b>
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Overskud / Underskud primo	13.446	11.694	11.694
+/- periodens resultat	-1.752	-98	-508
Overskud / Underskud ultimo	11.694	11.596	11.186

	UMV 2008	UMV 2009	UMV 2010	UMV 2011
	48.256	48.256	48.256	48.256
	0	0	0	0
	5.621	5.697	5.030	5.260
	19.000	20.000	21.000	22.000
	6.628	7.653	7.053	7.633
	1.980	2.042	2.105	2.167
	4.900	5.300	5.700	5.700
	<b>86.385</b>	<b>88.948</b>	<b>89.144</b>	<b>91.016</b>

	67.940	69.490	70.090	70.940
	4.055	4.055	4.055	4.055
	120	120	120	120
	1.713	1.913	1.963	2.113
	7.400	7.500	7.400	7.700
	550	550	550	550
	32	32	32	32
	0	0	0	0
	0	0	0	0
	0	0	0	0
	13.870	14.170	14.120	14.570
	0	500	0	0
	4.359	4.525	4.693	4.859
	<b>86.169</b>	<b>88.685</b>	<b>88.903</b>	<b>90.369</b>

	<b>216</b>	<b>263</b>	<b>241</b>	<b>647</b>
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	11.186	11.402	11.665	11.906
	216	263	241	647
	11.402	11.665	11.906	12.553

# UMV for 2008 - 2011 BYG•DTU

UNDERKONTO  
INSTITUT  
BASISAR

Ordinær (UK 10)  
11 (BYG)  
2007

	Regnskab 2006	Budget 2007	Prognose efter 1. Kvartal 2007
<u>Indtægter:</u>			
Varig økonomisk ramme	45.803	46.103	46.103
Anlægsbevillinger	0	0	0
Øvrige bevillinger	2.738	6.017	6.353
Eksterne midler til forskning	0	0	0
Andre indtægter	10.753	5.144	5.144
Interne overførselsindtægter	1.941	1.917	1.720
DTU finans. Ph.d. og elever	4.123	4.452	4.452
<b>Indtægter I alt</b>	<b>69.281</b>	<b>63.633</b>	<b>63.772</b>

<u>Omkostninger:</u>			
Løn	52.662	52.573	53.300
Rejse & repræsentation	2.633	3.501	3.000
Energi	53	100	50
Konsulentytelser	616	700	600
Øvrige varer og tjenester	11.834	6.000	6.500
Leje, rep. og vedl.	875	500	600
Skatter og afgifter	17	150	20
Omkostninger ved lukning af projekter	75	0	0
Afskrivninger	0	0	0
Finansielle omkostninger, netto	5	0	0
Driftsomkostninger	16.107	10.951	10.770
Anlægsinvesteringer	3.188	350	350
Interne overførsler	44	0	0
<b>Omkostninger I alt</b>	<b>72.001</b>	<b>63.874</b>	<b>64.420</b>

<b>Driftsresultat</b>	<b>-2.720</b>	<b>-241</b>	<b>-648</b>
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Institutt kapital primo	15.364	12.644	12.644
+/- periodens resultat	-2.720	-241	-648
Videreførsel ultimo	12.644	12.403	11.996

	UMV 2008	UMV 2009	UMV 2010	UMV 2011
	48.256	48.256	48.256	48.256
	0	0	0	0
	5.621	5.697	5.030	5.260
	0	0	0	0
	4.628	5.453	4.853	5.433
	1.980	2.042	2.105	2.167
	4.900	5.300	5.700	5.700
	<b>65.385</b>	<b>66.748</b>	<b>65.944</b>	<b>66.816</b>

	54.400	55.250	55.250	55.600
	3.000	3.000	3.000	3.000
	100	100	100	100
	750	750	700	750
	6.500	6.500	6.300	6.500
	500	500	500	500
	20	20	20	20
	0	0	0	0
	0	0	0	0
	0	0	0	0
	10.870	10.870	10.620	10.870
	0	500	0	0
	0	0	0	0
	<b>65.270</b>	<b>66.620</b>	<b>65.870</b>	<b>66.470</b>

	<b>115</b>	<b>128</b>	<b>74</b>	<b>346</b>
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	11.996	12.111	12.239	12.313
	115	128	74	346
	12.111	12.239	12.313	12.659

# UMV for 2008 - 2011 BYG•DTU

UNDERKONTO  
INSTITUT  
BASISÅR

Kommerciel (Uk 90)  
11 (BYG)  
2007

	Regnskab 2006	Budget 2007	Prognose efter 1. Kvartal 2007
<b>Indtægter:</b>			
Variø økonomisk ramme	0	0	0
Anlægsbevillinger	0	0	0
Øvrige bevillinger	0	0	0
Eksterne midler til forskning	0	0	0
Andre Indtægter	1.194	1.800	2.300
Interne overførselsindtægter	0	0	0
DTU finans. Ph.d. og elever	0	0	0
<b>Indtægter i alt</b>	<b>1.194</b>	<b>1.800</b>	<b>2.300</b>

<b>Omkostninger:</b>			
Løn	816	440	700
Rejse & repræsentation	45	55	55
Energi	0	0	0
Konsulentydelse	130	0	800
Øvrige varer og tjenester	93	463	100
Leje, rep. og vedl.	19	50	50
Skatter og afgifter	0	0	0
Omkostninger ved lukning af projekter	-20	0	0
Afskrivninger	0	0	0
Finansielle omkostninger, netto	0	0	0
Driftsomkostninger	267	568	1.005
Anlægsinvesteringer	0	0	0
Interne overførsler	341	792	595
<b>Omkostninger i alt</b>	<b>1.424</b>	<b>1.800</b>	<b>2.300</b>

<b>Driftsresultat</b>	<b>-230</b>	<b>0</b>	<b>0</b>
Overskud / Underskud primo	93	-137	-137
±- periodens resultat	-230	0	0
Overskud / Underskud ultimo	-137	-137	-137

	UMV 2008	UMV 2009	UMV 2010	UMV 2011
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	2.000	2.200	2.200	2.200
	0	0	0	0
	0	0	0	0
	2.000	2.200	2.200	2.200

	540	640	640	640
	55	55	55	55
	0	0	0	0
	463	563	563	563
	100	100	100	100
	50	50	50	50
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	668	768	768	768
	0	0	0	0
	792	792	792	792
	2.000	2.200	2.200	2.200

	0	0	0	0
	-137	-137	-137	-137
	0	0	0	0
	-137	-137	-137	-137

# UMV for 2008 - 2011 BYG•DTU

UNDERKONTO  
INSTITUT  
BASISAR

Ekstern (UK 95)  
11 (BYG)  
2007

	Regnskab 2006	Budget 2007	Prognose efter 1. Kvarter 2007
<b>Indtægter:</b>			
Variø økonomisk ramme	0	0	0
Anlægsbevillinger	0	0	0
Øvrige bevillinger	0	0	0
Eksterne midler til forskning	17.162	18.000	18.000
Andre indtægter	-9	0	0
Interne overførselsindtægter	60	0	0
DTU finans. Ph.d. og elever	0	0	0
<b>Indtægter i alt</b>	<b>17.213</b>	<b>18.000</b>	<b>18.000</b>

<b>Omkostninger:</b>			
Løn	9.542	11.900	11.900
Rejse & repræsentation	1.093	750	1.000
Energi	0	20	10
Konsulentydelse	413	1.150	400
Øvrige varer og tjenester	1.193	625	1.100
Leje, rep. og vedl.	38	12	50
Skatter og afgifter	0	0	0
Omkostninger ved lukning af projekter	-55	0	0
Afskrivninger	0	0	0
Finansielle omkostninger, netto	0	0	0
Driftsomkostninger	2.682	2.557	2.560
Anlægsinvesteringer	0	0	0
Interne overførsler	3.792	3.400	3.400
<b>Omkostninger i alt</b>	<b>16.016</b>	<b>17.857</b>	<b>17.860</b>

<b>Driftsresultat</b>	<b>1.197</b>	<b>143</b>	<b>140</b>
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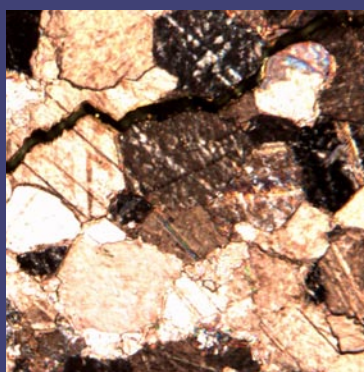
Forskningssaldo primo	-814	-814	-814
+/- periodens resultat	1.197	143	140
Forskningssaldo ultimo	-814	-671	-674

	UMV 2008	UMV 2009	UMV 2010	UMV 2011
	19.000	20.000	21.000	22.000
	0	0	0	0
	0	0	0	0
	0	0	0	0
	19.000	20.000	21.000	22.000
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	19.000	20.000	21.000	22.000

	13.000	13.600	14.200	14.700
	1.000	1.000	1.000	1.000
	20	20	20	20
	500	600	700	800
	800	900	1.000	1.100
	0	0	0	0
	12	12	12	12
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	2.332	2.532	2.732	2.932
	0	0	0	0
	3.567	3.733	3.901	4.067
	18.899	19.865	20.833	21.699

	101	135	167	301
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	-674	-573	-438	-271
	101	135	167	301
	-573	-438	-271	-30





## From the Head of Department

***The Department of Civil Engineering, BYG•DTU was established in 2001 in order to unite the technical disciplines, which are applied in a building design process.***

### **BYG•DTU**

The new department included staff from the former departments: Structural Engineering and Materials, Applied Building and Environmental Technology, Buildings and Energy, Geology and Geotechnical Engineering, and Planning. In addition BYG•DTU integrated the B.Eng. programme in Civil Engineering ("diplomingeniøruddannelsen"), which was previously independent from the university.

In March 2003 BYG•DTU adopted a new strategy for the planning period 2003-08. The Strategy was developed by the Advisory Board for BYG•DTU, the Deans of Research and Education of DTU, and members of the staff of the Department. The strategic goals are to establish BYG•DTU as an internationally recognized university department, which, through its activities in education, research, and innovation, contributes to the technical development of the building and construction industry and the infrastructure development of society.

In 2003 and 2004 the Strategy has acted as the basis for a reorganization and refocusing of the departments activities. Fol-

lowing the strategy and as part of a generation alternation the Department has recruited the department head, three professors, three associate professors and one assistant professor since 2003. The renewal of staff will continue during the planning period. On this new foundation BYG•DTU is well under way in fulfilling the strategic goals.

### **Education**

Education at BYG•DTU comprises

- the B.Sc. and M.Sc. programmes: Civil Engineering (Students graduate as "civilingeniør")
- the B.Eng. programmes: Civil Engineering, Architectural Engineering, and Arctic Technology. (students graduate as "diplomingeniør"):

In 2004 DTU adopted the Bologna Declaration on the European Space for Higher Education. Thus BYG•DTU initiated a revision of the B.Sc. and M.Sc. programmes in Civil Engineering. The B.Sc. programme has now been organized according to four well defined recommended study plans and a thorough revision of the M.Sc. programme is under way. The Department has established a dialogue with the employers of civil engineers as part of the work with the revision.

The B.Eng. programme in Civil Engineering went through an



## BYG•DTU Strategy 2003-2008

BYG-DTU is a university department within the Civil Engineering area.

The mission of the department is education, research, and innovation. The department contributes through knowledge creation to the generation of social and commercial value.

The vision is to become one of Europe's leading Civil Engineering institutions and through this to become a preferred partner for companies and institutions in the building sector.

external evaluation and was accredited by the Ministry of Education in 2004.

The B.Eng. programme in Architectural Engineering started in 2002. This new programme has attracted a new group of students to DTU. The programme has attained a stable admission of around 40 each summer.

The B.Eng. programme in Arctic Technology started in 2001. Between eight and fourteen students have started their Arctic Technology education in Sisimiut, Greenland each summer since 2001. After one and a half year in Greenland the students enter the B.Eng. in Civil Engineering programme at DTU in Denmark.

### Research

Research at BYG•DTU is orga-

nized in five focus areas:

- Structural engineering
- Geotechnology
- Building materials
- Construction processes, planning and management
- Building physics and installations

The publication rate increased from 44 refereed papers in 2003 to 63 in 2004, even though the research productivity was severely hampered by a very large teaching load.

Building research is unfortunately not a very jazzy theme at the present time. Thus BYG•DTU has entered the international research network European Construction Technology Platform, ECTP, which seeks to influence the priorities of EU's 7th Framework for Research in order to bring building research higher on the research agenda. In Denmark BYG•DTU, together with the Danish Technological Institute and the Danish Building Research Institute, constitute the secretariat for ECTP-Denmark, which during 2004 has strived to bring building research back into the national research agenda. 2005 will show if these activities have been fruitful in terms of generating funds for a renewal of Danish building research.

In autumn 2004 the Department established the International Research School for Civil Engineering at BYG•DTU. The Research School organizes the

Department's research education and we plan to use the Research School as recruitment and fund raising platform. Two Ph.D. summer school courses were conducted in 2004 and a number of new courses are under way.

### Innovation

Innovation at BYG•DTU comprises activities directed towards direct economic value generation together with external partners. This is done through patenting for future licensing, collaborative research, commercial testing and consultancy, and continued education programmes.

In 2004 BYG•DTU registered three proposals for patenting with DTU's patent office. In 2005 a preliminary business plan will establish the basis for possible further investment in the patents.

In 2003 the department organized commercial testing and consultancy in a separate organization, BYG-test. BYG-test offers access to research facilities at commercial terms. In 2004 BYG-test experienced a decrease in commissioned work; however, an increase is forecasted for the coming years as more effort is put into marketing the unique facilities and competencies of the Department.

BYG•DTU has developed the continued education programmes Master in Fire Safety

and Master in Management of Construction, and offers a number of courses as part of the Vacant Places Scheme.

The department is actively involved in development of the Danish building codes for energy consumption and for fire. The collapse of the roof of the Siemens sports arena near Copenhagen initiated a revision of the rules for certification of constructions with BYG•DTU participation.

### **Staff development**

Staff development at BYG•DTU has high priority and continued education of the staff was enhanced in 2004.

A comprehensive English course for technical and administrative staff was developed in collaboration with London City University. The English course concluded with a successful study tour to London.

The department initiated a plan for management and leadership development for section heads. The plan is based on DTU's common course programme.

In addition to these coordinated efforts a number of individual staff has attended administrative, language and other courses.

### **Technical resources**

In general it is difficult to maintain a level of investment that is sufficiently high to

maintain and develop the technical equipment needed for advanced research and research based education.

Thus it was positive that the Department in 2004 could start a much needed building renovation programme. The building renovation programme comprises a number of improvements in our main civil engineering laboratory, a renovation of the buildings' materials laboratory, and improved ventilation and other safety measures. The building programme is expected to be completed in 2005.

### **Outlook**

The steadily increasing international competition within civil engineering is the most important challenge for BYG•DTU. A recent seminar for employers held by BYG•DTU pinpointed international collaboration and proper reaction to globalisation as the most important activities for the department in the coming years.

In spite of the challenges the basics remain: The Department will maintain focus on selected topics and expand the research activities in order to sustain the research based education. Increased external funding is required to fulfil this goal. A recent report "The Building Sector in the Knowledge Society" submitted by the Danish Ministry of Economic and Business Affairs calls for an increased effort in building

research, unfortunately very little action has hitherto been taken to ensure the associated funding.

"We build the quality of life" is a slogan used by the American Society of Civil Engineers. The true meaning of "quality of life" is debatable, but in spite of this I believe the slogan captures an essence of the work of the civil engineer: To create and make a difference in the physical world that surrounds us, impresses us, and sustains our life.



Jacob Steen Møller  
Ph.D. M.Sc. (Civ.Eng.)  
Head of Department



## Highlights 2004

### **3 March: New database and program for calculating window performance**

Professor Svend Svendsen participates as work package leader in the final meeting in the EU project WinDat (see [www.WinDat.org](http://www.WinDat.org)) on the development of a common European database and program for calculating the energy performance of windows. The project is attended by about 40 research institutes and companies with expertise in glass, glazing units and windows.

### **4 March: Open House at DTU**

The department presented its education programmes to potential students at the annual open house at DTU.

### **10 March: Education Seminar**

The future education at BYG•DTU was the theme of a seminar with employers of our candidates. The meeting facilitated a positive dialogue and the many engaged participants gave very useful viewpoints on how to balance different strategic goals.

### **12 March: Head of Department meets Iraqi minister**

Head of Department Jacob Steen Møller meets Iraqi Minister for Municipalities and Public works Mrs. Nesreen M. Siddeek Berwari to discuss capacity building within civil and architectural engineering.

### **17 March: Presentation in the international standardization organisation**

Professor Svend Svendsen presents results from a large research project on energy efficient buildings at a meeting in international standardization organisation, ISO/TC 163 Thermal performance and energy use in the built environment. The research project has been carried out in cooperation with the Danish building sector. The results of the project are used in the revision of the building code that enforces energy savings of about 30%.

### **30 March: Grants for construction research**

Professor Ole Mejlhede receives 250.000 DKK from Ingeborg and Leo Dannins Foundation to research cracking of high-performance concrete.



### **31 March: Scientific Seminar**

The DANVAK-seminar "Solar Energy Potential of the EU Directive on Building Energy Efficiency" is held at BYG•DTU. Members from the Industry, from The Danish Energy Authorities and from other research institutions participate.

### **22 April: Section leader seminar**

Section leaders meet to discuss university management. Rector Lars Pallesen participates.

### **30 April: DTU 175 years**

Professor Victor Li, visiting professor at BYG•DTU was appointed Dr.Tech. Honoris Causa at the DTU 175 years anniversary festival. At the same event Professor Niels Jørgen Gimsing and Managing Director at COWI Klaus Ostenfelt (member of our Advisory Board) received a gold medal for their extraordinary contribution to bridge construction.

### **13 May: Scientific Seminar**

Mr David Brohn was key speaker on a scientific Seminar on "Intuitive Understanding of Structural Behavior" organized by the Danish Construction and Concrete Institute.

### **17 May: Meeting with Danish Concrete Council**

Professor Ole Mejlhede Jensen, Associate Professors Mette Geiker, Henrik Stang, John Forbes and Head of Department Jacob Steen Møller meet with Danish Concrete Council.

### **1 June: Velux A/S joins BYG•DTU Research project**

Velux takes an active part in supporting the research and development of solar heating for the future as they join the research project "Competitive Solar Heating Systems for Residential Buildings". The research project is co-funded by the Nordic Energy Research.

### **June: Ph.D. summer school on cement and concrete**

The summer school: Phase equilibria and reactions of cement and concrete had 27 participants from nine countries. The summer school was organized by Associate Professor Mette Geiker and sponsored by Knud Højgaard Foundation.





**1-30 June: BYG•DTU organizes international Master course**  
BYG•DTU organizes the international Master course "Solar Energy", which takes place in relation to the international congress Euro-Sun 2004. Students from Norway, Denmark, Austria, Turkey and Germany participate.

**2 June: BYG•DTU field trip**

The annual summer field trip went to Frederiksdal where we enjoyed the glass exhibition at Sophienholm. After a delicious lunch we lost ourselves in kite building.

**20-23 June: BYG•DTU Researchers invited as Keynote Speakers**

Associate Professors Simon Furbo and Louise Jivan Shah are invited as keynote speakers for the international congress EuroSun 2004, which takes place in Freiburg, Germany.

**July-August: ARTEK course in Greenland**

26 students completed their courses in Arctic Technology with a 2½ week programme in Sisimiut.

**2-6 August: Lean Construction Conference**

The conference on Lean Construction received great international attention. The Section for Planning and Management of Building processes was co-organizers of the conference as well as the related summer school.

**August-December: Architectural Engineering students in practical training**

The first group of 25 students started their practice period.

**6 September: DHL-Stafetten**

BYG•DTU participates in DHL-Stafetten in Fælledparken.

**7 September: Grants for research in protection of painted church vaults**

Associate Professor Lisbet Ottosen received 1.4 mill. DKK from Velux Foundation to research in electrochemical removal of damaging salts from painted church vaults



### **26 September: Ph.D. day**

Ph.D. day is the annual event where Ph.D. students present their projects to each other and to the department in general.

### **17 September: Alumnen day**

The Alumnen day was a big event at DTU and at BYG•DTU, thanks to all the former students and colleagues who made this a fun and interesting reunion.

### **12 October**

The Danish Construction Association presents a report on the energy efficiency improvements of the building stock. BYG•DTU is involved in the background work on the report. The BYG•DTU report R-080 Energy Savings in existing and new domestic buildings, documented energy saving potential of 80%.

### **25 October: First working meeting in BYG•DTU's Advisory Board**

The department started a very constructive dialogue with our Advisory Board.

### **21 October: Approval of International Research School**

DTU approved the International Research School in Civil Engineering at BYG•DTU (IRS@BYG). Leader of the research school is Professor Stephen Emmitt.

### **4 November Open house at DTU**

BYG•DTU promoted the B. Eng. (Civil Engineering) programme for potential students starting spring 2005.

### **13 December: Visit at Indian Institute of Technology**

Head of Department visits Indian Institute of Technology, New Delhi, to explore potential research and education collaboration.





