Annual Report 2008

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Department of Civil Engineering
Annual Report 2008

DTU Civil Engineering
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Charlotte Welin

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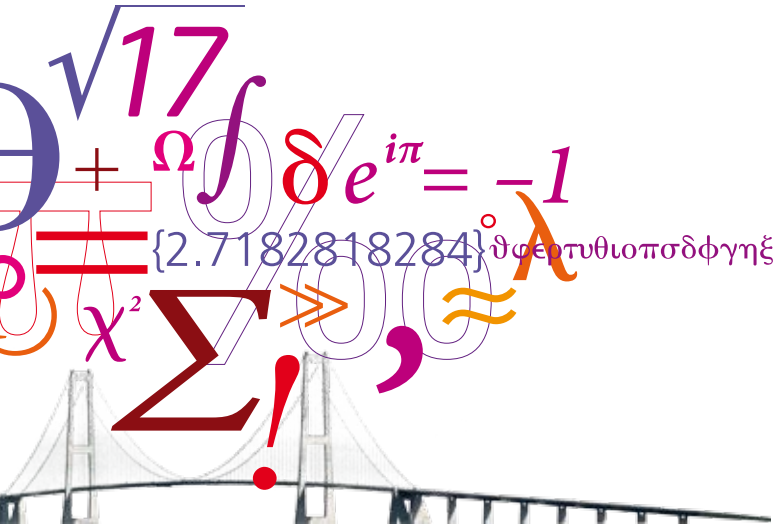
DTU Civil Engineering
Technical University of Denmark
Brovej, Building 118
DK-2800 Kgs. Lyngby

Phone: +45 4525 1700
Fax: +45 4588 3282

byg@dtu.dk
www.byg.dtu.dk



Contents

Management Report 2008:

A new era for DTU Civil Engineering

DTU Civil Engineering is a university department within the building and construction sector.

Our mission is research, education, 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 and Architectural Engineering department and a preferred partner for companies, authorities, and institutions in the building and construction sector.

Strategy and organisation

By beginning of 2008 all the major goals of the department's Strategy 2003-08 were fulfilled. An international research panel concluded that the department is following a clear road map for elevation of the research, and that some of our research groups had moved their level to "high international". Also a revision of all the study programmes following the Bologna Declaration on higher education was completed. Thus the basis was established for a new strategy for the coming years. In stead of writing a new static strategy, the department decided to use DTU's planning cycle as the framework for the strategy process. In April 2008 we held a strategy seminar and developed a new rolling four year development plan (in Danish: UdviklingsMål og Virkemidler, UMV 2009-12), The UMV is now the document that implements DTU's general strategy at department level and sets the strategic goals for the department.

By 1st January 2008 a new organisation following the university merger was established. The International Centre for Indoor Climate and Energy, ICIEE, became a part of DTU Civil Engineering. ICIEE has brought a strong group of dedicated researchers to the department and several new projects and study programme revisions were initiated as a result of the synergy between ICIEE and the Section for Building Services and Building Physics. The new organisation of DTU Civil Engineering has further focused the department's research on technology for the benefit of the building sector.

Research

DTU Civil Engineering focuses research on the areas: Construction Materials, Geotechnics, Structural Engineering, Indoor Climate, Building Physics and Energy, and Building Design.

2008 was a year of scientific conferences organised by DTU Civil Engineering: ICIEE organised The 11th International Conference on Indoor Air Quality and Climate with more than 1100 scientists from all over the Globe. The Indoor Air Conference is the biggest and most prestigious conference in its field and the event in Copenhagen was a great success. The Section for Building Physics and Services organised the Nordic Symposium in Building Physics 2008 in Copenhagen, this conference attracted more than 250 Nordic researchers and was followed by the first "DTU Climate Technology Workshop" on Sustainable Buildings with more than 100 scientist, industrialists and public sector managers. In Sisimiut, Greenland ARTEK organised the conference: Sustainable Energy in the Arctic. The Section for Construction Materials rounded off the year with the Salt Weathering on Buildings and Stone Sculptures conference in Copenhagen with more than 100 scientists from 21 countries.

Two major strategic applications were granted: The Realdania Research Centre for Indoor Climate and Health, CISBO, was established with a budget of 40 Mkr. over five years in collaboration with the Danish universities and research centres AAU, SBi, AU, KU, and NFA, and the National Council for Strategic Research

granted 25 Mkr. to a Research Centre for Zero Emmission Building, ZEB, with participants from the High Tech Network for Low Energy Building, LavEByg. LavEByg is hosted by DTU Civil Engineering.

A major step forward for the research is our continuous collaboration with Femern Bælt AS. Femern Bælt is the owner of the coming rail and road link between Denmark and Germany across the Femern Belt. The collaboration includes several PhD projects in the fields of cable vibration and wind engineering, large diameter piling, and concrete research. We hope to be further involved in this mega civil engineering project in the coming years.

Private and Public Sector Research and Consultancy

DTU Civil Engineering wishes to contribute to the development of an innovative and research based construction sector. In order to do this we seek to inspire and collaborate with industry and authorities in common research and innovation projects. In 2008 the department participated in the creation of a national coordination board for building and construction research (In Danish: Koordinations- og InititivGruppen for Byggeerhvervet, KIG) under the auspices of the Ministry of Economics and Business Affairs. KIG will publish a national research plan for construction research in April 2009 and KIG is working to increase public and private investment in research and innovation in construction related topics.

Education

DTU Civil Engineering manages DTU's education programmes in Civil, Architectural and Arctic Engineering. The annual uptake to the BSc and BEng programmes has increased since 2007 and admission is now restricted using admission grades.

On all BEng programmes we introduced the CDIO concept. CDIO is an international initiative originally established by MIT and KTH with the aim to improve undergraduate engineering education. The vision is to provide students with an education that stresses engineering fundamentals that are set in the context of Conceiving - Designing - Implementing - Operating (CDIO) real-world systems and products.

The new MSc in Architectural Engineering had its first uptake in February 2008. The curriculum is under development and new courses has been introduced. We expect that this new master education will attract a number of international students in the coming years and an international profile is being developed.

All in all the year 2008 marks the begining of a new era in the continuous positive development of DTU Civil Engineering.

Head of Department
Jacob Steen Møller, PhD
jsm@byg.dtu.dk

Organisation