## Education

***BYG•DTU is the anchor for the following bachelor-programmes: B.Eng in Civil Engineering, B.Eng in Architectural Engineering, B.Eng in Arctic Technology, B.Sc. in Building Technology, and the master programme M.Sc. in Civil Engineering. We contribute to the master programmes of Material Technology, Transport and Logistics, Production and Management, and Energy.***

Planning for the new Bachelor of Science (B.Sc.) programme has initiated a comprehensive revision of our current courses and resulted in the following recommended study plans.

- Construction
- Building energy and services
- Building constructions and materials
- Physical planning and traffic

The process of developing our teaching activities will continue in 2005 in order to start the new Master of Science (M.Sc.) programme in summer 2006.

New courses have been introduced in the Bachelor of Engineering (B.Eng) programme in order to achieve more integrated knowledge of materials and constructions. Other courses have been developed in coordination with the Bachelor of Science (B.Sc.) programme.

The first students at Architectural Engineering (B.Eng.) finished their second year in the summer of 2004. The students had their internship in the fall; however there was a lack of internships with a profile matching Architectural Engineering. For the coming practical training periods about 40 new internships per year need to be organized in collaboration with especially consulting companies.

### Strategic goals - education

- BYG•DTU is recognised for providing relevant, future-oriented M.Sc (engineering) programmes, with a solid academic foundation which can provide a basis for life-long learning.
- The Department contributes to all categories of education: B.Sc, B.Eng, M.Sc, and continuing Master programmes.
- The Department has a simple academic structure geared towards imparting a comprehensive understanding of construction processes, buildings and structures as well as towards training specialists with a view to research and development.
- The Department's course selection is closely coordinated with courses at DTU's other departments, which provide teaching of high relevance to the field of Civil Engineering.
- The Department's courses use state-of-the-art IT tools and attach great importance to project work and synthesis.
- The Department's courses and course structure provide for international student exchange.
- The Department ensures topicality and contact with the business and industry community in the teaching of practice-oriented subjects.

The Arctic Technology (B.Eng.) programme started in 2001 and the second year group came to Denmark in September 2004.

The programme includes 1½ year in Sisimiut, 2 years in Lyngby and ½ year in practice.



## Research

***BYG•DTU conducts research within a well-defined selection of focus areas with key importance to construction processes, buildings structures and services, and urban development. The institute has a strong research environment attracting Danish and foreign Ph.D.-students and visiting researchers.***

### **The Section for Building Materials and Geotechnics**

A new formula was developed for assessment of reduction of strength and stiffness of concrete and reinforcing steel exposed to fire, and data was derived for most concrete and reinforcement applied in practice. A new test series has completed the design data for quenched and self-tempered bars. These new materials data improves design for the load case of fire, which is decisive for the proportions of 20-30 pct of all concrete structures in buildings. The new set of data is a part of a major project providing design methods for concrete structures exposed to fire load

Associate Professor Ole Hededal was employed as part of the ongoing efforts to strengthen research in geotechnical engineering. The field is further strengthened through a 1.8 mill. DKK research grant from STVF on "Numerical and

physical modelling of laterally loaded pile in sand subject to cyclic loading"

Visiting Professor Victor Li was appointed Dr.Tech. Honoris Causa for his development of a new family of engineered fibre reinforced cement based materials (ECC) with extreme ductility. These materials are presently being introduced in full scale construction projects around the world, including USA, Korea, Japan and Australia. The section is participating in a global network on ECC technology

The Ph.D. project by Kristian Krappenhøft "Moisture Transport in Wood" was completed. The study focus was on physical-mathematical models and their numerical implementation. The project resulted in valuable contributions to the fundamental understanding of the influence of moisture and load variations on the mechanical properties of wood.

The Ph.D. project by Erik Pram Nielsen "The durability for white Portland cement to chemical attack" was completed. The project was founded entirely by Aalborg Portland A/S.

### **The Section for Building Physics and Services**

The Ph.D. project by Peter Weitzmann "Modelling Building Integrated Heating and Cooling System" was completed. The

project demonstrated the potential for energy savings by use of thermo active cooling systems. The research continues in the test facility, which was built as part of the project - among others in collaboration with COWI A/S.



An analysis of the potential for energy saving in the Danish domestic buildings was carried out, and showed it is possible to reduce the energy consumption of all domestic buildings by 80% in 40 years.

The section continued the research on and development of solar heating systems. Current projects focus on advanced storage technologies, flat plate collectors for solar heating centrals, and evacuated tubular collectors suitable to arctic climate.

The Ph.D. project by Søren Knudsen "Investigation and

Optimization of Heat Storage Tanks for Low-Flow SDHW Systems" was completed. The study was based on a combination of computational and experimental fluid dynamics.

Research in arctic building technology materialized in the construction of a low energy house in Sisimiut, Greenland. A new method for ventilation with heat recovery was tested with promising results.

"Hygrothermal Performance of Whole Buildings" is an STVF project running 2003-2006. The aim is to achieve better knowledge about hygrothermal behaviour of buildings to ensure good indoor climates and to avoid damages caused by moisture.

The Ph.D. project by Eva Møller "Hygrothermal Performance and Soiling of Exterior Building Surfaces" was completed. The project was carried out in collaboration with Birch & Krogboe A/S.

### **The Section for Planning and Management of Building Processes**

The section coordinated the activity "Best in Building" under the development programme "Digital Building".

The Ph.D. project by Mikkel Andreas Thomassen "The Economic Organisation of Building Processes - Specialisation and

Coordination in Interfirm Relations" was completed.

The Section strengthened its research base with the announcement of two new positions. The area of facilities management was established through new courses and research activities. Members of the Section have continued to produce books, journal papers and research reports and many are involved in national and international research networks.

A large number of research projects, many of which include collaboration with industry, are ongoing. These include research into safety on building sites, areas of working environment, quality of building site operations, implementation of autonomous workgroups on construction sites, communication in construction teams, value-based management and the implementation of lean construction. A project on partnering has been followed with the development of a management tool "Partnering Performance Indicators".

Work continued on the EU FP 5 projects PETUS (2003-2005) - "Practical Evaluation Tools for Urban Sustainability". The project is concerned with planning methods and decision support systems for cost-, resource- and energy-efficient building.

Work continued on the EU FP5 project INTERMEDIARIES

(2002-2005) - "New Intermediary Services and the Transformation of Urban Water Supply and Wastewater Disposal in Europe". The project is concerned with facility management and interaction with urban infrastructure.

Members of the Section were involved in the organisation of the IGLC 12th Annual Conference on Lean Construction at Helsingør and organised the first international Ph.D. Summer School on lean construction, which followed the main conference.

### The Section for Structural Engineering

The section is in a process of generational alternation and one full professor and two associated professors were employed according to the new section research plan. Another two full and three associate professor positions are to be filled in 2005.

A new research plan identified three research areas:



### Strategic goals – research

- BYG•DTU conducts research within a well-defined selection of focus areas of key importance for construction processes, buildings and structures.
- All focus areas achieve international research excellence, and the Department is among the best in Europe in its fields.
- Holistically-oriented, interdisciplinary research is conducted through activities and projects as collaborative efforts between several of the Department's focus areas.
- The Department has a strong research environment, which attracts Danish and foreign Ph.D. students and guest researchers, and takes part in the international guest exchange of researchers, Ph.D. students and post-doctorates with leading foreign research environments.
- The Department educates 10-15 Ph.D.s and industry-sponsored researchers annually, distributed among all its focus areas. At least half of these enter into external collaborative relationships.

- Design of civil engineering structures
- Structural performance
- Integrated structural and materials modelling

Collaboration with the industry generated interesting projects: Testing the strengthening of wind turbine towers, testing the robustness of 6 m high glass columns, testing the load carrying capacity of very slender columns made from CRC (Compact Reinforced Composite) a very high strength fibre reinforced concrete material,

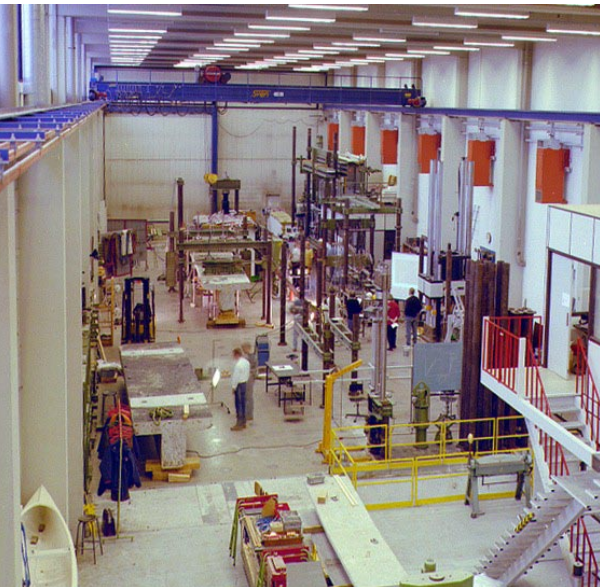
and testing the improvement of fatigue life of grinded weldings.

C•PROSAM a new Centre for Protective Structures and Materials was established. The Centre is an open framework established in order to promote and facilitate the cooperation of Danish research activities in this field. Partners: Defence Research Dept., Densit A/S, Risø, NIRAS/DEMEX A/S, Maticon. An industrial PhD-project was initiated at the Centre.

## Innovation

***BYG•DTU conducts research, development, Ph.d.-projects and student projects in collaboration with companies. We offer in-service training like e.g. Master in Fire Safety and Master in Management of Construction. The Industry contributes to BYG•DTU activities through co-operation agreements, research collaboration, and external lectureships.***

The department has a large Civil Engineering. Laboratory with unique testing facilities.



During 2004 we among others conducted projects on solar heating, tested the capacity of glass constructions, tested carbon fibres for use in satellites equipment and conducted FEM simulation of window profiles for industrial clients.

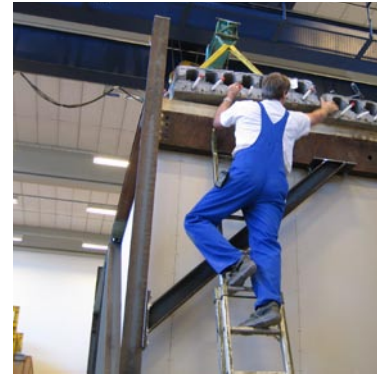
### **Master Education in Fire Safety**

The Danish architect Arne Jacobsen was a pioneer introducing function based requirements for building design for his Royal Hotel in Copenhagen, and function based requirements have since become a precondition for the development of the Danish prefab industry. But the fire requirements were never formulated as function based, because it was too difficult.

Meanwhile fire technology and structural fire safety design has developed, and Denmark is now introducing function based fire safety design in the building regulations, and a similar development is taking place internationally.

It is foreseen that this development means the greatest innovation of building design for 50 years, because it is now possible to create open plans and structures, which were previously not allowed. The precondition is that the engineers are capable of formulating reasonable function based requirements and making the analyses necessary to document the fulfilment of them. Furthermore a research should be made in order to enhance the available knowledge, and maintain it when building design changes.

BYG•DTU supports this development, offering a Master Education in Fire Safety as a



modular Internet based supplementary education, and is leading in research on structures exposed to fully developed fires.

The master education has become a success, and it is now offered the third time for 25-30 students, and the graduated masters have already used their knowledge creating a number of buildings by means of function based requirements, among which are Nykredit, Fisketorvet and Fields in Copenhagen. A special updating course is made each year for the graduated masters to keep them informed of the recent research and as a forum for them to share their

experiences from practice with colleagues and with DTU. More information: [www.brand.dtu.dk](http://www.brand.dtu.dk).

### **The Master Programme in Management of Construction**

The construction industry has in the last 10 years – in Denmark as well as in many other countries – been criticized for low productivity and poor quality. The construction industry has been described as locked in and insensitive to the needs in the market. However, a report in 2001 from the Danish Building Council showed that the construction industry was undergoing change that pointed towards increased use of prefabrication, integration of the project term, partnering and strategic partnerships, use

of ICT etc. This development calls for new competences.

The target group for the programme is BAs and engineers, architects and others working in all parts of the building industry: construction firms, consulting engineers, architectural firms, clients, organizations, authorities, technical schools etc. The master programme started in January 2003 with 15 participants coming from all areas of the building industry. The second group started in January 2005. More information: [http://www.byg.dtu.dk/subwebs/construction\\_management/index.htm](http://www.byg.dtu.dk/subwebs/construction_management/index.htm)



### **Strategic goals - innovation**

- Within its focus areas, BYG•DTU is the preferred collaborative partner in Denmark for the undertaking of commissioned research in collaborative projects, industrial research projects and research and innovation consortiums.
- The Department has state-of-the-art experimental facilities and expertise at its disposal. These facilities and expertise make up a substantial portion of the Department's activities in the area of innovation.
- The Department permanently houses a number of innovative companies, the activities of which form part of the Department's life in the areas of both research and teaching.



# Organization

**BYG•DTU is organized in sections with a professional identity corresponding to the research focus areas. Joint institute resources are organized in departments.**

## Sections and Departments

- Section for Planning and Management of Building Processes: Associate Professor Sten Bonke.
- Section for Structural Engineering: Associate Professor John Forbes Olesen.
- Section for Building Physics and Services: Associate Professor H. Thorkild Jensen.
- Section for Building Materials and Geotechnics: Associate Professor Henrik Stang.
- Department for Administration and IT: Administration Manager Michael Berthelsen.
- Department for Laboratories and Workshops: Laboratory Manager Jørgen Bjørnbak Hansen.

## Study Programmes and Programme Managers:

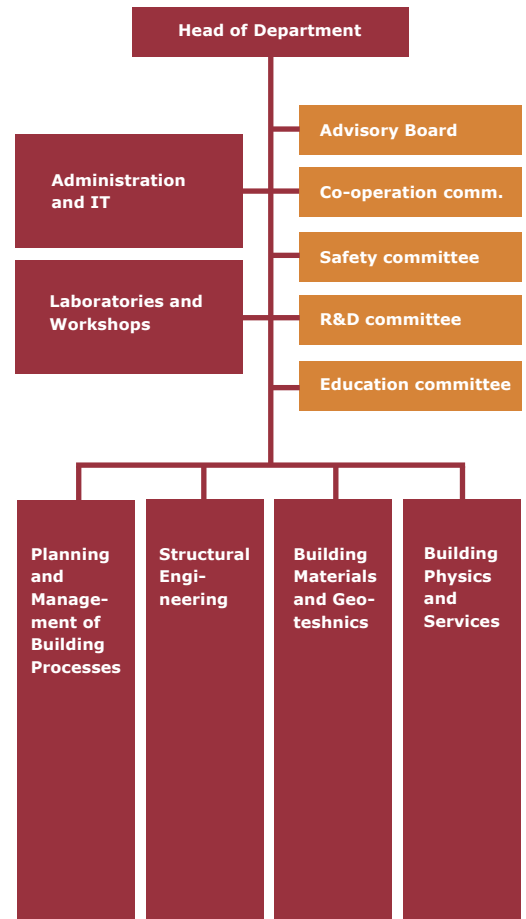
- Civil Engineering (B.Eng.): Associate Professor Ole Mærsk-Møller.
- Architectural Engineering (B.Eng.): Associate Professor Kirsten Christensen.
- Arctic Technology (B.Eng): Associate Professor Egil Borchersen in Greenland. Associate Professor Ole Mærsk-Møller in Denmark.
- Building Technology (B.Sc.): Associate Professor Henning Larsen
- Civil Engineering (M.Sc.): Associate Professor Kristian Hertz.

## BYG•DTU hosts the following centres:

- IRS@BYG, The International Research School in Civil Engineering at BYG•DTU. Research School Leader, Professor Stephen Emmitt.
- ARTEK, Centre for Arctic Technology. Centre Leader, Professor Arne Villumsen.
- C•PROSAM, Centre for Protective Structures and Materials, Centre Leader, M.Sc. Civil Engineer Benjamin Riisgaard.

## The Advisory Board at BYG•DTU:

- Director John Cederberg, Danish Association of Consulting Engineers.
- Director Peter Lundhus, Sund and Belt Partners.
- Managing Director Klaus Ostenfeld, COWI A/S
- Senior Consultant Jørgen Vorsholt, E. Pihl & Søn A.S



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- Associate professor Ole Hededal (geotechnics)
- Associate professor Jeppe Jönsson (structural engineering)
- Associate professor Christos Georgakis (structural engineering)
- Assistant professor Toke R. Nielsen (installations)

**Guests:**

- Dr. Tech. Honoris Causa (DTU), professor Victor Li (Univ. Michigan) 01.03.04-31.08.04
- Professor Bushan Karihaloo (Univ. Cardiff). 06.09.04-05.04.05
- Professor Jason Weiss (Purdue University). 17.05.04-31.10.05
- Professor Hamlin Jennings (North Western Univ.) 01.06.04 - 30.06.04





## Journal articles

*Peer reviewed and  
ISI-indexed*

**Andersen, Elsa ; Shah, Louise Jivan ; Furbo, Simon**

Thermal performance of Danish solar combi systems in practice and in theory. In: Journal of solar energy engineering, vol:126 (2), pp. 744-749 (2004). ASME ISSN: 0199-6231

**Bandler, John W. ; Hailu, Daniel M. ; Madsen, Kaj ; Pedersen, Frank**

A Space-Mapping Interpolating Surrogate Algorithm for Highly Optimized EM-Based Design of Microwave Devices. In: IEEE Transactions on Microwave Theory and Techniques, vol:52 (11), pp. 2593-2600 (2004). IEEE - Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ, 08855-1331, USA ISSN: 0018-9480

**Bentz, Dale P. ; Jensen, Ole Mejlhede**

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**van Breugel, Klaas ; Koenders, Eddie ; Ye, Guang ; Pietro, Lura**

Modelling of Transport Phenomena at Cement Matrix—Aggregate Interfaces. In: Interface Science, vol:12 (4), pp. 423-431 (2004). Kluwer Academic Publishers ISSN: 0927-7056

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**Hansen, Henrik K. ; Ottosen, Lisbeth M. ; Villumsen, Arne**

Electrodialytic removal of cadmium from straw combustion fly ash. In: Journal of Chemical Technology and Biotechnology, vol:79 (7), pp. 789-794 (2004). Compendex ISSN: 02682575

**Hertz, Kristian Dahl**

Reinforcement Data for Fire Safety Design. In: Magazine of Concrete Research, vol:56 (8), pp. 453-459 (2004). Thomas Telford Ltd. ISSN: 0024-9831

**Illum, Klaus ; Meyer, Niels I**

Joint Implementation: Methodology and Policy Considerations. In: Energy Policy, vol:32, pp. 1013-1023 (2004).

**Jakobsen, M. R. ; Fritt-Rasmussen, J. ; Nielsen, S. ; Ottosen, Lisbeth M.**

Electrodialytic removal of cadmium from wastewater sludge. In: Journal of Hazardous Materials, vol:106 (2-3), pp. 127-132 (2004). elsevier ISSN: 0304-3894

**Kamp, Annette ; Hagedorn-Rasmussen, Peter**

Diversity management in a Danish context : towards a multicultural or segregated working life In: Economic and industrial democracy, vol:25 (4), pp. 525-554 (2004). Sage

**Koch, Christian**

Innovation networking between stability and political dynamics. In: Technovation, vol:24 (9), pp. 729-739 (2004).

**Koch, Christian**

Innovation networking between stability and political dynamics. In: Technovation, vol:24 (9), pp. 729-739 (2004). Elsevier ISSN: 0166-4972

**Krabbenhøft, Kristian ; Bechgaard, C. ; Damkilde, Lars ; Hoffmeyer, Preben**

Finite element simulation of boron diffusion in wooden poles. In: Wood and Fiber Science, pp. 15 (2004).

**Krabbenhøft, Kristian ; Damkilde, Lars**

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**Kamp, Annette; Bottrup, Pernille; Larsen, Alex**  
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## Books

## Book Chapters

Carlsson, Monica ; **Hoffmann, Birgitte**

Netværkssamfundet - nye muligheder og vilkår for samarbejde

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In: Samarbejde om Bæredygtig Udvikling : Nye perspektiver på samarbejde mellem skole og eksterne aktører, pp. 145-164 - 1 ed. - København : Danmarks Pædagogiske Universitets Forlag, 2004 ISBN: 87-7613-056-8

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In: Samarbejde om bæredygtig udvikling : Nye perspektiver på samarbejde mellem skole og eksterne aktører, pp. 41 - 54 - Copenhagen : Danish University of Education Press, 2004 ISBN: 87-76-13056-8

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Correlation between Microclimate and Macroclimate

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On the plastic behaviour of multi directional epoxy-bolted CFRP laminates

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**Jensen, Aage**

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In: The Management of Innovation : The International Library of Critical Writings in Business and Management ; 2, pp. 509-532 - 1 ed. - Cheltenham : Edward Elgar, 2004 ISBN: 1 84376 429 6



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In: Simulationsmethoden bei der Planung von Neubauten und Instandsetzungen, pp. 63-80 - München : WTA, Wissenschaftlich-Technische Arbeitsgemeinschaft für Bauwerkserhaltung und Denkmalpflege, 2004

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**Hertz, Kristian Dahl**

Review of differences of steel related properties between proposals of European structural codes ISBN : 87-7877-164-1. In: BYG Rapport ; r-099

**Holck, Ole ; Olsen, Lars ; Rode, Carsten**

Varmeisoleringsevne for ydervægge målt i Borup Seniorby. In: BYG Rapport ; R-095

**Knudsen, Søren**

Investigation and optimisation of heat storage tanks for low-flow SDHW systems ISBN : 87-7877-138-2. In: BYG Rapport ; r-075

**Kragh, Jesper ; Svendsen, Svend**

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**Löfgren, Ingemar ; Olesen, John Forbes ; Flansbjerg, Mathias**

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**Nielsen, Lauge Fuglsang**

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**Olufsen, Katrine Alling ; Foged, Niels Nielsen**

Boreability and Bit Wear in Siliceous Limestone and Flint in Malmö

**Pedersen, Anne Juul ; Ottosen, Lisbeth M. ; Simonsen, Peter ; Christensen, Terkel C.**

Elektrokemisk fjernelse af cadmium fra bioaske ISBN : 87-7877-167-6. In: BYG Rapport ; r-101

## Reports

**Richter, Anne ; Pedersen, Elsebet Frydendal**

Arbejdsulykker! Alle har en historie : om sikkerhedsstruktur og læring i tømrerbranchen.  
ISBN: 87-7877-154-4. In: BYG Rapport ; R-090

**Tommerup, Henrik M.**

Måling af bruttoenergiforbrug i nybyggeri svarende til BR2005 energikrav : Byggesystem: Fuldmuret ISBN : 87-7877-170-6. In: BYG rapport ; r-104

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**Tommerup, Henrik M.**

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**Tommerup, Henrik M.**

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**Tommerup, Henrik M. ; Rose, Jørgen**

Forsøgshus med nye typer klimaskærmskonstruktioner, fuldmuret : Del 1: konstruktioner/systemer ISBN : 87-7877-128-5. In: BYG Rapport ; R-070

**Weitzmann, Peter**

Modelling building integrated heating and cooling systems ISBN : 87-7877-155-2. In: BYG Rapport ; R-091

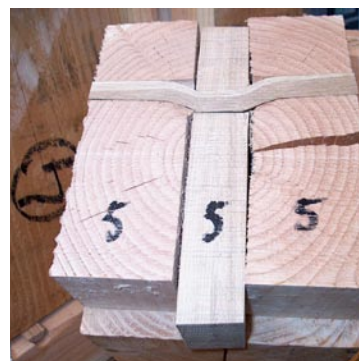
**Østergaard, Lennart**

Early-age fracture mechanics and cracking of concrete. experiments and modelling ISBN : 87-7877-133-1. In: BYG Rapport ; R-070

## M.Sc. projects (Civilingeniør)

Student	Project title	Supervisor
Alistarabadi Jamal	High rise building	Johnsen Finn
Andersen Karin Dyhr	Advanced solar heatingssystem	Furbo Simon
Andreasen Michael J.	Experimental and numerical study of pin connections	Gimsing Niels J., Gath Jesper
Arifovic Fedja	Anchors in concrete and masonry	Nielsen, M.P.
Astrup Thomas	Stress concentrations in glulam beams subjected to varying load	Hoffmeyer Preben, Hansen Kurt Kielsgaard, Olesen John Forbes
Beck Patrick, Tvermose Henrik	Fire exposed carbon fibre reinforcement	Hertz Kristian
Bernth Peter H., Jensen Morten T.	Fracturemechanical modelling of reinforced concrete beams during cyclic load in pure bending	Poulsen Peter Noe, Olesen John Forbes
Buhelt Louise Munkholm	Friction between soil and steel	Krogsbøll Anette
Christensen Christian P.	Housing refurbishment	Engelmark Jesper
Christensen Christina	Determination of a convective heat transfer coefficient between a flame and timber construction	Sørensen Lars Schjøtt
Christiansen Anders P., Ellekjær Anders R.	Lateral torsional buckling stabilization	Nielsen Leif Otto, Agerskov Henning
Christophersen Morten	Geotechnical investigation in the Østersø region	Krogsbøll Anette, Foged Niels

Dam Anders Christian	Modernizing the material flow in the Danish construction business	Koch Christian
Dick-Nielsen Lars, Døssing Henrik	The influence of packings in bolted joints	Gath Jesper Olesen John Forbes
Dohn Jacob T.	Comparative analysis of the Danish and Swedish consulting engineering business in the field of construction	Bonke Sten
Elkjær Andreas, Riisgaard Benjamin	Development of blast resistant system for high rise buildings	Olesen John Forbes
Elsmark Morten	Utilization of marginal materials for road building	Geiker Mette
Frandsen Christian M., Jørgensen Stefan	Design of sports centre	Larsen Henning
Gjødvad Johan	Analysis of continues concrete box girder with different erection methods	Gimsing Niels J., Poulsen Peter Noe
Gynde Vibeke, Pedersen Nina	Bridge over Femernbælt	Svensson Eilif, Agerskov Henning
Hansen Anders R., Lund Andreas C.	The competition of housing development among the municipalities in the Øresund region – consequences for the town structure	Elle Morten, Nielsen Peter Hartoft
Hansen Morten Juel	Structural use of glass	Stang Henrik, Olesen John Forbes
Hansen Rikke K., Moesby Sabrina B.	Facilities Management and Public Privat Partnership	Elle Morten
Henriksen Rikke	Housing refurbishment	Engelmark Jesper, Agerskov Henning
Hermansen Jakob	Integrating facilities management information	Christensen Knud
Høgensen Erling, Soldalen Tobias	Combined suspension/beam bridge	Gimsing Nielsen, Poulsen Peter Noe
Isaksdottir Hlif	Rockmechanical studies of volcanic tephra and sand for a hydroelectric power station in Iceland	Foged Niels
Jensen Bruno	Building renovation with focus on mould	Rode Carsten, Thrane Ulf
Jensen Lina, Mortensen Trine	Management and working environment in the building site	Pedersen Elsebet Frydendal
Jacobsen Jan Rune	Complex resistivity logging for permafrost mapping	Baumgartner Francois
Johansen Jakob	Design of building structures	Larsen Henning
Kortegaard Peter C.	Electrodialytic removal of cadmium from wasteren water sludge	Ottosen Lisbeth
Lange Martin Haslund	Composite bridge deck plate with emphasis on the application of CRC and FRC	Olesen John Forbes, Gimsing Niels J
Larsen Anders	Road construction in areas with permafrost	Villumsen Arne
Larsen Signe S., Paulsen Belinda M. E.	Measurements and calculation of indoor climate and energy performance of single family house	Svendson, Svend





Lauridsen Mona Nygaard	Numerical procedures for perfect plastic modelling of timber connections	Clorius Christian O., Hoffmeyer Preben
Li Hongwei	CFD investigations on inlets for hot water tanks	Furbo Simon, Shah Louise J.
Madsen Tobias Thorup	Windows with improved energy performance	Svendsen Svend
Mahmudovski Sajet	Inside insulation of buildings with capillary active insulation	Rode Carsten, Hansen Kurt Kielsgaard
Meier Allan, Møller Henrik Stenholm	Point resistance of sheet pile walls	Fuglsang Leif
Møgelberg Stine Ørbæk	Public-private partnership	Koch Christian
Mølholm Christian, Varming Niels	Building integrated heating and cooling systems	Svendsen Svend
Niclasen Petur H.M.K.	Bridge over Haraldssund	Gimsing Niels J., Nielsen Leif O.
Nielsen Jakob Kinimod	Timber connections with screws in end grain	Hoffmeyer Preben, Riberholt Hilmer
Nygaard Sune	Assessment of methods for fire safety design	Thomsen Kim Roger
Pardo Daniel	FE-analysis of wind turbine blade sections	Stang Henrik
Pedersen Henrik Due	Laterally loaded piles and pile groups	Krogsbøll Anette, Foged Niels
Pedersen Ulrik E.	Wind loads on buildings and bridges	Nielsen M.P.
Siffusson Karl, Sigurdarson Fridjon	Partnering in construction	Bonke Sten
Stabell Sidsel	Classification and mechanical properties for construction in the Øresund region	Foged Niels
Sterregaard Morten	Solid wood	Jensen Aage Peter
Sørensen Martin Ulf	Officebuilding	Larsen Henning
Thorsen Peter S., Villumsen Casper	The influence of micro structure on properties of marble	Hansen Kurt Kielsgaard
Vestergaard Randi K.	Strenght of glass structures	Nielsen Leif Otto
Zatyko Judit	Solar radiation from Greenland	Furbo Simon, Andersen Elsa
Østby Tina M.	Urban development of harbour areas	Elle Morten

<b>Student</b>	<b>Project title</b>	<b>Supervisor</b>
Al-Naqqash Yusra Ali	Masonry	Thorsen, Torsten
Alsdorf, Morten, Christiansen Tommy	Double façade constructions	Christensen, Kaj, Svendsen, Svend
Andersen Janne, Jørgensen Rikke	Ventilation of canteens and kitchen in the E2 house	Petersen Børge Howald
Andersen Johnni, Kannevorff Jonas	Communication and coordination of a construction site	Koch Christian
Andersen, Marius, Øskan, Alan	Design and testing of vertical ground anchors	Fuglsang, Leif
Andersen Nikolaj, Christiansen, Johnny D.C.	Solid wood	Jensen, Aage Peter, Traberg, Søren
Astrup Kjartan	Diaphragm in structures	Kjærbye Per
Bach Morten, Jessen Ulrik	Comfort and indoor climate in the Royal Theatre	Pedersen Børge Howald
Bak Christian, Johansen Biran Howitz	Indoor environmental and low energy buildings	Christensen Kaj, Nielsen Toke Rammer
Berg Henrik J., Sørensen Anders Bak	Science of engineering and building materials	Thorsen Torsten
Bertelsen, Troels, Stenderup, Jacob	Building logistic	Christensen, Knud
Bille Rikke, Kinnberg Andreas	Science of materials	Thorsen Torsten
Christiansen Niels H., Tang Benne Korsholm	Structural design with vibration dampers	Nielsen, Leif Otto
Christensen, Laura, Lindberg, Thomas	Brickyard in Greenland	Gaardslev, Axel
Christensen, Peter Lund, Czuba, Dennis J.	Design of office building	Kjærbye, Per
Dalsgaard Simone H.	Energy savings in renovation of facades	Svendsen, Svend
Dietz, Christian	Standard houses in Denmark – a comparison of the building process and constructions	Engelmark, Jesper
Elverdam, Peter, Nielsen Christian T.	Design of pedestrian bridge	Jensen, Aage Peter
Emkjer Morten, Uglebjerg Ulrik	Science of materials	Thorsen Torsten
Fazliz, NIdzara, Samardzis, Maja	Steel connections	Jensen, Aage Peter
Finsen Ditte Møller, Maburi Susi	Flexible buildings	Kjærbye Per
Frankel Krista, Olsen Jannie Kristine	Solid wood – structures	Jensen Aage Peter, Kjærbye Per
Gawron, Sebrina E.	Lavenergihus i Grønland	Kjærbye, Per
Gharib HEnni, Nedelkowsky Saso	Industrial production concepts in construction	Bonke Sten, Engelmark Jesper
Hansen Anders D., Pedersen Jørgen B.	Up-grading of buildings	Kjærbye, Per

## B.Eng. projects (Diplomingeniør)



Hansen, Christian W.	Structural design	Kjærbye, Per
Hansen Lasse, Haraldsen Thomas	Energy performance and indoor climate of the new Royal Theatre	Petersen, Børge Howald
Hoffmann, Simon	Floors in solid wood	Jensen, Aage Peter
Holm Rasmus Wiboe, Jensen Henning Peer	Lateral stability of prestressed beams	Nielsen Mogens P.
Ilsøe Martin	Building f schools – planning, process, and functionality	Kristiansen Kristian
Isaksen Morten, Latif Mohamed A.	Evaluation of performance indicators in construction	Christensen Kaj
Jensen, Hans Færck, Madelung Thomas	Multy-storey buildings of wooden structures	Larsen, Henning
Jensen R. Møller, Johansen Christian R.	Design of industry house/main structure	Kjærbye Per
Josephsen Hjalti, Nielsen Danjal P.	Building structures	Larsen Henning
Kramer Martin, Sørensen Jan	Ventilation of office building in Vilnius	Pedersen Børge Howald
Lefecre, Claus, Nielsen Martin Daniel	Design of penthouse	Kjærbye, Per
Lyngsie Thor	Structure design of one-family house	Kjærbye, Per
Mortensen Brian, Mouritsen Ragnar	Ventilation of a tevision studio	Petersen, Børge Howald
Mortensen Katrine O., Nielsen Mia Fossing	Ventilated double envelope facades	Svendsen, Svend
Olesen Peter K.	Insulation of building services – optimization and design guideline	Svendsen, Svend, Christensen Kaj
Olsen Jesper Kühn	Comparative analyses of fire models	Thomsen Kim Roger
Pedersen, Allan G.	Ydervægskonstruktioner	Kjærbye, Per
Pedersen Dennis, Savic Sasha Aleksandar	Control tower	Kjærbye Per
Pedersen Frank H., Skibby Mik Sperling	Occasional accidents in the construction industry	Koch Christian
Rasmussen Kennet, Wilken Christian	Ruc extension	Kjærbye, Per
Vestergaard Tanja	Working environment an important piece in the day to day work on site	Pedersen Elsebet Frydendahl
Wittchen Nick	Time dependent properties for wood in tension perpendicular to grain	Clorius Christian O.
Wätzold Mette Louise	Urban planning in Vanløse	Elle Morten, Christensen Kirsten



## Key figures

### Staff pr 31. December

		2004	2003
VIP	Professor	11	12
	Associate Professor	44	45
	Assistant Professor	15	13
	Other VIP	4	2
	Ph.D.-students	40	42
	<b>Total</b>		<b>114</b>
TAP	Academic	10	10
	Clerical	12	12
	Technician	22	23
	Other TAP	4	4
	<b>Total</b>		<b>48</b>
<b>Total department staff</b>		<b>162</b>	<b>163</b>

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### Education

		2004	2003
STÅ <sup>1</sup> - total		519	469
Projects	PMP/B.Sc. (midterm)	56	25
	M.Sc. (civil)	74	60
	B.Eng. (diplom)	82	73
Admission	B.Eng. (Civil engineering) - summer	58	88
	B.Eng. (Civil engineering) - winter	32	32
	B.Eng. (Architectural Engineering)	42	49
	B.Eng. (Arctic Technology)	8	12
	B.Sc. (Building Technology)	60	60

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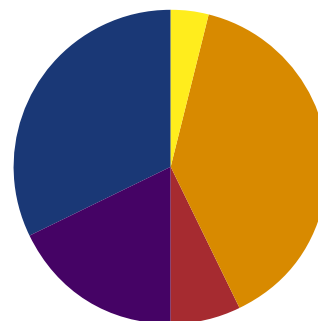
<sup>1</sup> 1 STÅ is one students annual work (1 STÅ=60 points/student)

## Research

		2004	2003
Refereed papers	Total	63	44
	Of these in ISI	37	n.a.
Ph.D.		10	7

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## Expenditures distributed by activities



## Finances in 1.000 DKK

		2004	2003
Revenues	DTU-grant	52.531	51.189
	External revenue	28.563	26.191
	<b>Total</b>	<b>81.094</b>	<b>77.380</b>
Expenditures	Wages	62.917	61.927
	Other expenses	16.445	14.688
	<b>Total</b>	<b>79.362</b>	<b>76.615</b>

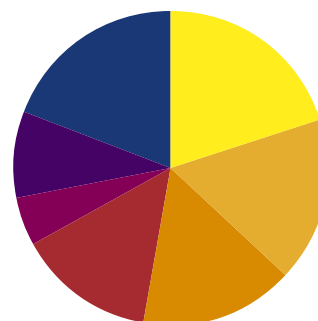
Innovation	4 %
Education	39 %
Ph. D. scholarships	7 %
Faculty Research	18 %
External financed research	32 %

## Result

		2004	2003
Available amount carried forward:	January 1	4.532	3.767
	December 31	6.264	4.532

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## External revenue



Private foundations	20 %
EU research programmes	17 %
Danish Research Agency	16 %
Energy research programmes	14 %
Work environment programmes	5 %
Other ministerial programmes	9 %
Others	19 %

**BYG•DTU**  
**Annual Report 2004**

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Hansen, Jesper Ole Jensen, Kristian  
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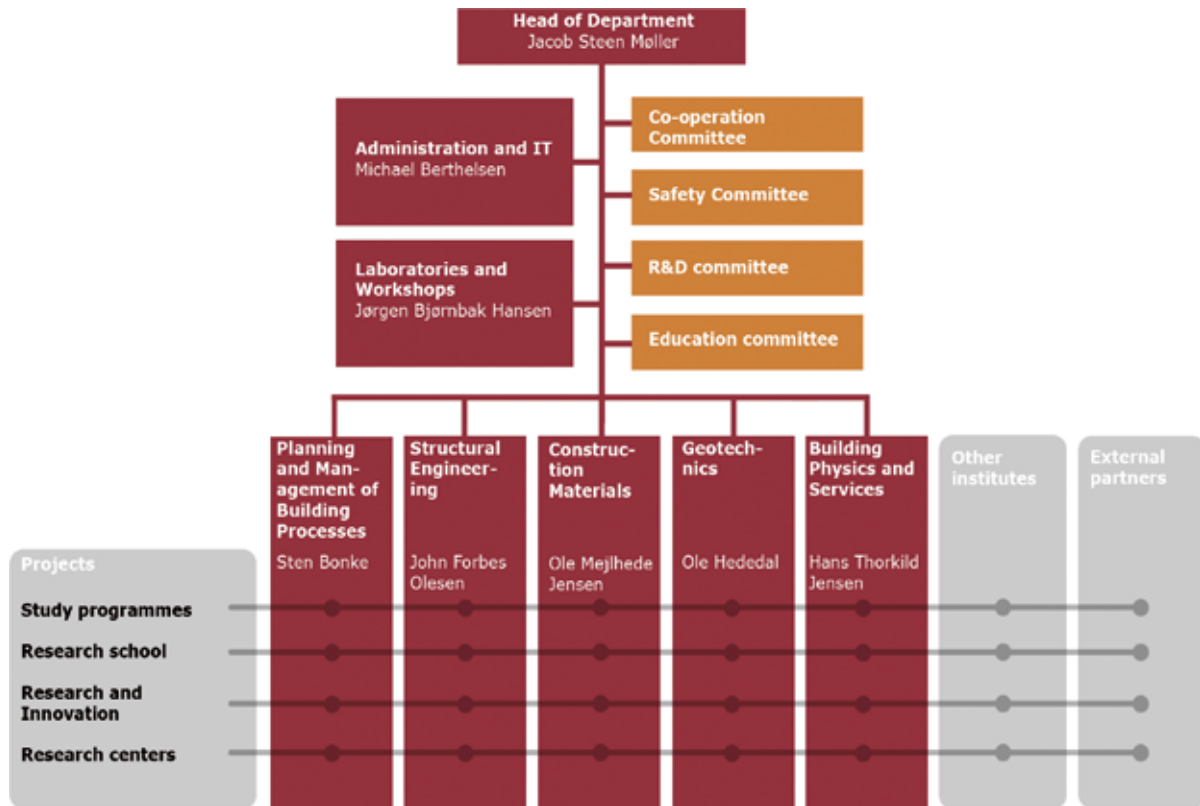
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# Organisation



## Study Programmes and Programme managers:

- Civil Engineer (B.Eng.). Associate professor Ole Mærsk-Møller.
- Architectural Engineering (B.Eng.). Associate professor Kirsten Christensen.
- Building Technology (B.Sc.). Professor Henrik Stang.
- Arctic Technology (B.Eng). In Greenland, Associate professor Egil Borchersen. In Denmark, Associate professor Ole Mærsk-Møller.
- Civil Engineer (M.Sc.). Associate professor Kristian Hertz.

## Department of Civil Engineering hosts the following centers:

- IRS@BYG, The International Research School for Civil Engineering. Professor Stephen Emmitt.
- ARTEK, Arctic Technology Centre. Professor Arne Villumsen.
- C•PROSAM, Centre for Protective Structures and Materials. M.Sc. Civil Engineer Benjamin Riisgaard.

## The Advisory Board:

- Executive director Mette Lis Andersen, Københavns Kommunes Bygge- og Teknikforvaltning
- Development director Thomas Heldgaard, Rockwool A/S
- Executive director Peter Lundhus, Femern Bælt A/S - Sund og Bælt Partner A/S
- Executive director Klaus H. Ostenfeld, COWI A/S
- Senior advisor Jørgen Vorsholt, E. Pihl & Søn A.S

## From the Head of Department

**The Department of Civil Engineering, BYG•DTU, unites the technical disciplines, which are applied in the building design, construction and operation process.**

The Department focuses on: Planning and Management of Building Processes, Structural Engineering, Construction Materials, Geotechnics, and Building Physics and Services. In 2005 a section was established for each focus area. The Department has further strengthened these areas through strategic recruitment, renewal of laboratories and further development of the research organization and yearly planning cycle.

As part of the fundamental reorganization and strategy renewal that took place in 2002-03 BYG•DTU was the first Department at DTU to establish an external Advisory Board. In 2005 DTU's new by-laws were approved, and now Advisory Boards are established at all DTU Departments. Research, Education and Innovation in Civil Engineering at a technical university thrives on close collaboration with industry. Thus the headline for BYG•DTU in 2005 has been a further development of the strong relations with industry partners.

### Education

In 2004 DTU adopted the Bologna Declaration on the European Space for Higher Education, thus all the Department's Civil and Architectural Engineering education programs were revised during 2005 and now follow the Bachelor/Master structure. The revision is based on new competence descriptions, which were developed in dialogue with industry partners and employers.

A new Department Study Board (studienævn) was elected and Study Program Managers (ud-

dannelsesledere) were appointed. The Program Managers have a leading role in the ongoing development of the study programs.

Civil and Architectural Engineering are attractive fields for future students. In 2005 we experienced a general increase in admission to all our education programs (see key figures).

The Department employs a large number of external associate professors with their primary employment in industry, and we have reorganized the practical engineering training program (see feature article).

### Research

There is a strong need for research based innovation in the building sector. BYG•DTU aims at supporting this via basic research and industry collaboration.

In spite of the large exchange in staff and very large teaching load BYG•DTU researchers published 61 peer reviewed scientific papers in 2005. This is a consolidation compared to 2004 and in accordance with the planned output.

BYG•DTU together with the Danish Building Research institute (SBI) and Technological Institute (TI) manages the Danish section of European Construction Technology Platform (ECTP). The ECTP-Denmark maintains a network of 30 companies and institutions. The network has interacted with the Danish Research Foundations and EU in discussions on future priority areas.

The International Research School for Civil Engineering, IRS@BYG, was successful in attracting funds from the Ministry of Research and a number of Ph.D. projects with industry started. In general, the recruitment of industry funded Ph.D.s has been satisfactory.



Head of Department  
MSc (Civil Engineering) Jacob  
Steen Møller

The Research School has established an agreement with RILEM (International Union of Laboratories and Experts in Construction Materials, Systems, and Structures) through which our PhD courses are advertised and endorsed. The international perspective will be further expanded via two new Marie Curie programs in cement based materials and solar heating.

Two conferences were conducted by the Department: The Knud Højgaard Conference on Advanced Cement-based Materials – Research and Teaching, and the CIBW096 (International Council for Building, Work Group 96) Conference on Architectural Management.

### Innovation

Innovation at BYG•DTU comprises activities directed towards direct economic value generation together with external partners. This is done through patenting, collaborative research and networks, commercial testing and consultancy, and continued education programs.

In 2005 BYG•DTU researchers registered two proposals for patenting with DTU's patent office. A business plan is currently being developed for one patent; however, commercialization of ideas has been hampered due to lack

of funds for establishing proof of concept prototypes and tests.

Via ECTP-Denmark BYG•DTU initiated and is now leading a high tech network on integrated low energy solutions for the building sector supported by Danish national research grants (Højteknologisk Netværk for Integreerede Lavenergiløsninger på Bygningsområdet). The network includes nearly all major players in Denmark in the field of energy and buildings.

The continued education programs include the Master in Fire Safety and the Master in Management in Construction (see feature article). Both programs have run repeatedly and a stable future admission is forecasted.

### **Staff development**

The generational change continued in 2005 and resulted in a significant strengthening of the scientific groups.

Three faculty professors were employed within structural engineering: Björn Täljsten (Structural Performance), Jeppe Jönsson (Design of Civil Engineering Structures), and Henrik Stang (Integrated Structural and Materials Modelling)

In addition, Facilities Management, Architectural Engineering, Building Services and Concrete Research were strengthened through strategic recruitment of new faculty.

### **Technical Resources**

The Department has completed a full renewal of the laboratories for construction materials and a number of much needed investments in process ventilation and building adjustments for the structural and building services laboratory.

There exists a large need for investments in laboratory renewal and equipment. The basic DTU

grant cannot sustain the large stock of equipment needed to maintain the experimentally based research and education, thus the Department continuously is seeking external grants.

In 2005 BYG•DTU together with the Department of Mechanical Engineering was successful in attracting major grants for advanced photo-grammetry equipment for deformation monitoring.

### **Outlook**

The steadily increasing internationalization of education and research is the most important challenge for BYG•DTU, thus the Department will give priority to international activities within Education, Research and Innovation.

In education a major challenge is to establish attractive international opportunities for student exchange. In research we must become further integrated in the international community through staff exchange, international research projects and PhD education. In innovation our activities should be expanded with international partners.

A recent report on globalization from the Danish Government states that major increases in public research funding will be established over the coming few years. It remains to be seen to what degree these funds will be available for civil engineering research, and if the building industry is willing to establish matching funding.

In any case BYG•DTU is well prepared. Civil Engineering is about creating.

## First Candidate in Arctic Technology

### The first Bachelor of Engineering in Arctic Technology graduated in June 2005

Now four years after start in Sisimiut, Greenland of the B.Eng. Education in Arctic Technology, the primary objective, graduation of bachelors from Greenland, was achieved. Each year 7-8 students from Greenland and 2-4 students from Denmark start in Sisimiut. Until now 52 students have been enrolled, and 35 are still active.

### Greenland/Denmark

The education is unusual compared to other B.Eng. educations at DTU. The first 3 terms take place in Greenland, at the Building and Construction School in Sisimiut. Teachers from DTU are travelling to Sisimiut and are lecturing 2-week courses. The fourth and fifth terms are at DTU in Lyngby, and after that parts may take place somewhere in Arctic or at DTU. The prescribed period of study is 4 years, six months more than the ordinary B.Eng. studies at DTU. The extra time is used for specialization on different arctic subjects.

The education is a combination of the regular civil engineering courses with a dedicated arctic approach. The Arctic is unusual in a lot of ways. One is the ground. Foundations or roadbeds in areas with permafrost may be destroyed due to thawing and freezing parts of the soil. This is just one of the many challenges the new Arctic engineers will be equipped to handle.

### The very first Arctic candidate

Ujarak Rosing Petersen became the first candidate in Arctic Technology graduated as B.Eng. The examination took place 24th of June in the Arctic Technology Centre in Lyngby. Ujarak defined the style for the new education with the grade 10 for his final thesis "Waterpower in Tasersuaq". He started at his new job in Inuplan, a leading consulting engineering firm in Greenland, just weeks after he received his diploma.



Dean of Studies Gunnar Mohr congratulates Ujarak with his new degree



Arctic Technology students in front of the place of their studies in Greenland, the The Building & Construction School in Sisimiut

## First Graduates from the Master Programme in Construction Management

### To become a master

The Master Programme in Construction Management is a postgraduate programme. It started in January 2003 with 15 participants coming from all sides of the construction industry: contractors, architectural firms, client organisations, local municipalities, technical schools and consulting engineers with equally varied educational backgrounds: engineers, architects, constructing architects and social sciences.

To qualify, at least 2 years of working experience is needed. The programme is half time or less. The participants continue working full time in their normal jobs.

Total study time is 60 ects points. The final dissertation is 15 points, and 45 points are covered by nine courses in:

- Trends in Construction Industry
- Innovation in Construction

- User orientation in Construction
- Change management
- Project management
- Project economy
- Facilities Management
- Partnering
- Lean Construction

Throughout the four semesters a wide range of international lecturers and prominent individuals from the Danish building industry have been giving guest lectures. The first graduates have among others experienced: professor Graham Winch, Manchester University, director John Olie, Joint Origin, Holland, professor Tore Haugen, Norway, professor Carl Haas, University of Texas, professor Stuart Green, Reading University and professor Lauri Koskela, Reading University.

The final dissertations from the first group of graduates covered a wide range of subjects such as: Lean Construction, Innovation

and Learning in Construction Industry, Risk management in Contracting, Value in Construction and Management of Complex, Technologically Advanced Projects in Construction.

### More than satisfied

The programme has been evaluated, and the participants express more than plain satisfaction. The integration of their practical insights acquired through many years of working experience with the more theoretical knowledge of their teachers has challenged them personally and professionally. A year after graduation the former participants say that they feel they have learned a lot and that the programme was a great experience. Some of the graduates have moved on to better jobs others feel that their jobs have been enriched.

The Master programme in Construction Management wishes to play its part in pushing the Danish construction industry towards excellence. With the first graduates of 2005 a first step has been taken.



Teachers and students from the graduation party for the new Masters in Construction Management

## Engineering Training in the B.Eng. Programme

### Focus on interplay with companies to ensure the best engineering training

To develop professional skills in the field of practical civil engineering the studies "diplom B" and "diplom" Architectural Engineering includes a semester of engineering training. This is a very exciting period for the students and has always been appreciated by the students and also by the companies. The course "Engineering Training" has been a part of the 3½ year of curriculum for B.Eng. in Civil Engineering in 40 years and this experience has been very useful in the development of our students. However BYG•DTU wants to play a more active role in creating a dialogue with the companies that employ a trainee. Furthermore BYG•DTU wants to keep a stable and growing network of companies that are keen to employ our students in their practice period.

### Elements of training

The core elements of a training period are as follow. It is the students who must find their own employment; however BYG•DTU

will announce all expressions of interests from contractors, consulting engineers, and architect firms or other companies and institutions working within the building sector. In the beginning of the trainee period, BYG•DTU organizes a half day meeting where the students present to each other their company and what they do. This is a very constructive day and the students inspire and support each other to be more responsible for their outcome of the trainee period. Later in the training period a teacher from BYG•DTU will visit the student and the company to discuss the status of the training period, the experiences so far, eventual problems, expectations and plans for the remaining period. These visits will have high priority in the future, because the face to face meeting is important to create a common understanding of how to make the best out of this training period for this student in this company. At these meetings the BYG-teacher will also gain knowledge about the company and their interest in trainee employment. This

can help us improve our way of organizing engineer training and build long term relations with the company. Possible side effects are the personal connections which can lead to other collaborations within teaching, research and innovation.

### The future

So far our experience is that some companies would also like to share experiences with others in the same situation on how to create a good practice period. This is why we plan to expand our trainee activities with meetings for the company contact persons and the teachers from BYG•DTU to exchange experiences, view-points and possible actions in order to ensure the best practice periods.



Assistant Professor Susanne Balslev Nielsen from the section for Planning and Management of Building Processes is the new coordinator for BYG•DTU's trainee service.

In 2005 116 students took part in the programme. The largest group of students were taken by building contractor, consulting engineering companies and architectural companies.

A trainee session last 20 weeks and starts either at the 1st of February or the 1st of August.



One of this years students in Engineering Training

# International Research School for Civil Engineering at BYG•DTU

## A Home for the PhD students to grow and achieve

The proposal to establish a PhD School was submitted and approved by DTU in the autumn of 2004. The International Research School for Civil Engineering at BYG•DTU (IRS@BYG) was then formed on the 1st January 2005 to provide a home for the Department's PhD students.

We created this PhD School to help facilitate knowledge transfer and share best practice within a dynamic, friendly and student centred environment.

IRS@BYG is here to offer and arrange a variety of activities to help, assist and enhance the research experience of the PhD students. These activities range from, for example, presentations to industry and research communities through to periods of study as visiting researchers in other countries. Activities are supported by modern facilities, including state of the art laboratories and well equipped offices.

The primary aim is to provide a stimulating PhD environment that helps you to achieve world class

scientific research and disseminate your findings effectively.

The school has an international approach to teaching and research and welcome students of all nationalities to experience the high quality research environment.

## What we do

PhD projects are centred on (but not exclusive to) a number of focus research areas. These are:

- Building physics and services
- Construction Materials
- Geotechnics
- Planning and management of building processes
- Structural engineering

The working language for the management of the International Research School for Civil Engineering at BYG•DTU is English. Students may choose to write their doctoral thesis in Danish or in English.

Individual activities (such as PhD courses, research projects etc.) are organised and managed by academics within the Department. These individual activities are

co-ordinated by the International Research School for Civil Engineering at BYG•DTU.

## The PhD Day

Part of the stimulating environment is gained by having established a tradition - the PhD Day where students presents their work to their peers and industry/academic partners. The PhD day is organised by our doctoral students and has proved to be a popular and rewarding event, both for the students presenting their work and for those who come to listen and participate in the debate.

The PhD day is held twice a year, thus all PhD students will have the opportunity to present their work at least once during their studies. Visiting PhD students are also invited to talk about their work during their stay in the Department.



A group of PhD students in one of the open offices



Professor Stephen Emmitt from the section for Planning and Management of Building Processes is the coordinator at The International Research School for Civil Engineering at BYG•DTU.

At the end of 2005 40 PhD students were registered under the IRS@BYG. Two PhD days were held and 10 students successful completed their PhD.

## Removal of Salt and Water from Masonry

### Rising dampness in brick masonry is a large problem in Denmark due to increasing moisture and salt concentrations in the walls.

According to "The Building Damage Fund" rising dampness is among the 10 most frequent damages in connection to building repair.

At present, two groups of methods are used to preventing rising dampness: mechanical methods and injection. The principle of both is to prevent rising dampness with a horizontal damp-proof layer. In the mechanical methods a layer of typically steel is placed in joints and in the injection methods the damp-proof layer is obtained chemically by filling water-proof material in holes and this material must distribute from the holes to the area between them by capillary transport to obtain the damp-proof layer.

### A new electrochemical method developed

In this method an electric DC field is applied to the masonry wall, and in the electric field it is possible to control both water and ion movement within the masonry. Thus both water and salt removal can be obtained. The method has several advantages; primarily no holes are made in the masonry since the electrodes are placed on the surface and further the removal of salts decreases the hygroscopic moisture content, and the risk for salt-induced decay is eliminated.

In laboratory



The electrodes in the pilot-plants have been constructed as cheap and simple as

scale very promising results have been obtained with the electrochemical method. Water has been removed from water saturated bricks to a water content of about 1%. Salts such as NaCl and Ca(NO<sub>3</sub>)<sub>2</sub> have been removed from concentrations that according to the Austrian ÖNORM B3355-1 (there is no Danish norm) were so high that active salt removal is advised, to concentrations where there is no risk from the salts.

Pilot scale experiments have been initiated at two places in older buildings. One pilot scale experiment is placed outdoors at Kavalergården, Bernstorff Castle and the other is placed indoor in a private basement. In the basement the primary goal is drying of the masonry whereas both water and salt removal is in focus at Kavalergården. The concentration of salts is very high in the latter and the masonry appears wet due to the high hygroscopic moisture content. In this case the problem could not be solved with a horizontal damp-proof layer, which would not remove the salts.

In both of the pilot plants, the electrodes are placed on the same side of the masonry. This is an advantage in e.g. situations with cavity wall or in situations with salt induced decay. Another possibility could be to place the positive electrodes indoor and the negative electrodes outdoor (the water moves from the positive electrode towards the negative). However, such an electrode arrangement has not been tested yet.

possible. They consist of a bar of reinforcement steel placed in a layer of carbonate rich clay. When the electric field is applied to the steel it is important that the products from the processes occurring at the surface of the electrodes cannot enter the masonry, and this is prohibited by the clay.

Both pilot-plants are running at present, and the preliminary results have been very promising. In the basement water has been collected underneath the negative electrode, and at Kavalergården very high salt concentrations have been found in the clay around the electrodes showing efficient salt removal. Further the outdoor pilot plant has been running during January and February at temperatures below 0°C without any problems.



Associate professor Lisbeth M. Ottosen is conducting her research in the section for Construction Materials.

This section is the base for BYG-DTU's activities in the fields of construction materials, with vital importance to the function and performance of structures. The area has its strong professional tradition and identity and it is through the interaction with the other professional areas in BYG-DTU the importance of construction materials becomes clear.

## Smart Windows

### Smart windows, second generation liquid crystal glazings – where nanotechnology meets fenestration

Push a button and your glazing switches from transparent to reflective or translucent. So thanks to applied nanotechnology in glazings, you can dumb your curtains and Venetian blinds.

Ordinary windows and glazings have constant optical proper-

ties, whereas so-called smart or dynamic windows can switch between three optical modes:

- 1) a reflective mode limiting the overheating
- 2) a transparent mode with an excellent transparency
- 3) a scattering mode with translucency.

Smart windows can be widely applied within the building field and e.g. the automotive one. These new glazing components are very interesting due to the fact that they soon can be manufactured with controllable daylight and solar energy transmittances. Hereby, the quality of life can be improved as well as the energy consumption for lighting, heating and cooling can be reduced even further.

Liquid crystal (LC) glazings are available on the market today, e.g. Priva-Lite from Saint Gobain. These glazings can switch from translucent to transparent when a small electric current is applied. When the current is cut off, the glazing switches back to translucent. However, these glazings are the first generation LC glazings, and the solar and daylight modulations are negligible. The second generation LC glazings

**Top)** A SmartWin II prototype without voltage, i.e. in reflective mode.

**Middle)** The active area is divided into five sections, which can be controlled individually. Only the stripe in the middle has an applied voltage and hence it is transparent.

**Bottom)** The opposite situation of the previous image; only the stripe in the middle is without voltage.

can switch fast between three different modes and with high modulations regarding daylight and solar energy, and thus solar shading with no mechanically moving parts are obtained.

BYG.DTU was manager of an EU FP5, EESD project: New Liquid Crystal SmartWindow and Its Production Process – SmartWin II – contract ENK6-CT-2001-00549, which was finished in 2005. Within this project, second generation LC glazings, which only require a voltage or a voltage pulse for switching between the three modes, were developed. Furthermore, pre-industrial manufacturing methods and equipment were developed for technical glazing prototypes up to a size of 1 m<sup>2</sup>.



Associate professor Karsten Ingerslev Jensen is conducting his research in the section for Building Physics and Services.

This section takes a holistic approach to the building envelope and installations as the basis for creating buildings with a good indoor climate and low energy consumption. It deals with the technical, social and environmental problems that require a development towards sustainable building design based on energy conservation and sustainable energy systems.

## Learning from Failures in Construction Operations

### Better coordination between the parties in construction can save billions

Poor quality has been a long-term feature and debate in Danish construction. Especially the final quality vis-à-vis the client has been in focus. The last wave of reforms from the state as a response to this commenced in 2000, but still in 2006 failures cost the industry and its clients paramount sums.

An empirical study of failures and their causes has been carried out by researchers at the Section for Planning and Management of Building Processes. The observation period was three months covering the assembly phase.

### Failures broken down in percent

In each case the analyses showed a mixture of causes, and it was not possible to assign single causes to the single cases. More specifically, 14 % of the failures had exclusively distal causes, and 19 % exclusively proximal causes, whereas 67% had mixtures of those. In the vast majority of our cases a series of "subsequent" actors as well as one originator were involved in the generation of the failure on the site. It was found that 56% of the failures were predictable on the basis of existing knowledge on the site.



A coordination failure between the HWS team and the architect led to the installation of radiators not fitting the previous made holes. This resulted in a lot of rework.

There is thus a large room for improvement.

Of the total failures the organisational causes were the most prevalent. Of the organisational the following causes scored the highest: Problems with communication and cooperation 61%, design activities 45%, production planning and control 42%, project review meetings 36%, production work 34%, process and product control 29%, weather and theft 20%, and access to skilled workforce 15%. Although organisational factors played the most important role, we found failures related to all kinds of interaction between the actors in the project. It involves formal organisational elements such as meetings as well as informal interaction. Communication and cooperation are central activities in a multi-actor project, and speculatively it could be added, that the found level of problems is less alarming since it should be compared to the amount of communication and cooperation carried out in the project.

Apart from the organisational factors, the analysis covered technological and individual factors as well. The technological failures relate to 37% of the observed failures. They relate to issues like purchasing of material, equipment, which had not been properly cleaned, and features of the product like a too broad plinth. The individual factors were found at 40% of the failures. They relate to competence (24%), erroneous acts (18%), avoided acts (11%), and hindrance due to limited resources (53%). Indirectly, it follows from these figures

that focusing on the individual would have less impact in terms of improvement.

After the failures occurred the actors put various measures in place to repair the damage, and the analysis shows that only 7-8% of the failures affected the final quality. The consequences and costs involved thus relate to man-hours and materials used to obtain an acceptable final result. The losers in this game are the participating companies who obtain less surplus.

### Cost equal 8%

The total amount of observed failures in the study was 160. This equals to a calculated cost of 80.800 euro and 8% of the production costs. The study has shown that the main focus on improvements can be on operational quality, developing procedures that prevent reworking and thus bring down this amount.



Associate professor Christian Koch is conducting his research in the Section for Planning and Management of Building Processes.

This section has as its prime goal through research and education to contribute to the transition of the building industry from a reactive, problem-strained state towards an innovative and customer oriented production field.

# Modelling of Reinforced Concrete applying Fracture Mechanics – XFEM

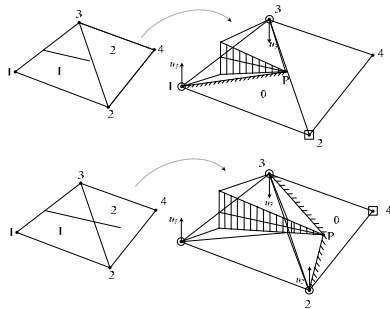
**Throughout the last century intense research has been carried out regarding methods to determine the ultimate strength of reinforced concrete structures. We are now moving further and deeper.**

Today, methods for estimating the ultimate strength of most reinforced concrete structures are well documented. Most of these methods, however, require the use of empirical factors and do not consider phenomena such as size effects and reinforcement arrangement in a fully consistent way.

The predictive capability of the existing methods of analysis is limited for reinforced concrete structures in the serviceability limit state. Complete models for this state require prediction of the complex cracking, which takes place in the concrete during loading.

## Understanding cracks

Modelling of cracks in concrete has been a focus area in the research community since the mid seventies. Detailed information about cracking and crack propagation is particularly important



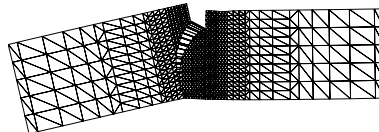
Propagation of a crack across an element boundary. Upper figures illustrate situations just before the crack reaches the element boundary, while the lower figures illustrate the case where a crack continues into a new element.

with respect to durability and service life prediction.

An optimal designed reinforced concrete structure relies heavily on extended knowledge of the complex mechanical interaction between concrete and reinforcement and on methods for modelling reinforced concrete structures in serviceability state.

Today, several commercial Finite Element Method (FEM) codes have interface elements suitable for concrete cracking and discrete elements for smeared cracking based on the concept of a crack band. The use of interface elements for crack modelling, however, requires the crack path to be known beforehand, while crack modelling applying the smeared approach is not well suited for modelling of localized crack growth.

One of the promising new approaches for modelling of localized crack growth within the framework of finite elements is the eXtended Finite Element Method also now as XFEM. In XFEM the traditional continuous displacement field of an element is enriched with a discontinuous displacement field allowing a crack to develop within the interior of the element.

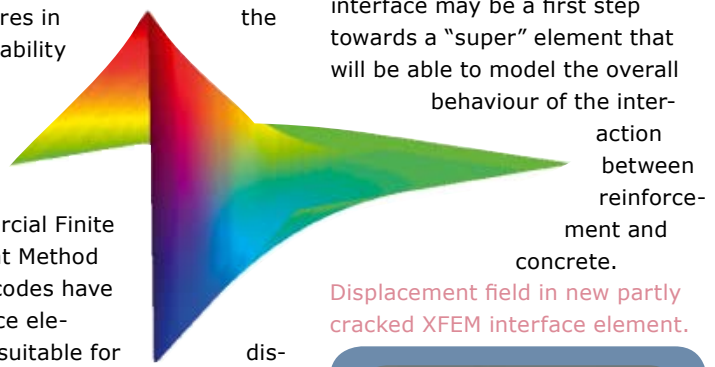


Crack propagation in four point shear beam modelled applying XFEM.

## XFEM at BYG•DTU

So far at BYG•DTU new XFEM elements have been developed for modelling of crack propagation in the bulk concrete, and good results have been obtained applying those elements. More lately, work has been carried out in the development of a new interface element suitable for modelling of the bond zone between reinforcement and concrete. The XFEM interface may be a first step towards a “super” element that will be able to model the overall behaviour of the interaction between reinforcement and concrete.

Displacement field in new partly cracked XFEM interface element.



PhD student Jesper L. Asferg is conducting his research in the section for Structural Engineering.

The field covers the overall design of the structure and particular design aspects including the demonstration of strength, durability, etc. with regard to the loads and effects on the structure from, e.g. climate, wear and breakdown processes. It is central to the technical sciences of civil engineering in general, and they are primarily based on the fundamental sciences of mechanics and physics.

## Research Geotechnics

### A proper foundation for a large farm of offshore wind turbines

BYG•DTU has recently started a PhD project sponsored by the Danish Research Council on "Modelling of laterally loaded pile in sand subject to cyclic loading", where models of piles will be tested in the geotechnical centrifuge at BYG•DTU – the only facility of its kind in Scandinavia.

Centrifuge testing is a physical modelling technique that is well-suited for doing scale models of geotechnical structures. The properties of soil are in general dependent on the actual stress level. Therefore, if it is necessary to perform realistic tests on a geotechnical structure, there will often only be two options: Full scale testing or scale testing in a centrifuge. Since geotechnical structures are often very large, full scale testing is complex, tedious and - most importantly - very costly.

In the geotechnical centrifuge we are able to scale the model. The correct stress level is obtained by increasing the gravity, meaning that length is equally scaled. Hereby a 30 m long pile may be reduced to 30 cm in case the centrifuge can generate a gravitational acceleration of 100g. Such models are evidently much

easier to handle and less complex, hence also less costly.

Centrifuge modelling is a means to gain insight into the soil-structure interaction of geotechnical structures under well-controlled conditions. The method thereby provides a valuable input to the development of other types of models – theoretical or numerical - since it may reveal important mechanisms that need to be incorporated in the theoretical or numerical model.

### From small to large scale

The current PhD study on laterally loaded piles is motivated by the need for establishment of large offshore wind farms with wind turbines founded on single large diameter piles – monopiles. The industry has recognized the importance of understanding the long term effect of cyclic loading on such foundations. The aim of the project is therefore to provide better understanding of the performance of piles subjected to cyclic loading. The PhD project involves aspects on sample preparation, verification of specimen properties, analysis of pile loaded in one and two horizontal directions with cyclic loads.

At present, we are redesigning existing equipment and controls for the sample preparation and two-directional loading of the pile.

Initial tests showing very promising results have been made with respect to standardisation of preparation method for sand specimen and verification by use of a small scale cone penetrometer.



Pictures from test in centrifuge with small scale Cone Penetrometer.



PhD student Caspar Thrane Leth is conducting his research in the section for Geotechnics.

This section deals with the foundation of structures. The foundation of a structure is determining for its load bearing capacity and hereby a central element in the load-bearing construction. Furthermore, the deformation of the foundation is a key element in the total performance of the structure. The area covers rock and soil properties as well as the shape and size of the foundation, its load-bearing capacity and deformation during daily use.



Beam centrifuge at BYG•DTU

## Low Energy House in Sisimiut, Greenland

**In April 2005 BYG•DTU and Centre for Arctic Technology inaugurated a new low-energy house in Sisimiut, Greenland.**

The low-energy house in Sisimiut is designed to test and demonstrated state of the art low-energy technology in an arctic climate with the purpose of inspiring a general development of sustainable buildings in Greenland.



Floor plan of the low-energy house

Building the house became a reality with a generous donation from the Villum Kann Rasmussen Foundation of 5 million DKK. The Municipality of Sisimiut provided the serviced building plot.

In connection with this donation it was an objective, that the project should involve as much Greenlandic labour as possible. Therefore Rambøll Greenland was selected as principal consultant and has had the job of tendering among local contractors to carry out the turnkey contract. A local contractor, Arctic Sanasut ApS, was chosen, and they have built the house to great satisfaction.

Sisimiut is located just north of the Polar Circle and has mean average temperatures of around 5 to 6° C in the summer and -10 to -15° C in the winter months.

### Low energy?

The definition of a low-energy house is that the house consumes only half the energy permitted in the building code, which for this project has been understood as the requirements of the coming building code of Greenland. Thus, the objective was to build a house with an annual energy consumption for heating of not more than

80 kWh/m<sup>2</sup>.

The house is approximately 200 m<sup>2</sup> and is built as a double house with common boiler room and entrance hall.

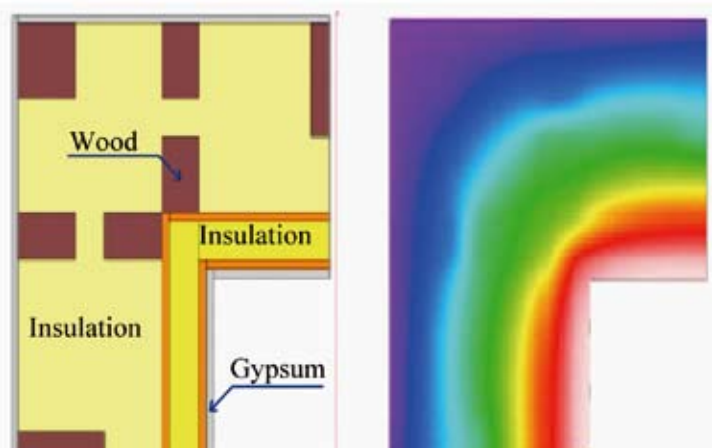
The means to reduce the energy consumption in

comparison with common Greenlandic houses has been to use extra insulation in exterior walls (300 mm) and in the floor and roof (350 mm). The house has a ventilation system with a heat

exchanger with an efficiency of 90% that uses the warm exhaust air to heat up the cold inlet air. Furthermore, improved windows are installed with low energy glazing using 3 layers of glass. A solar collector is installed on the roof to heat water for domestic use. In addition, the house is orientated to exploit the light, and it has a geometry which optimizes the daylight.

Many of the chosen solutions have required new developments or use of technologies not applied to date in Greenland. For instance the heat recovery system had to be constructed with intermittent changing of the pathways for the air flows so that blockage of the ducts by freezing of the humid exhaust air could be prevented. This solution was developed and tested first in the laboratories of BYG•DTU. Another solution, which until now has not been used in Greenland, is the heating of the house by a floor heating system.

The heat loss due to thermal transmittance through the building envelope constructions is reduced by use of increased insulation thickness and wood profiles with minimum thermal bridge effect.



Heat loss: Simulation model of the outer wall corner. To the right a temperature plot

**Solar collectors**

The solar panels installed on the low-energy house are flat plate collectors which are oriented south-east and tilted 70° from horizontal to have the optimal



The solar collectors on the low-energy house

position in relation to the sun. The solar collectors have a total surface area of 8 m<sup>2</sup> and the system is able to produce around 1,600 kWh/year. This covers more than 60 % of the hot water consumption of the house.

**The windows**

Three types of glazing units are tested in the low-energy house. Sealed units comprise two or three layers of glass with either vacuum in between or with a gas-filling of argon or krypton. In the case of double-layered sealed units, a third layer of glass with low emission coating completes the window.

**Moisture conditions**

The outdoor air in Greenland is generally very dry because it is so cold that the air is unable to hold much moisture. However, because of high indoor humidity production and minimal ventilation (to avoid draft), it is not unlikely to see moisture problems in Greenlandic homes. It has been important to demonstrate that it was possible to construct a low-energy house without moisture problems in the indoor air or in the constructions. Therefore, the house has been instrumented with a number of humidity sen-

sors positioned in potential critical places. The sensors have not shown any gravely high moisture levels, and the building has continually dried out even more since it was created.

**Measurements of energy performance**

The house is equipped with energy-meters, which are available for on-line viewing on the Internet. The data can be found on the address: <http://www.energyguard.dk/> (Brugernavn = DTU & Password = sisimiut).

The energy consumption for space heating during the first year of operation of the house has been around 28,000 kWh. This is not quite as low as anticipated but still less than the permitted consumption according to the coming Greenlandic building code. The extra energy consumption can partly be explained by necessary tuning of the advanced systems during the first year, and by the fact that the indoor temperature has been slightly warmer than assumed.

**Closure and follow-up**

In connection with the inauguration ceremony in April 2005 an international symposium was held in Sisimiut about low-energy buildings in arctic climates. Proceedings from this symposium can be found on the homepage for the low-energy house: <http://www.arktiskcenter.gl/Artek-Lowenergy/>. It is anticipated that the symposium along with the house itself will serve as good inspiration for future developments of sustainable buildings in arctic climates, and in Greenland in particular. The achievements of the house will help Greenlandic legislators, local builders and the Building and Construction School of Sisimiut to set new standards for achievable low-energy solutions in buildings in cold climates.

The low-energy house is now inhabited by a Greenlandic family. The performance of the house will be followed and reported by researchers and students from BYG•DTU and Centre for Arctic Technology for a five year period.



The inauguration of the Low Energy House in Sisimiut in April 2005

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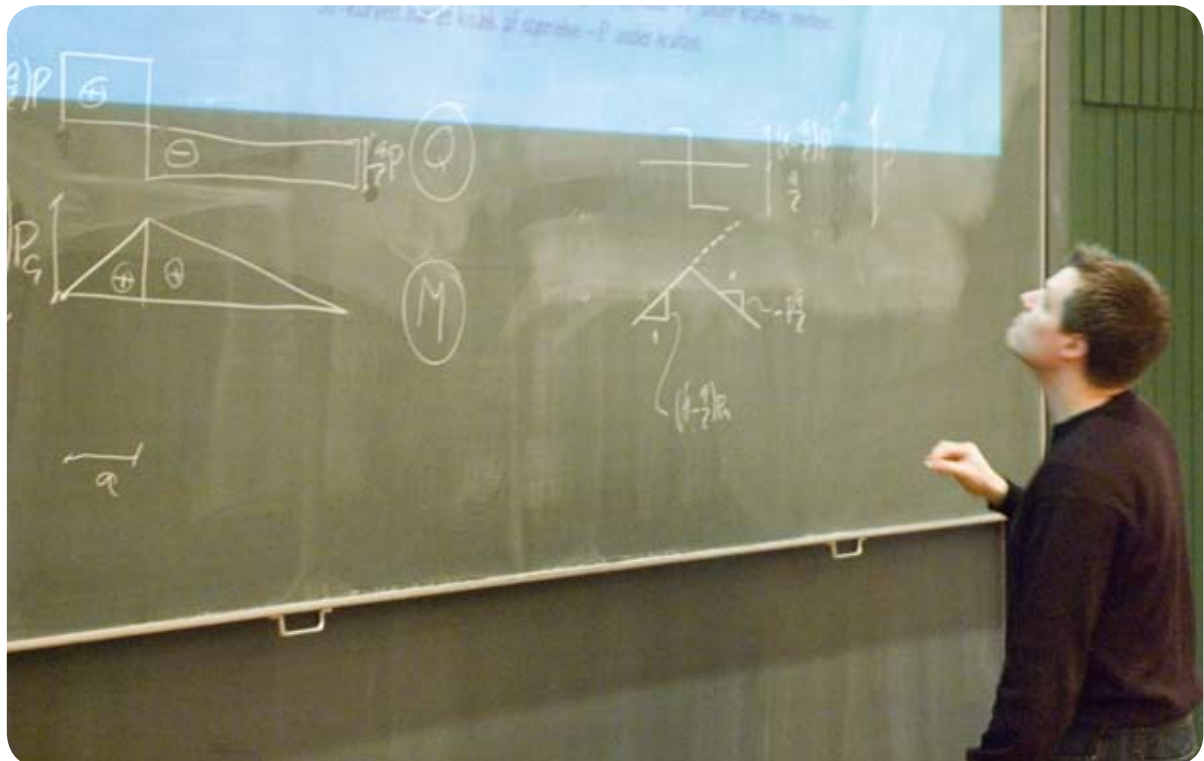
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Researchers at BYG•DTU applied for two patents in 2005:

Henrik Stang and Mette Geiker: Suspension of clay in water

Christos Georgakis: Liquid Dampers or spherical Tuned Liquid Dampers.

DTU chose to adopt the later.

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Nye informations- og kommunikationssystemer på byggepladsen : Evaluering af et pilotprojekt med internetopkoblede, håndholdte terminaler på byggepladsen ISBN : 87-7877-184-6 In: BYG Rapport ; R-116

**Reports**

## PhD theses

### **Ferreira, Célia Maria Dias**

Removal of Heavy Metals from Municipal Solid Waste Incinerator Fly Ash by an Electrolytic Process  
*Ottosen, Lisbeth M.*

### **Findsen, Karsten**

Murede skivers styrke - murværk påvirket til plane spændingstilstande  
*Nielsen, Mogens Peter*

### **Gudmand-Høyer, Tim**

Instability of Concrete Slabs  
*Nielsen, Mogens Peter*

### **Hansen, Lars Zenke**

Unreinforced Masonry Walls, Transversely and Axially Loaded  
*Nielsen, Mogens Peter*

### **Lykke, Miriam Mølgaard**

Displacement of Oil by Waterflooding in Fractured Chalk  
*Foged, Niels Nielsen*

### **Nystrøm, Gunvor Marie**

Electrolytic Removal of Heavy Metals from Contaminated Harbour Sediments  
*Ottosen, Lisbeth M.*

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### **Abdelrasul, Hasanin S.**

Urban quality-experiences from Denmark transferred to Iraq and vice versa  
*Elle, Morten*

### **Akram, Zobia, Yasser Qaddoura**

Design of school building  
*Kjærbye, Per*

### **Andersen, Ann-Louise, Dorte Nygaard Pedersen**

Drainage of soil in the Arctic  
*Villumsen, Arne*

### **Andersen, Caroline H.H.**

Earth pressure on walls – variation with time  
*Krogsbøll, Anette*

### **Andersen, Claus Wessel, Jakob Blichert-Toft**

Integrated design with focus on indoor climate and energy performance  
*Svendsen, Svend*

### **Andersen, Susanne Førgaard**

Pedestrian bridge at Kvæsthusbroen  
*Gimsing, Niels J. and Poulsen, Peter Noe*

### **Barandalla, Daniel Garcia**

Monitoring of a solar combisystem prototype  
*Furbo, Simon and Thür, Alexander*

### **Bech, Kristian Alberg**

Cyclic loading of sand  
*Krogsbøll, Anette and Hededal, Ole*

### **Bech, Ronni and Anders Dragsted**

External fire spread  
*Sørensen, Lars Schiøtt*

### **Bech, Ronnie, Anders Dragsted**

External fire spread  
*Sørensen, Lars Schiøtt*

### **Bisgaard, Ann**

Moisture buffer capacity of buildings  
*Rode, Carsten*

### **Blichert, Christian**

Deformation of fire exposed concrete  
*Hertz, Kristian*

### **Bøhm, Anja Hillmann**

Cement-based materials, microstructure property relationships  
*Geiker, Mette and Kjeldsen, Ane Mette*

### **Christensen, Rasmus M.**

Bolted endplate connection of tubes  
*Poulsen, Peter Noe*

**Christiansen, Ulla**

Stabilizing wood frame walls in multistorey housing  
*Kjærbye, Per, Hoffmeyer, Preben and Egerup, Arne*

**Cravo, Antonio M.**

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*Furbo, Simon*

**Fabricius, Jesper Sværke and Admir Mehic**

Innovative liquid dampers for the passive vibration control of structures  
*Georgakis, Christos*

**Fino, João and Mahomed Y. Gani**

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*Svendsen, Svend*

**Hansen, Mark Normann, Rasmus Knudsen**

Movable bridge between Amaliehaven and the Opera  
*Gimsing, Niels J. and Skettrup, Erik*

**Haukohl, Jens Christian, Martin Hoff Jørgensen**

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**Henningsen, Søren**

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*Foged, Niels*

**Henriksen, Jørgen Bryn**

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**Højman, Anders**

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*Sørensen, Lars Schjøtt*

**Hvidberg-Hansen, Anna**

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*Reitzel, Erik, Aagard and Gimsing, Niels J.*

**Jacobsen, Mads**

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*Nielsen, Leif Otto and Mualla, Imad*

**Jebjerg, Christian P.**

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*Engelmark, Jesper and Larsen, Henning*

**Jensen, Christian, Jesper Ring Christensen**

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*Agerskov, Henning and Bonke, Sten*

**Jensen, Mads Nicolai, Jesper Vinholt**

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*Gimsing, Niels J. and Gath, Jesper*

**Jensen, Mikkel Vibæk**

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**Jensen, Thomas Søby**

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**Jóhannesdóttir, Fjóra**

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**Jørgensen, Anders Stuhr**

Carrying capacity of Greenlandic Roads and Airfields  
*Villumsen, Arne*

**Jørgensen, Jørgen Højbjerg**

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*Hoffmeyer, Preben*

**Kalbakk, Thale**

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*Bonke, Sten*

**Kold, Dorte**

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**Larsen, Casper Schultz and Morten Schultz**

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*Koch, Christian*

**Larsen, Charlotte**

Movable pedestrian bridge across shipping lane  
*Gimsing, Niels J. and Poulsen, Peter Noe*

**Lauritzen, Mads**

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*Bonke, Sten and Christensen, Knud*

**Levi, Vibeke**

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*Krogsbøll, Anette and Christensen, Helle*

**Lyby, Karsten**

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**Madelung, Thomas and Hans Færck Jensen**

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*Johnsen, Finn*

**Marciniak, Darek**

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**Meincke, Joan Alexander, Henrik Pahl**

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**Mikkelsen, Henrik Nordentoft**

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*Elle, Morten*

**Møller, Karen Louise**

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**Møller, Steffen C.**

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*Vestergaard, Flemming*

**Mortensen, Henrik**

Geotechnical properties of melted – earlier frozen silt and clay deposite in Sisimut  
*Foged, Niels and Clausen, Helle*

**Munck, Peter Martin, Kasper Køppen**

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**Nguyen, Anh Duy and Mesut Ocak**

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**Nielsen, Jacob Ringsholt and Søren Egholm Hansen**

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**Nielsen, Jacob**

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*Rode, Carsten, Nielsen and Toke Rammer*

**Nielsen, Jens Henrik**

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*Poulsen, Peter Noe*

**Nielsen, Lene Markvad**

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**Nielsen, Tryggvi**

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*Svendsen, Svend, Nielsen and Toke Rammer*

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**Ómarsson, Sturlaugur Aron, Hákon Örn Ómarsson**

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**Petersen, Gry**

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*Georgakis, Christos*

**Sea, Samuel Cordova**

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**Skov-Larsen, Niels Clemens**

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**Søren Risvig**

Thind-walled beams  
*Jönsson, Jeppe and Nielsen, Leif Otto*

**Sørensen, Anne**

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**Sveinsson, Sigurour S.**

Lean construction and work and environment  
*Pedersen, Elsebet F.*

**Thangarajah, Srirengan and von Holstein, Steffen J.**

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**Ureta, Maite B.**

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*Furbo, Simon and Thür, Alexander*

**Vienberg, Trine Hee**

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**Ick, Mirko**

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 Arena  
*Koch, Christian and Hansen, Per Richard*

**Zass, Katrin**

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*Furbo, Simon and Thür, Alexander*

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### **Akkas, Yakup**

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*Traberg, Søren*

### **Alm, Anne Birkedal and Johansen, Søren Udengaard**

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*Kjærbye, Per*

### **Andersen, Louise Toftebjerg**

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*Thorsen, Torsten*

### **Andersen, Marie-Louise N. and Rauø, Hanna**

Material Science  
*Thorsen, Torsten*

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### **Bossow, Brian and Jensen, Lars Mikael**

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### **Christensen, Knud**

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*Kjærbye, Per and Andersen, Jens*

### **Christensen, Peter Mainz and Helmer, Lars**

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*Sørensen, Lars Schiøtt*

### **Christiansen, Toni Mühlestein and Kastbjerg, Nicolas Michael**

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*Kjærbye, Per*

### **Ferdinandsen, Rikke Amalie and Henriks, Mette**

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*Bonke, Sten*

### **Frederiksen, Ronnie R. H. and Hoffmann, Nicolai H.**

Effect of entrained air on chloride ingress into concrete  
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### **Hanjani, Melissa Jamali and Schwarz, Frank**

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*Kjærbye, Per*

### **Hansen, Peter Mose**

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*Kjærbye, Per*

### **Hansen, Morten Ingemann**

Urban Planning at the water-front  
*Christensen, Kirsten and Elle, Morten*

### **Haugaard-Jensen, Lars Peter**

Professional development of projectmanagement competences in a construction company  
*Christensen, Knud*

### **Hejnfelt, Thomas and Øksengaard, Rene**

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### **Højgaard, Bardur and Madsen, Anders Møller**

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*Stang, Henrik, and Jensen, Ole Mejlhede*

### **Jensen, Marie Nygaard**

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*Christensen, Knud*

### **Jensen, Simon Rich and Jacobsen, Morten Brogaard**

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### **Jensen, Mette Hegelund and Bjørnlun, Lars Bo**

Project Web  
*Koch, Christjan and Christensen, Knud*

**Jørgensen, Anne Marie and Laustsen, Sara**

University construction  
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**Kruse, Lars and Christensen, Anders Mygind**

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*Bonke, Sten*

**Kryger, Morten**

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**Mørch, Søren and Yang, Yuan-Yuan**

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**Morelli, Martin and Bennedsen, Nicolai**

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*Villumsen, Arne*

**Nørrelund, Claus D. and Rosenkjær, Peter**

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*Thorsen, Torsten*

**Olsen, Pia Kaaber and Jørgensen, Trine Gotha**

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**Pedersen, Brian and Hansen, Anders**

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*Thorsen, Torsten*

**Pedersen, Frank Schou Kruse and Buch, Bjørn**

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*Christensen, Knud*

**Petersen, Ujark Rosing**

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*Villumsen, Arne*

**Poulsen, Kim Thomas and Høiagaard, Tobias**

Strengthening existing steel constructions by use of carbon fibers  
*Thorsen, Torsten and Poulsen, Ervin*

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Construction project in a third world country  
*Bonke, Steen*

**Rasmussen, Thomas**

Cost of construction for road to Sarfanguaq, Grønland  
*Villumsen, Arne*

**Volsing, Kristoffer and Jørgensen, Nicolaj Mac**

Energy renovation of one family house  
*Svendsen, Svend and Tommerup, Henrik*



## Staff

On 31. December 2005

		2005	2004	2003
Scientific	Professor	9	11	12
	Associate Professor	38	44	45
	Assistant Professor	15	15	13
	Other VIP	6	4	2
	PhD students	44	40	42
	<b>Total</b>	<b>112</b>	<b>114</b>	<b>114</b>
Technical and Administrative	Academic	11	10	10
	Clerical	12	12	12
	Technician	22	22	23
	Other TAP	5	4	4
	<b>Total</b>	<b>50</b>	<b>48</b>	<b>49</b>
Total department staff		<b>162</b>	<b>162</b>	<b>163</b>

## Education

STÅ <sup>1</sup> – total		508	519	469
Projects	BEng (diplom)	62	82	73
	PMP/BSc (midterm)	36	56	25
	MSc (civil)	92	74	60
Admission	BEng (Civil Engineering) - summer	63	58	88
	BEng (Civil Engineering) - winter	30	32	32
	BEng (Architectural Engineering)	52	42	49
	BEng (Arctic Technology)	9	8	12
	BSc (Building Technology)	72	60	60

## Research

Refereed papers	Total	61	63	44
	Of these in ISI	43	37	N.A.
PhD		8	10	7
Doctoral		1	0	0

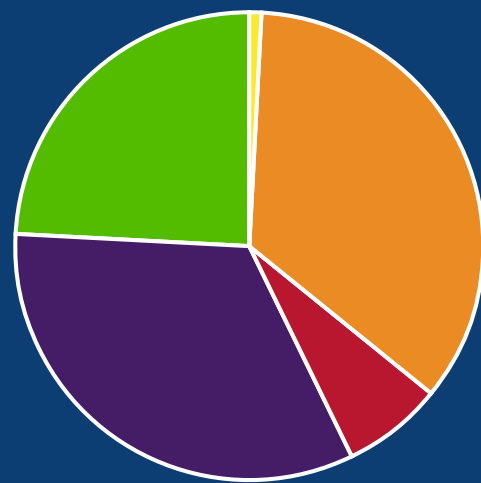
## Finances

Finances in 1.000 DKK

Revenues	DTU-grant	53.184	52.523	51.189
	External revenue	30.862	28.563	26.191
	<b>Total</b>	<b>84.046</b>	<b>81.094</b>	<b>77.380</b>
Expenditures	Wages	62.725	62.917	61.927
	Other expenses	19.628	16.445	14.688
<b>Total</b>		<b>82.353</b>	<b>79.362</b>	<b>76.615</b>
<b>Result</b>		<b>1.693</b>	<b>1.732</b>	<b>765</b>
Available amount	January 1	6.264	4.532	3.767
Carried forward	December 31	7.957	6.264	4.532

1 1 STÅ is one student annual work (1 STÅ=60 points/student)

## Turnover 2005



Innovation	1%
Education	35%
PhD scholarships	7%
Faculty reasearch	33%
External Financed reasearch	24%

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**BYG•DTU**  
Annual Report 2006

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Jensen

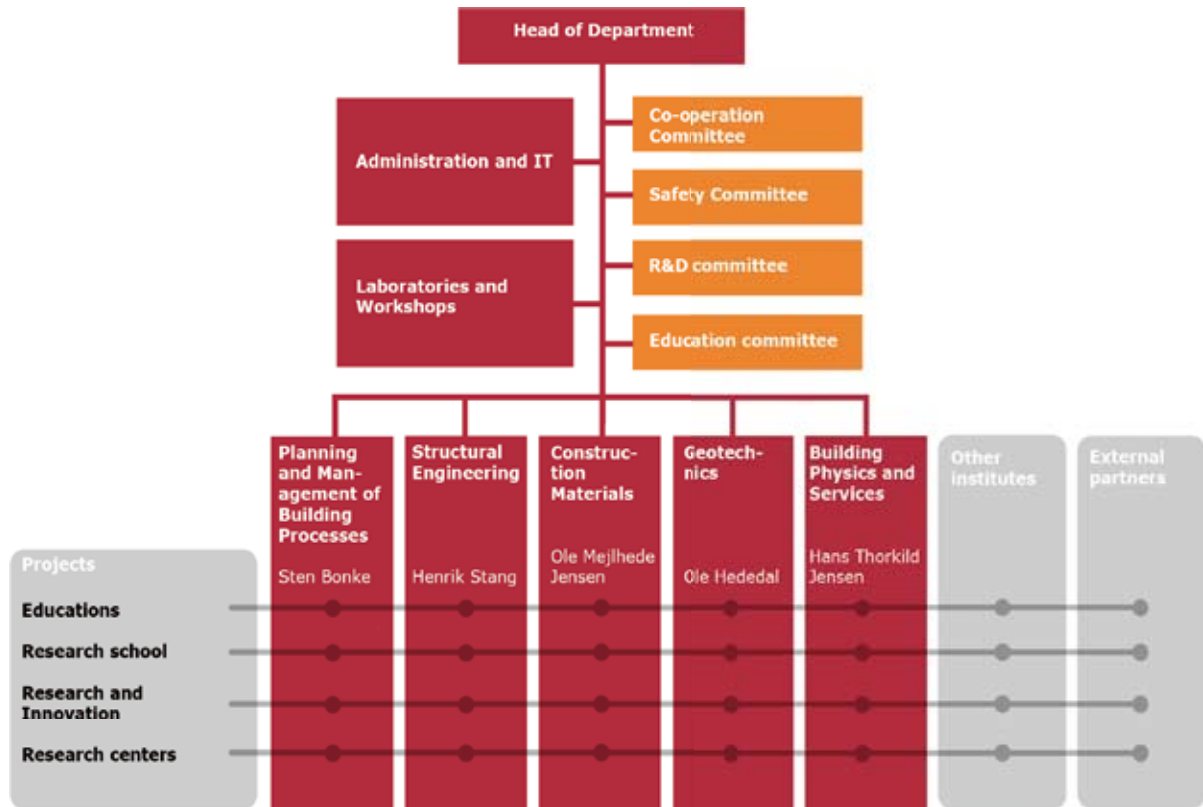
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## Organisation



### Study Programmes and Programme managers:

- Civil Engineering (MSc). Associate professor Kristian Hertz.
- Civil Engineering (BSc). Associate professor Per Goltermann.
- Architectural Engineering (BEng). Associate professor Kirsten Christensen.
- Civil Engineering (BEng). Associate professor Ole Mærsk-Møller.
- Arctic Technology (BEng). In Greenland, Associate professor Hans Peter Christensen. In Denmark, Associate professor Ole Mærsk-Møller.

### Department of Civil Engineering hosts the following centres:

- IRS@BYG, The International Research School for Civil Engineering. Professor Stephen Emmitt.
- ARTEK, Arctic Technology Centre. Professor Arne Villumsen.
- C•PROSAM, Centre for Protective Structures and Materials. MSc Civil Engineer Benjamin Riisgaard.

### The Advisory Board:

- Executive director Mette Lis Andersen, Københavns Kommunes Bygge- og Teknikforvaltning
- Development director Thomas Heldgaard, Rockwool A/S
- Executive director Peter Lundhus, Femern Bælt A/S - Sund og Bælt Partner A/S
- Executive director Klaus H. Ostenfeld, COWI A/S
- Senior advisor Jørgen Vorsholt, E. Pihl & Søn A.S

## From the Head of Department

**The Department of Civil Engineering, BYG•DTU, is a university institute within the building and construction sector.**

**Our mission is education, research, innovation and public sector consultancy. Through our work we contribute to the generation of social and commercial value.**

**Our vision is to become a leading European Civil Engineering Department and a preferred partner for companies, authorities and institutions in the building and construction sector.**

The Department of Civil Engineering was established in 2001 through a merger of a number of smaller departments in order to unite the technical disciplines applied in a building or construction design process. Now six years later, it can be concluded that the merger is successful.

However, results do not come of themselves. The Department of Civil Engineering has, since it was established, conducted a series of prioritised development steps for selected areas of initiative. Each step has raised the institute to an international university level within the selected areas:

### Organisation

The Department established the organisational and administrative framework and together with our Advisory Board we developed an ambitious new Strategy for the institute. In 2007 all major strategic goals in the Strategy will be reached.

### Staff renewal

Focus was on a large generational change: Twenty-three faculty including four full professors plus ten permanent technical staff members were employed. The generation change has established a strong research and technical staff with an internationally reputed research background and with large experience from construction and consultancy for industry and authorities.

### National esteem

The institute has established a national position as a favoured partner in research and continued education. The master education programmes in Fire Safety and in Construction Management have consolidated as well sought continuing education programmes. The industry network LavEByg on energy efficient buildings, and the industry network C-Prosam on protective structures and materials, together with an increasing number of industry sponsored research and PhD projects document the growth in collaboration with the national civil engineering community.

### Education

Since 2001 the bachelor and MSc programmes in Civil Engineering have been revised. The Department opened the new bachelor programme in Arctic Technology in 2001, and the new bachelor programme in Architectural Engineering in 2002. All education programmes have since 2004 complied with the Bologna declaration. From 2007 the bachelor in engineering (diplomingeniør) programmes will follow the CDIO (Conceive, Design, Implement and Operate) system of education developed by MIT, KTH, DTU and a number of other technical universities. From 2007 all MSc programmes will be taught in English.

### Priority areas

Alongside with the development in relation to organisation, staff, national position and education the Department has increased the quality of our research, innovation and public sector consultancy.

Based on the positive development since 2001, the Department is well prepared to engage in further initiatives in order to raise the international standing of the institute. Thus the priority areas for the coming years will be research, innovation and public sector consultancy at a high international level.

**Head of Department  
MSc (Civil Engineering)  
PhD Jacob Steen Møller**



### **Research**

In 2007 our focus on research quality will be enhanced. An international research evaluation conducted by an international panel of experts will establish the basis for improvements in research over the coming years. In the years to come the Department will increase its contribution to the international research organisations such as RILEM (International Union of Laboratories and Experts in Construction Materials, Systems and Structures) and CIB (International Council for Research and Innovation in Building and Construction) and network such as ECTP (European Construction Technology Platform).

### **Innovation**

In 2007 the Department in collaboration with IPU has established an Innovation Centre in Civil Engineering. IPU is a DTU controlled company facilitating industry collaboration. The Innovation Centre will enhance the collaboration with industry and help to increase funding for our research infrastructure.

### **Public sector consultancy**

The university merger in Denmark in 2006 has added Public Sector Consultancy to the University portfolio. The Department is well prepared to take on this new challenge.

I am confident that the Department of Civil Engineering will make its

mark on the international research and education scene in the years to come.

Head of Department,



Jacob Steen Møller, PhD

## Teaching glass and glass structures

**Positive feedback from students and industry alike has made the test course in glass a regular part of the curriculum.**

Load carrying structures made from glass give exciting possibilities both architecturally and from an engineering point of view. Glass structures can be very aesthetically pleasing, the transparency can be a significant asset and glass facades can be intelligently designed to allow for a maximum amount of daylight in the building. Though glass has many excellent properties as construction material, it is extremely brittle, the strength in tension is highly influenced by defects, and therefore the tensile strength is somewhat unreliable. Thus the design of structures using glass as structural material presents significant challenges. In particular care must be taken in mounting, fixing and joining glass elements.

### Form test course to curriculum

In 2004 the need for consulting engineers with a background in glass and glass structures sparked the establishment of a special course in 'Glass and Glass Structures' in collaboration between Birch & Krogboe, Ove Aarup Consulting Engineers and BYG•DTU.

Now the course is a part of the regular teaching curriculum at the Department. The course contains an introduction to the structural use of glass and an overview of architectural aspects on the use of glass in buildings.

Since it is essential for the students to be aware of the special properties of glass, production and the microstructure of glass is also dealt with. Glass types relevant in construction are dealt with: laminated glass, toughened glass as well as typical mechanical properties, specifications and safety aspects. Structural design issues include plates, beams, cable supported structures, fins, shells and membranes. Finally, structural connections are considered: adhesive joints as well as bolted connections. Invited lectures on topics such as indoor climate and safety in relation to glass structures are also given.

### Student projects

The establishment of the course has initiated a significant amount of Master and Bachelor projects dealing with many of the still unresolved problems related to the use of glass as structural material: the stress distribution and strength in adhesive joints and bolted connections, the long and short term stiffness of laminated glass, reinforced glass beams and analysis of shell structures made entirely from glass – to mention a few.

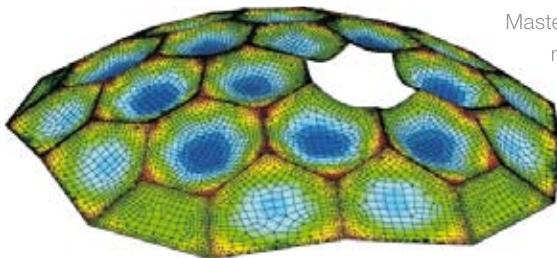
The research challenge has also been taken up, and at this point in time two PhD students are working with glass research projects related to bolted connections in toughened glass and analysis of faceted shell structures.



Master thesis project examining the long and short term stiffness of reinforced glass beams. Even after severe cracks in the beams much of the load capacity remained.

### Preparing for the future

No doubt glass structures will play a significant role in the future, and much development in both technology and design tools is expected for instance in new innovative multi-functional, intelligent facades with daylight regulating, insulation and load carrying capabilities combined. Educating students with a solid competence in glass is the best way to ensure that both the research and innovation capabilities at DTU as well as in the industry are in place to meet these future challenges.



Master thesis on the FEM-modelling of a faceted shell. The picture shows the largest principal stress for snowfall on a shell with a broken facet

**Professor Henrik Stang and Professor Jeppe Jönsson, Responsibles for the course in Glass and Glass Structures**

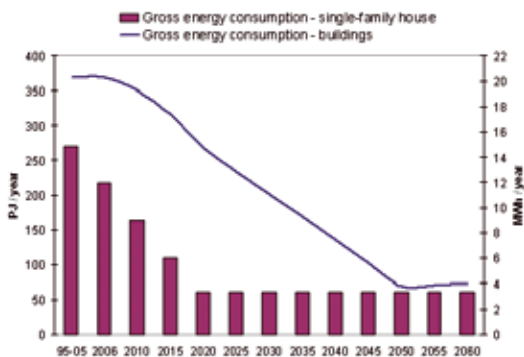
[www.kurser.dtu.dk](http://www.kurser.dtu.dk) course number 11365



## No need for oil in 2050?

**Industry and science working together to reduce the energy demand from our biggest energy consumer - our buildings**

LavEByg is a state-supported “Network on Integrated Low Energy Solutions in Buildings”, a network of knowledge institutions and professionals in the building industry. BYG•DTU is the project leader with professor in building energy Svend Svendsen in front. The main partners are: ICIEE, SBi, AAU and Teknologisk Institut.



The potential for energy savings

The aim of LavEByg is to ensure that the great potential for energy savings (60-80% over the next 40 years) is achieved - both in connection with new buildings and with energy renovation of existing buildings. Through stimulation of research and development of the necessary technologies, the network tries to realize the vision of low-energy buildings with a good indoor climate, but without the need for fossil fuels.

### Energy use from our buildings

The energy use in our buildings is about 40% of the total energy use in EU. Most of the energy is used for low temperature heating of rooms and domestic hot water but electricity

is used for lighting, air conditioning, ventilation and other building services as well as all electrical equipment.

A sustainable development with no use of fossil fuels in the energy system may be realised by use of an economically optimised combination of extensive energy savings and use of renewable energy. The potential for energy savings in the building sector is very large and the technology for renewable energy supply of the buildings with heating and electricity is available.

The realisation of the energy savings in buildings is in focus in the EU Energy policy and especially in the EU Energy Performance of Buildings Directive (EPBD). Due to this directive a revolution is taking place in the way energy requirements are formulated in national building codes of EU.

### How to save energy

With the implementation of the EPBD the focus has shifted from design of individual HVAC systems to integrated design of integrated building concepts, which allow for optimal use of natural or passive energy strategies

Highly insulated and airtight low-energy house in Kolding (Seest). The house has a mechanical ventilation system with high efficient heat recovery.



(daylighting, natural ventilation, passive cooling, etc.) as well as integration of renewable energy supply. Thus, there is a need for integrated overall solutions regarding energy savings and energy supply. Extensive energy savings and use of renewable energy can create an overall energy solution without fossil fuels. The basis for such a solution is to have new and existing buildings built or reno-



Integration of roof/ceiling construction and ventilation duct system in a low-energy house. A special rafter-solution makes it possible to install the ventilation ducts in the lower warm part of the ceiling construction instead of in the unheated attic (i.e. minimal heat loss).

vated to low-energy class 1 or better.

In urban areas the buildings may be heated by low-energy district heating based on incineration of waste or other renewable energy sources. There is a need to go all the way with 80 % energy savings and renewable energy to cover the remaining energy demand. Existing buildings should be energy renovated to almost the same level as new buildings, and that is a challenge. However, the Germans have shown that extreme low-energy renovation to passive house standard is possible.

### Can it happen?

Extensive energy savings and use of renewable energy is now the general long term policy and strategy worldwide, and it is also the recommended path by the United Nations stated in the 2007 report on Buildings and Climate Change. But there is a great need to support the development of integrated low energy solutions for an optimal realization of low-energy buildings. This development is carried out in Denmark in the framework of LavEByg.



**Secretary leader Henrik M. Tommerup,  
Secretariat for LavEByg**

[www.lavebyg.dk](http://www.lavebyg.dk)

## BYG•DTU and large ship diesel engines – A paradox?

**The engines can be treated like any steel structures and at BYG•DTU we have the large equipment to handle the size.**

BYG•DTU has for a period of almost 20 years been involved in a series of quite large Nordic research projects on fatigue in welded steel structures. These projects have had strong industry participation and financing by leading Nordic companies and Universities. All projects have had a considerable economical support from Nordic Innovation Center (Nordisk Industrifond).

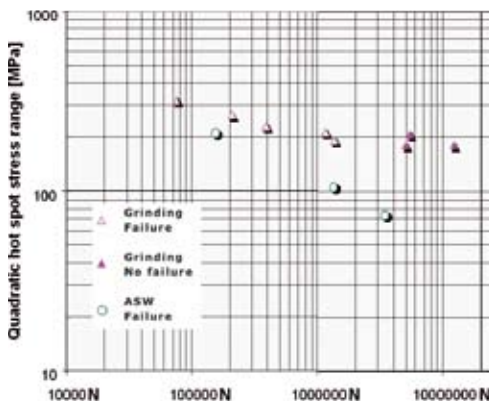
### BYG•DTU and MAN B&W

The last two projects have involved a close cooperation between the two Danish participants, MAN B&W Diesel and BYG•DTU. And the main topic for these investigations has been fatigue life of large ship diesel engines.

Large diesel engine installed in 300,000 DWT tanker (Photo: MAN B&W Diesel)

From an immediate consideration it seems illogical that research on fatigue in diesel engines is carried out at BYG•DTU. However, these engines are carried out with the main parts as large welded steel structures, and with a total height as for a 4-storey building. And when studying the fundamental problems in connection with fatigue in welded steel structures, it appears that the physical and mathematical basis for fatigue crack initiation and crack propagation is independent of the type of structure. Thus, the results which are obtained in studies of fatigue in welded steel structures in diesel engines, ships or automobiles may as well be used for more

traditional civil engineering steel structures, as e.g. bridges, offshore structures or wind turbine towers.



The fatigue life is increased by a factor ranging from 2.8 to infinity, depending on stress level

### Grinding the weld toes

BYG•DTU has carried out studies of the possibility for improvement of the fatigue life of welded steel structures by treatment of the weld toes by grinding. The results obtained showed that a considerable increase in fatigue life may be obtained by grinding the weld toes. If grinding is used, it will normally be carried out according to international recommendations. However, in this project an alternative type of grinding and its effect on the fatigue life was studied. The fatigue tests carried out demonstrated that the alternative type of grinding had at least as good fatigue life as the internationally recommended. And the advantage of the alternative type of grinding is that it saves about 30% of the machining time, which for these large structures has a considerable economical impact. In welded steel structures, a stress relieving by post-weld heat treatment is in some cases carried out to increase the fatigue life. The purpose is to remove harmful tensile residual stresses due to the welding. This has also

traditionally been done for the welded structures for diesel engines, and with the large components in question this is a costly process. However, theoretical determination of the residual stresses indicated that favourable compressive residual stresses from the welding

would develop at the critical areas with respect to fatigue crack initiation for the actual structures. The fatigue tests demonstrated this to be the case, since the as-welded test specimens were found to have significantly higher fatigue strength than the stress relieved specimens. Thus, a costly stress relieving could be avoided and at the same time a longer fatigue life was obtained.

### The academic bonus

As well as having provided BYG•DTU income via BYG•innovation, which facilitates testing in the large laboratory a lot of academic rewards have been harvested as well. A strong network and very successful cooperation has been built up during these almost 20 years between leading Nordic industry companies and the involved universities. This is planned to continue in the years to come. The work has also fostered a large number of publications e.g. the latest project, Q-FAB, has resulted in totally more than 70 publications. Within Q-FAB, 8 international publications have been worked out in the MAN B&W Diesel/BYG•DTU project over the last 4 years.



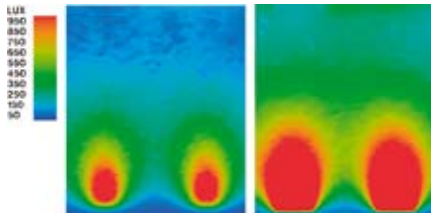
**Professor Henning Agerskov, using BYG•innovation**

[www.byg.dtu.dk/english/byginnovation](http://www.byg.dtu.dk/english/byginnovation)

# The energy efficient window

Imagine windows which will contribute positively to the energy balance of your home in the heating season, provide your rooms with more light, and which require less maintenance

The windows in a building are not just responsible for letting out most of the heat they also bring in energy through sunlight. Energy-wise, the challenge is to have the windows gain more energy from the sunlight than they lose through the glass and joints. In the summertime, this is easy



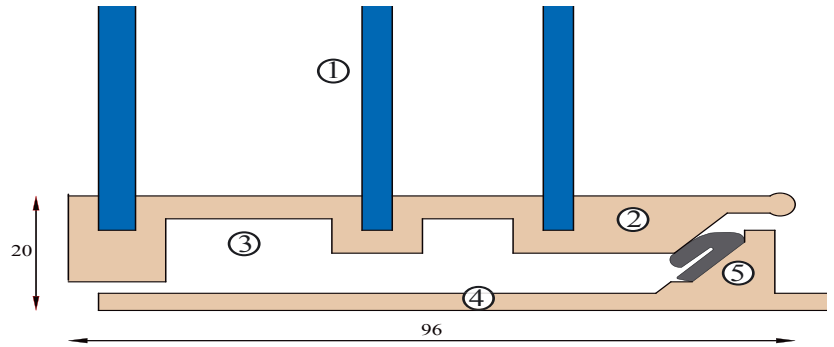
The influence of the smaller frame for the inflow of light to a room with a depth of 3,5 meters

because of the high temperatures and the many hours of sunlight. The real challenge lies in making a window that gives a positive result in the months where you normally will have to pay for heating up the building.

## What are the principles?

Research projects funded by Villum Kann Rasmussen Fonden have, in combination with student projects, provided the window

design, which can match the above specifications. The window consists of three single layers of glass glued together in a profile of glass- fibre reinforced polyester, which makes it strong, easy to maintain and well insulated. Three sheets



## Cross section of window design with dimensions in mm

- 1: Glazing of three single panes.
- 2: Glass-fibre reinforced polyester with the sheets glued in.
- 3: Container with desiccant that can be regenerated.
- 4: Window fitting attached directly to the wall.
- 5: Weather stripping and part of closing mechanism.

of glass with hard low emittance coatings towards the air gap reduce the heat loss of the glazed part of the window to a minimum. The air in the cavities of the glazings is kept dry by an externally placed container with desiccant that can be regenerated. The window fitting is attached directly to the wall with a 3 mm frame sheet. Overall, the profile of the window has been reduced from 10 cm to only 2

cm to provide a better field of view from inside the building and to let in more light. This increased amount of light entering the building also means a substantial increase in solar energy compared to a traditional window.

## Future challenges

There are still a lot of challenges left for having a product fit for the consumer market. The design of the windows may cause superheating in the summer time, however calculations made by BYG•DTU suggest ventilation during the night and outer shading for the south-facing windows as a possible solution. The research continues in cooperation with Fiberline A/S, a leading company in the production of fibre-glass reinforced polyester profiles.

## The energy savings in a 180m<sup>2</sup> house

Window type	Glazing	Glass area of Window	Net energy contribution	Annual energy use of building
Traditional	2-layer glazing unit	73 %	-47 kWh/m <sup>2</sup>	87 kWh/m <sup>2</sup>
Slim alu/wood	2-layer glazing unit	82 %	-39 kWh/m <sup>2</sup>	85 kWh/m <sup>2</sup>
Passive house	3-layer glazing unit	66 %	-4 kWh/m <sup>2</sup>	74 kWh/m <sup>2</sup>
BYG•DTU	3 single panes	94 %	15 kWh/m <sup>2</sup>	69 kWh/m <sup>2</sup>

The new energy demands BR-95 lists that the energy use per m<sup>2</sup> heated room space must be no more than 82 kWh/m<sup>2</sup> per year. BYG•DTU's window design provides the house with a positive net energy gain, which proves that the use of better windows

makes it easy to bring your living space up to these demands and even to the 25% increase in the demands expected in 2010.



**Professor Svend Svendsen,**  
Section for Building  
Physics and Services

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## Full scale destructive load testing on a bridge in Sweden

**BYG•DTU in collaboration with the Swedish rail authorities Banverket and the European founded project Sustainable Bridges seeks to bring more clarity around the shear problem and the shear capacity of existing concrete bridges.**

In the early days, structures were designed by trial and error. This method gave eventually a structure, which succeeded in carrying the loads, but the high risk of a failure at some point of the building process was obviously the drawback. The development has led to generally accepted design criteria which, if properly used, should prevent failure. The failure is evaluated for different modes, i.e. shear and bending, and no failure should have occurred at the design load. The shear capacity is especially hard to determine due to analytical difficulties, and the shear failure is at the same time not desired as it is generally very brittle.

### Strengthening

To be able to prevent a traditional bending failure and obtain a shear failure the bridge needed to be strengthened in flexure. The method chosen was Near Surface Mounted Reinforcement (NSMR) rectangular carbon fibre bars that was bonded with an epoxy adhesive in pre-sawed grooves in the concrete cover in the soffit of the bridge beams. The size

of the grooves was 15 x 15 mm.

The strengthening design is based on calculations regarding the bridge's original capacity, which was estimated to approximately 7 MN for the actual placement of the load. To obtain a shear failure, the bridge needed to be loaded up to approximately 10-11 MN. The strengthening design provided an additional flexural capacity of 4 MN, i.e. approximately a 40 % increase in flexure. The additional 4 MN corresponded to 18 CFRP rods, 9 per beam, with a length of 10.0 m. The rods chosen were provided by Sto Scandinavia AB with the brand name Sto FRP Bar M10C. These rods consisted of a high quality carbon fibre with the modulus of elasticity of 250 GPa and a strain at failure of approximately 11 %.

### The tests

The performance of the strengthening system and the effects of it were analyzed by monitoring these four quantities: temperature, strain distribution, deflection and load. The strain distribution was established by applying strain gauges both on the compressed concrete, tensile steel reinforcement and the CFRP rod. In addition strain was also monitored by FOS (Fibre Optic Sensors).

The bridge was loaded during two occasions, one time before and after it was strengthened.

The load was applied by placing a beam reaching over the bridge deck

which was fastened by cables anchored into the rock some 6 metres below the ground surface. Two 1000 ton hydraulic jacks provided the force.

### The result

The first test ended at about 2 MN, at which the cracking load of the slab was reached. For the second test the bridge was loaded up to failure and



Placing the high quality carbon fibre rods in the pre-sawed slots helped the bridge to resist a load increase from 2 MN to 12 MN before failure

at almost 12 MN the bridge failed and the load went back to zero.

At failure the CFRP rod reached a strain of approximately 8000 micro-strain before the bridge failed in shear. The bending capacity was consequently enough to force the desired failure mode to occur. The utilization of the strengthening material was fairly high, around 70%. A "fishbone-pattern" was formed around the slot, indicating that the concrete surrounding the sawed slot was taking damage from the transferred shear force. However, no bond problem was noticed during the failure test. The test was considered as very successful.



**The Örnsköldsviks bridge:** 12+12m two span concrete trough bridge with one railway track from 1955 was designed for an axle load of 250 kN. The new high-speed railway, the Botnia Line, has made this bridge redundant and thus soon to be the subject of full scale testing.

**Professor Björn Täljsten,  
Section for Structural Engineering**

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## Greenlandic permafrost conditions – a geotechnical perspective

Permafrost is a section of the subsurface in which the temperature is continually below 0°C year round. Research helps with risk assessments for urban areas with respect to the predicted climatic changes

The much debated global warming effect is expected to cause a 2.8 to 7.8°C rise in the mean annual air temperature in the arctic region over the coming century, according to the fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Such an increase in temperature is expected to cause severe changes in the ground thermal regime and hence cause permafrost degradation. The resulting instability and settlement will severely affect existing roads, airports and buildings as well as large infrastructure projects currently under development.

### Permafrost mapping with geophysical methods

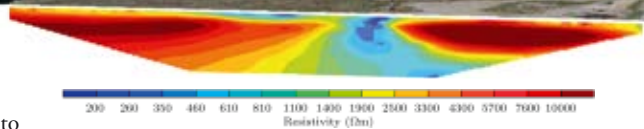
Our current research is aimed at describing permafrost conditions in West Greenland and at developing risk assessments for urban areas with respect to the predicted climatic changes. This goal is pursued through geotechnical and geological investigations and establishment of ground temperature monitoring stations.

Geophysical measurements have proven to be a valuable tool in this investigation. We are using an integrated approach, where the interpretation of geotechnical boreholes is extended to the surrounding areas by means of geophysical techniques. These are non-invasive surface based measurements that map the physical properties of

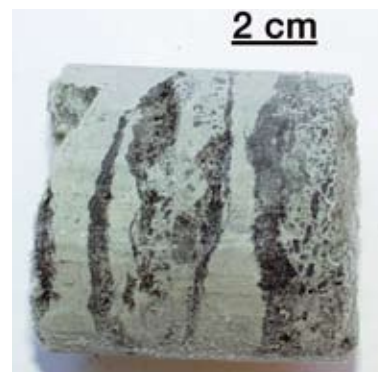


the subsurface materials.

With reference to the borehole information, the mapped distribution of physical properties can be used to establish material types, layer boundaries and whether the material is frozen or unfrozen. Especially a combination of electrical and ground penetrating radar measurements have proven powerful in determining the lateral distribution



Resistivity profile obtained near Sisimiut. The highly resistive areas (red) correspond to frozen sandy and silty sediments, whereas the low resistive area (blue) is an unfrozen section of the same sedimentary unit. The unfrozen “talik” is caused by a small river, which drains the lake visible in the background photo. This example illustrates the unstable state of the permafrost in the Sisimiut area. The additional heat conducted into the ground from the flowing water is sufficient to keep the ground unfrozen year round.



Samples like this from the town Sisimiut in central West Greenland show that common permafrozen clay and silt rich sediments may have up to 25% vertical settlement during controlled laboratory thawing, due to the presence of massive ice lenses (dark areas) (Photo by Niels Foged).

of frozen sediments and the annual summer thaw depth. The electrical measurements are conducted by injecting a current into the ground using two electrodes at the ground surface, and measuring the resulting difference of potential between two additional

electrodes. By combining a number of measurements with different electrode geometries, the resistivity structure of the subsurface can be obtained through a mathematical inversion procedure. As most of the current is conducted through the pore water in the sediments, the effect of frozen ground will be an increased resistivity compared to similar unfrozen material.

Not only natural water flow and global warming may cause permafrost thawing. Similar effects may occur below buildings that are not properly insulated or by the changes in albedo and insulation properties of the topsoil and vegetation induced by the construction of roads or airstrips. In regions with high ground ice content, this will lead to instability and settlement of the subsurface. Thus, the knowledge of permafrost conditions is of utmost importance in the planning of construction projects in the arctic.

Assistant Professor Thomas Ingeman-Nielsen,  
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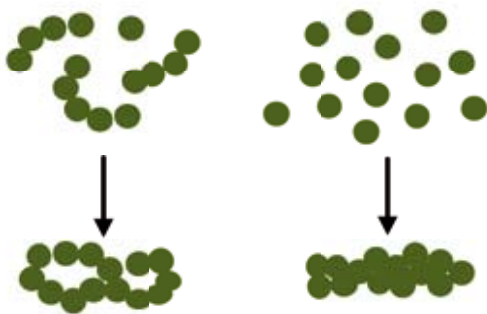
## Bringing the use of concrete to its fullest potential?

**One way is through microstructure manipulation. Research has brought us further down the road in the understanding of how this may be done**

The microstructure of concrete is of paramount importance for almost all performance aspects of the material. Therefore, the ability to model both initial and hydrated microstructure is a key to the subsequent understanding and prediction of many macroscopic properties of the material. Correct modelling of the initial microstructure requires knowledge of, among others, the forces acting on and between the constituent particles. In the hydrated state, the pore structure of a cement-based material is often assessed experimentally. However, assessment is always based on a number of assumptions and simplifications. In the project, theoretical and experimental investigations of the effect of inter-particle forces on the consolidation behaviour of fresh cement-based materials have been carried out. Furthermore, the basis for interpretation of results obtained through an experimental method for pore structure characterization is assessed.

### Three forces apply

The three main inter-particle forces



If the net inter-particle force is highly attractive, the particles will tend to agglomerate in a loose network (left). Reducing the attractive inter-particle forces by means of absorbing polymers can therefore facilitate a closer packing of the constituent particles (right).

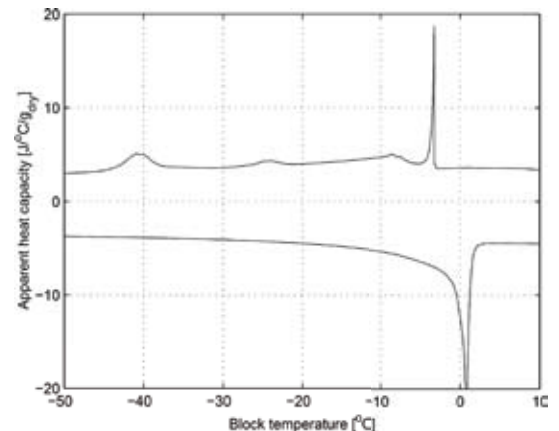
acting in the studied systems, the van der Waals force, the electrostatic force, and the steric force were theoretically evaluated, and changes in inter-particle forces were experimentally quantified. The changes were induced by the addition of different so-called superplasticizers. Superplasticizers are polymers that today are commonly used in concrete production to obtain a material with specific flow properties. The applied superplasticizers change the steric inter-particle force by adsorbing onto the cement particle. This helps prevent the particles from agglomerating, thus enabling them to rearrange during consolidation and form a dense network with a given packing density. The experiments verified, that changes in superplasticizer structure were reflected by changes in the obtained packing density and thus the inter-particle force.

### Low temperature experiments

Assessment of the pore structure in a hardened cement-based material may be carried out experimentally, e.g. by the Low Temperature Calorimetry (LTC) equipment at BYG•DTU. The principle of LTC is based on that the freezing of liquid is an exothermic process and that at subfreezing temperatures a solid meniscus exists, whose curvature lowers the free energy of the pore liquid and induces a freezing point depression. When performing LTC heat flow to and from a saturated porous material is measured during controlled cooling and heating. From the resulting heat flow curves the amount of ice formed or melted at a given temperature can be calculated. This information may be used to estimate threshold pore sizes or the pore size distribution in the material.

The basis for interpretation of results from this experimental technique was assessed in order to determine the possibilities of using

LTC for characterization of the porosity of cement-based materials. Effects like super-cooling of the liquid in the material, bottle neck pores, and ions being expelled from the pore water during freezing, were treated theoretically and evaluated experimentally. It was found that taking into consideration the obtained results, LTC may be used for characterization of pore connectivity as well as pore size distribution in cement-based materials.



When performing LTC, heat flow to and from a saturated porous material is measured while cooling and heating is carefully controlled. The amount of ice formed or melted at a given temperature can be calculated from the heat flow curves. This information may be used to estimate threshold pore sizes or the pore size distribution in the material.



**PhD Ane Mette Kjeldsen,  
Section for Construction Materials**

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## Real estate strategies and building values

### Developing theories of Facilities Management with studies of DR's building history during the last 80 years.

Facilities Management (FM) is a new discipline and has recently been included in BYG•DTU's research agenda. To understand how FM has originated, this research project has focused on the historical development of the roles as building client and building operator, and how these functions within the last 10-20 years have emerged into an integrated FM function together with various building related service functions. To understand the relations between building client and building operator, some theories, that connect the process of developing new buildings with the life cycle process of buildings in use, have been implemented and developed. These theories concern real estate strategies and values of buildings.

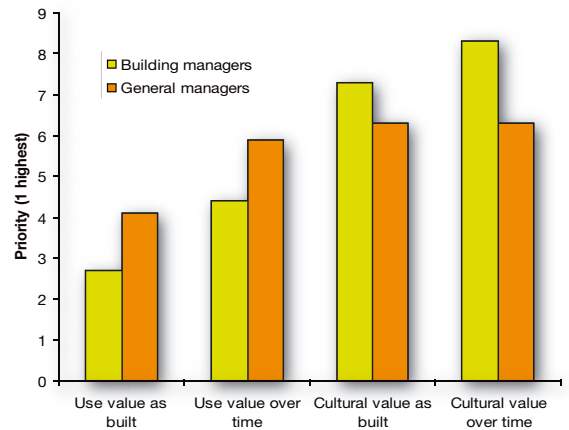
### Studying DR

The empirical basis of the project has been a longitudinal case study of the buildings of DR (Danish Broadcasting Corporation) during the corporation's 80 years history as a public service broadcaster of radio and television in Denmark. The researcher had personal experience from 14 years of employment in DR. The personal knowledge

has been supplemented by literature and archive studies, interviews among former building managers in DR and consultants for DR, and a questionnaire survey about DR's buildings among present and former managers in DR.

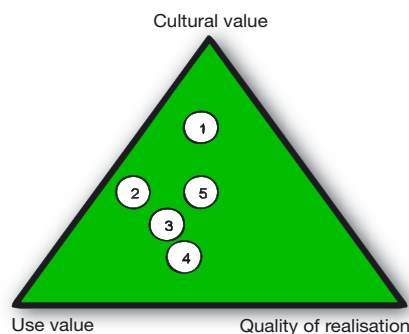
### Real estate strategies and building values

In relation to real estate strategies seven periods can be identified during DR's history with different strategies, and these have generally changed between an incremental strategy and a value based strategy. Only a period in the 1970's can be characterized by a standardization strategy, and this followed the appointment of the first professional building client internally in DR. Each of the three periods with a value based strategy included the start of major new headquarters: Radiohuset, TV-Byen and DR Byen.

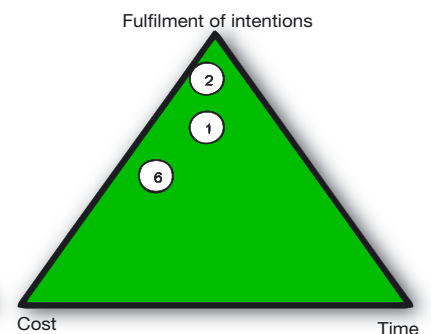


A questionnaire survey shows that 'value as built' is given considerable higher priority than 'value over time'. It also shows that building managers give higher priority to 'use value' than general managers. They however give higher priority to cultural value than building managers. This has important consequences for the way building managers communicate with top management about building investments, and how building consultants communicate with their clients.

### Product integrity



### Process integrity



- 1. Stærekassen
- 2. Radiohuset
- 3. TV-byen
- 4. R/TV-huset and Distrikthuse
- 5. DR Byen
- 6. TV-byen, R/TV-huset, Distrikthuse and DR Byen

DR's buildings is a combination of cultural important and technical complex buildings. The value aspects have had high priority in all building projects and in most cases there have been a good balance between cultural and use value. Cost and time have been given very little priority and this gives some background for understanding the present problems with cost overrun in the construction of DR Byen.

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Koch, Christian

### **Bak, Christian, Alan Øskan**

The plastic tension field method for steel girdes

Poulsen, Peter Noe, Jesper Gath

### **Bak-Kristensen, Kirstine Laurine**

Load modelling on large bridges

Goltermann, Per, Leif Otto Nielsen

### **Banghøj, Klaus, Thomas Brink Laursen**

Vibration control of symmetrical or near-symmetrical structures

Georgakis, Christos

### **Barrau, Xavier**

Seismic performance of base-isolated rail bridges

Georgakis, Christos

### **Benito, Sergio De Lucas**

Design a low energy office building in Spain

Svendsen, Svend

### **Bertelsen, Troels E.K., Johan S. Mathiesen**

Industrial construction

Jensen, Per Anker

### **Biskopsto, Regin Kongsbak,**

Feasibility of carbon-fibre cables on long-span cable-stayed

Georgakis, Christos, Bonke, Sten

### **Brix, Susanne, Ditte Alm**

Non Destructive Testing of Building Materials – with Special Focus on Natural Stones in Outdoor Exposure

Hansen, Kurt Kielsgaard, Bent Grelk, Rambøll

### **Brolund, Axel D.**

Modelling of ignition and flame spread phenomenaes in thin and thick materials

Sørensen, Lars Schiøtt

### **Burgos, Christian Gomez**

Design of facades and ventilation systems for energy efficient office buildings

Svendsen, Svend, Peter Weitzmann,

Toke Rammer Nielsen

### **Carlquist, Anneli E.L.**

Impact of heating system design on the performance of a solar combisystem

Furbo, Simon, Alexander Thür

### **Chrillesen, Casper, Ulrich Jørgensen**

Development of Carlsberg area in Valby

Hoffmann, Birgitte, Morten Elle

### **Christensen, Jesper Hågendal**

Product development of low energy houses

Svendsen, Svend

### **Christiansen, Michael Gould, Jesper Esmann**

#### **Emborg**

Shear failure of fire exposed concrete beams

Olesen, John Forbes

### **Conejos, Marta del Val**

Strain rate properties for cement based composites

Stang, Henrik, Benjamin Riisgaard

### **Czuba, Dennes John, Tim Andersen**

Change Management

Koch, Christian

### **Elverdam, Peter, Kira Hvam**

Redesign of one-family House

Engelmark, Jesper

### **Fazlic, Nidzara**

Anchoring in lightweight concrete elements

Goltermann, Per

### **Fritt-Rasmussen, Janne**

Oil Pollution in the Arctic

Villumsen, Arne

### **Hansen, Casper Roland**

Indoor climate in Greenlandic homes

Rode, Carsten

### **Hansen, Jesper Holm**

Galloping induced vibrations

Georgakis, Christos

### **Henriksen, Kåre**

Special report on progressive collapse

Kjærbye, Per Oluf

### **Howe-Rasmussen, Helle**

Non Destructive Testing of Building Materials – with Special Focus on Natural Stones in Outdoor Exposure

Hansen, Kurt Kielsgaard, Bent Grelk, Rambøll

### **Ingólfsson, Einar Thór**

Pedestrian induced vibrations of line like structures

Georgakis, Christos, Jeppe Jönsson

### **Jacobsen, Thomas Krag, Jacob Clemmensen**

OPP i brobyggeri

Koch, Christian

### **Jakobsen, Annette H.W.**

Implementation of the vision: Copenhagen as a creativ city

Nielsen, Susanne B.

### **Jansson, Jacob**

Assessment of concrete bridge decks affected by alkali silica reactions

Geiker, Mette, Kirsten Eriksen, Rambøll

### **Jensen, Gitte Dorteaa, Jens Hansen Petersen**

Digital construction

Koch, Christian

### **Jensen, Sara Ahle**

Corrosion of reinforcement, identification of corrosion products

Geiker, Mette

### **Jessen, Jens Christian**

Mixed mode fracture of concrete structures

Poulsen, Peter Noe

### **Johnsen, Nicolai L.**

Management and labour cultures

Bonke, Sten, Elsebet F. Pedersen

### **Jørgensen, Ditte Marie**

Natural ventilation with cooling an heat recovering

Svendsen, Svend, Peter Weitzmann

### **Jørgensen, Ditte Marie**

Use of IESVE-program for natural ventilation(Forprojekt)

Svendsen, Svend, Peter Weitzmann

- Jørgensen, Kasper C., Jonas H. Christoffersen**  
Modelling of the Alfred P. Murrah building bombing  
Poulsen, Peter Noe, Benjamin Riisgaard,  
Per grove Thomsen, IMM
- Jørgensen, Natalie A., Rebecca S. Bjerre**  
Refurbishment – alternative methods with steelbuildingsystem  
Engelmark, Jesper, Henning Agerskov
- Jürgensen, Thorsten, Morten H. Christiansen**  
Strengthening of concrete beams in shear with CFRP grids  
Täljsten, Björn, Peter Noe Poulsen
- Kinnberg, Andreas K., Rikke Bille**  
Fire exposed carbon fiber reinforcement  
Hertz, Kristian
- Kisbye, Henrik**  
Barriers and possibilities for dissemination of solar heat  
Elle, Morten
- Knorrenborg, Anders**  
Discrete cohesive cracks in concrete structures  
Nielsen, Leif Otto
- Krag, Anja**  
Rural areas in Denmark – with focus on Lolland-Falster  
Elle, Morten
- Lind, Claus**  
Building structures for supermarket  
Agerskov, Henning
- Thorsteinsson, Ingimundur, Jökull Pálmar Jónsson**  
Load-bearing walls of light weight concrete with combined loading  
Goltermann, Per
- Lyse, Carsten, Kenneth Hedenskog Borbjerggaard**  
Statically and cyclically loaded monopiles in soft clay  
Hededal, Ole, Caspar Thrane Leth
- Maburi, Susi, Dennis C. Pedersen**  
Analysis of a quasi-brick structure  
Jönsson, Jeppe, Leif Otto Nielsen
- Madsen, Morten Werner**  
Construction management and performance in Thailand
- Mikkelsen, Kristian K.**  
Systems for bracing of load-carrying structures  
Poulsen, Peter Noe, Jesper Gath
- Mortensen, Katrine Olesen**  
Floating Windmill Foundations  
Hededal, Ole, Harry Bingham. MEK, and Helge Gravesen, Carlbro
- Mougaard, Jens Falkenskov**  
Analysis of cracked concrete structures using partial cracked XFEM elements  
Poulsen, Peter Noe, Leif Otto Nielsen
- Mouritsen, Ragnar Karbech**  
Moisture conditions and indoor climate in arctic dwellings  
Rode, Carsten
- Nielsen, Christian T.**  
Prefab Roof Units  
Kjærbye, Per Oluf, Arne Egerup
- Nielsen, Kenneth Kevin**  
Smooth particle hydrodynamic modelling of giber reinforced concrete subjected to blast load  
Georgakis, Christos
- Nielsen, Rasmus Dahl**  
Dream House Production  
Koch, Christian
- Olsen, Peter K., Torbjørn Ærenlund**  
Integrated district heating systems for low energy houses  
Svendsen, Svend
- Pade, Eigil**  
Parameter study based on jointed limestone – with focus on tunnel structures in the “Øresund” region.  
Foged, Niels, Ole Hededal
- Qaddoura, Hala H.**  
Tuborg Havnepark  
Kjærbye, Per, Dr. Kuldeep Virdi, external
- Reynisson, Stefan**  
Strengthening of concrete beam with CFRP  
Täljsten, Björn, Peter Noe Poulsen, Fedja Arifovic
- Ruggiero, Caterina, Laura Huntington Villemoes**  
Ecotoxicology in Denmark and Greenland  
Villumsen, Arne, Ingela Dahllöf, DMU
- Schwarz, Frank, Daniel Eeg Lyng Justesen**  
Structural Design and Modelling of High Rise Buildings  
Kjærbye, Per Oluf, Dr. Kuldeep Virdi, England
- Søgaard, Christine, Morten de la Motte**  
Corrosion Monitoring of Concrete Structures – Evaluation of Methods  
Geiker, Mette R., Per Goltermann
- Uyar, Birol**  
Structural use of glass  
Olesen, John Forbes, Henrik Stang
- Westergaard, Dorthea M.**  
Bypass east of Nykøbing Falster  
Brock, Niels
- Yurokov, Dimitar Nikolaev**  
Rock Mechanical Modelling with Reservoir Applications done by PLAXIS  
Hededal, Ole, Niels Foged

## BEng theses

**Bach, Karina Skovborg F., Kamilla Due**  
Risk Management  
Andersson, Niclas, Niels Falck, SKANSKA

**Beenfeldt, Maria, Ivan Blom**  
The Implementation of the Digital Building at  
Contractors  
Jensen, Per Anker

**Birkholm, Jeanette, Inooraq Brandt**  
Permafrost foundations in Thule  
Foged, Niels and Sisimiut Kommune

**Christensen, Lars K., Jøn Petersen**  
Reused material in cold asphalt – the road of the  
future?  
Stang, Henrik, Jan Jansen, ekstern

**Duckert, Gitte**  
Methods for Determination of the Energy  
Performance of Dwelling with floor Heating  
Weitzmann, Peter

**Dzankovic, Elijan**  
Building Services  
Jensen, Hans Thorkild, Børge  
Howald Petersen

**Feddersen, Jesper**  
Reduction of Defects in Building Production  
Bonke, Sten, Knud Christensen

**Flyvholm, Jonas Langer, Kasper Stoger  
Nachman**  
Buildingsmodelling According to "Sketch for 3D  
Workmethods" as Part of the Digital Foundation,  
DDB  
Vestergaard, Flemming

**Froberg, Iben Lyck**  
Moisture Distribution in an Exterior Wood Wall  
Construction  
Hansen, Kurt Kielsgaard, Preben Hoffmeyer

**Gad, Rune**  
Engineering Design of Alterations in apartment  
Block  
Kjærbye, Per, Arne Egerup

**Gottlieb, Sara Wisbech, Rasmus Tofte  
Klinkvort**  
Bubiyah Sea Port Roads  
Bagge, Gunnar, Niels Holck

**Hansen, Anja J., Mette Thyregod**  
Examination of Tension Connection with Selected  
Angle Brackets from SIMPSON Strong-Tie  
Traberg, Søren

**Hansen, Sarah Heiberg, Irene Wilner Bergholt**  
School of the Future  
Kjærbye, Per, Lotte Bjerregaard Jensen

**Hansen, Stine Stensby, Signe Raymond Arnklit**  
New Housing in Lithuania  
Kjærbye, Per, Morten Toft Jensen

**Hemmingsen, Rene H., Johnny Larsen**  
Timber Houses with Several Floors  
Kjærbye, Per

**Henriksen, Maria**  
Roof Structures with long Spans  
Kjærbye, Per

**Holm, Mette**  
The Aesthetic Appearance of Concrete Surfaces  
Geiker, Mette

**Jensen, Dennis P. Sønderby, Niels Duvander**  
Method for efficient design of optimized of low  
energy office building.  
Svendsen, Svend

**Jessen, Mette Højgaard, Ida Lysbeck Madsen**  
Ventilation of Office Building with Respect to  
Energy  
Nielsen, Toke Rammer

**Johnsen, Eva Ehlig, Ulrik Pedersen**  
Design of New Energy efficient Window  
Svendsen, Svend

**Jønsson, Eva Maria**  
Asbest Renovation  
Engelmark, Jesper, Sten Bonke

**Jørgensen, Anette G.**  
Partnering in Construction  
Bonke, Sten

**Jørgensen, Micahael, Martin Vraa Nielsen**  
Upgrading an Existing Building with Regard to  
Energy and Function  
Nielsen, Toke Rammer

**Karlsen, Ina S. Hertz**  
The Workplace of the Future  
Koch, Christian, Anders Munck

**Krogsgaard, Helle, Niels Jakob Magnussen**  
Structural Alteration of Existing Building for  
Alternative Use  
Olesen, John Forbes, Carsten  
Munk Plum, Anders Munck

**Krogsgaard, Helle, Niels Jakob Magnussen**  
Structural Alteration of Existing Building for  
Alternative Use  
Olesen, John Forbes, Carsten  
Munk Plum, Anders Munck

**Lahiri, Said, Edita Talic**  
Bridge and Steel Joint Exposed to Arctic Climate  
Stang, Henrik, Christos Georgakis

**Larsen, Asker Selch**  
Handing-over Procedure  
Andersson, Niclas, Knud Christensen

**Larsen, Michael R., Fatma Yalcin**  
Design of Timber Based House  
Kjærbye, Per

**Lauridsen, Kim Guldberg, Martin Sanderhoff**  
Analysis of Composite Beam  
Poulsen, Peter Noe, Jesper Gath

**Lauridsen, Sune Tang, Mikkel Christiansen**  
Bracing Systems for Buildings  
Kjærbye, Per, Niels Holck, MEK

**Lind, Peter, Marek Dusan Calov**  
Design of an 8-storeys House Building  
Kjærbye, Per

**Lund, Mikkel Vhristensen, Martin Gerstrøm**  
Multistory House in Solid Wood  
Traberg, Søren

**Løjmand, Trine, Anne Sofie Overgaard**  
Tile, Leca etc. Utilized in Greenlandic Building  
Industry  
Villumsen, Arne

**Løvschal, Anders**  
The Workplace of the Future  
Koch, Christian, Anders Munck

**Marcher, Jens C.A., Mikkel H. Cordtz**  
Usability of Key Performance Indicators in the  
Construction Industry  
Koch, Christian

**Mauz, Clements E.**

Frost and thaw Mechanisms Related to Road  
Construction in Greenland  
Brock, Niels, Niels Foged and  
Greenland Contractors

**Molter, Jens Christian**

Flexability of CRC-slabs  
Olesen, John Forbes

**Møller, Sejer J., Andreas B. Ølgaard**

Renovation of Wooden Structures  
Traberg, Søren

**Nielsen, Eva Marie Paaske**

Design of Building  
Per Kjærbye

**Nielsen, Jens-Ole, Louise Finnerup Wille**

Planning of Building(s) in Holbæk Harbour  
Elle, Morten

**Nielsen, Susanne Prior, Bjarke Fogh**

Housing and Sustainability  
Elle, Morten

**Nilsson, Jannie F.R., Ditte B.K. Staunstrup**

A larger urban Transformation Project in  
Copenhagen  
Elle, Morten

**Nygaard, Thomas R., Jacob Rasmussen**

Supply Management  
Bonke, Sten

**Ohlsen, Lene Zwergius, Pernille Gry Andersen**

Interaction between Structure and Foundation  
Fuglsang, Leif D., Niels Holck

**Onib, Hamid Ahmad, Xarin Son**

Sct. Georg College in Sisimiut  
Kjærbye, Per, Per Goltermann

**Pedersen, Martin**

Cities of the Future  
Elle, Morten

**Petersen, Louise B.**

Risk Assessment on Site  
Pedersen, Bente Frydendal

**Petersen, Rune Bødker**

Structural Systems in High Rise Buildings  
Olesen, John Forbes, Jesper Gath

**Rasmussen, Christina W., Lillian Bonde**

Design of Steel Structures  
Kjærbye, Per, Jesper Gath

**Rasmussen, Claus Oved**

Bending Test with Steel Fiber Reinforced  
Concrete  
Stang, Henrik

**Rossen, Marianne, Teddy Hahn Olsen**

Examination of how Different Lighting Influences  
our Experience of External Spaces  
Nielsen, Hans Peter

**Russ, Mica**

Risk Assessment in Partnering Projects  
Bonke, Sten

**Sinding, Jesper Vedsted, Gajendiran**

Kailasanathan  
Covering of Permanent Way  
Christensen, Kirsten, Niels Holck, MEK

**Skifte, Hans-Ulrik T.**

Design of Building for Arctic Conditions  
Borchersen, Egil

**Petersen, Jacob E., Kåre D. Brandrup**

Stability of SCC during Casting  
Geiker, Mette, Henrik Stang

**Svendstrup, Mads L., Therese Schiang-Franck**

Fire Technical Analysis of Seest-disaster  
Sørensen, Lars Schiøtt

**Tindbæk, Jonas, Lars Færch K. Hansen**

Optimisation of Planning and Management  
Bonke, Sten, Jesper Engelmark

**Tolstrup, Henrik Martin, Jakob Strømmandersen**

Pent House  
Kjærbye, Per, Arne Egerup

**Tønnesen, Malte Fryd, Claus Størring**

**Jørgensen**  
Partnering  
Kristiansen, Kristian, Sten Bonke

**Wolf, Christian, Michael G. Jensen**

Select Compacting Concrete Assessment on Frisk  
of Blocking during Casting  
Geiker, Mette, Lars Nyholm Thrane

**Aalborg, Gitte Lerche, Lina Maria Wikstrøm**

Design Proposal for a Stand Base don Laboratory  
Tests on White Concrete  
Hansen, Kurt Kielsgaard, Lotte Bjerregaard  
Jensen, Carsten Munk Plum

## Staff

As of December 31 2006		2006	2005	2004
Scientific	Professor	7	9	11
	Associate Professor	46	38	44
	Assistant Professor	10	15	15
	Other VIP	9	6	4
	PhD students	37	44	40
	<b>Total</b>	<b>109</b>	<b>112</b>	<b>114</b>
Technical and Administrative	Academic	11	11	10
	Clerical	13	12	12
	Technician	18	22	22
	Other TAP	5	5	4
	<b>Total</b>	<b>47</b>	<b>50</b>	<b>48</b>
Total department staff		156	162	162

## Education

STÅ <sup>1</sup> – total		483	508	519
Projects (students)	MSc (civil)	85	92	74
	PMP/BSc (midterm)	31	36	56
	BEng (diplom)	130	62	82
Admission (students)	BSc (Building Technology)	62	72	60
	BEng (Architectural Engineering)	50	52	42
	BEng (Civil Engineering) - summer	75	63	58
	BEng (Civil Engineering) - winter	38	30	32
	BEng (Arctic Technology)	8	9	8

## Research

Refereed papers	Total	45	61	63
	Of these in ISI	30	43	37
PhD theses		5	8	10
Doctoral theses		0	1	0

## Finances

Finances in 1.000 DKK

Revenues	DTU-grant	56.656	53.184	52.523
	External revenue	31.033	30.862	28.563
	<b>Total</b>	<b>87.689</b>	<b>84.046</b>	<b>81.094</b>
Expenditures	Wages	63.021	62.725	62.917
	Other expenses	26.420	19.628	16.445
<b>Total</b>		<b>89.441</b>	<b>82.353</b>	<b>79.362</b>
<b>Result</b>		<b>-1.757</b>	<b>1.693</b>	<b>1.732</b>
Available amount	January 1	7.957	6.264	4.532
Carried forward	December 31	6.200	7.957	6.264

1 1 STÅ is one student annual work (1 STÅ=60 points/student)



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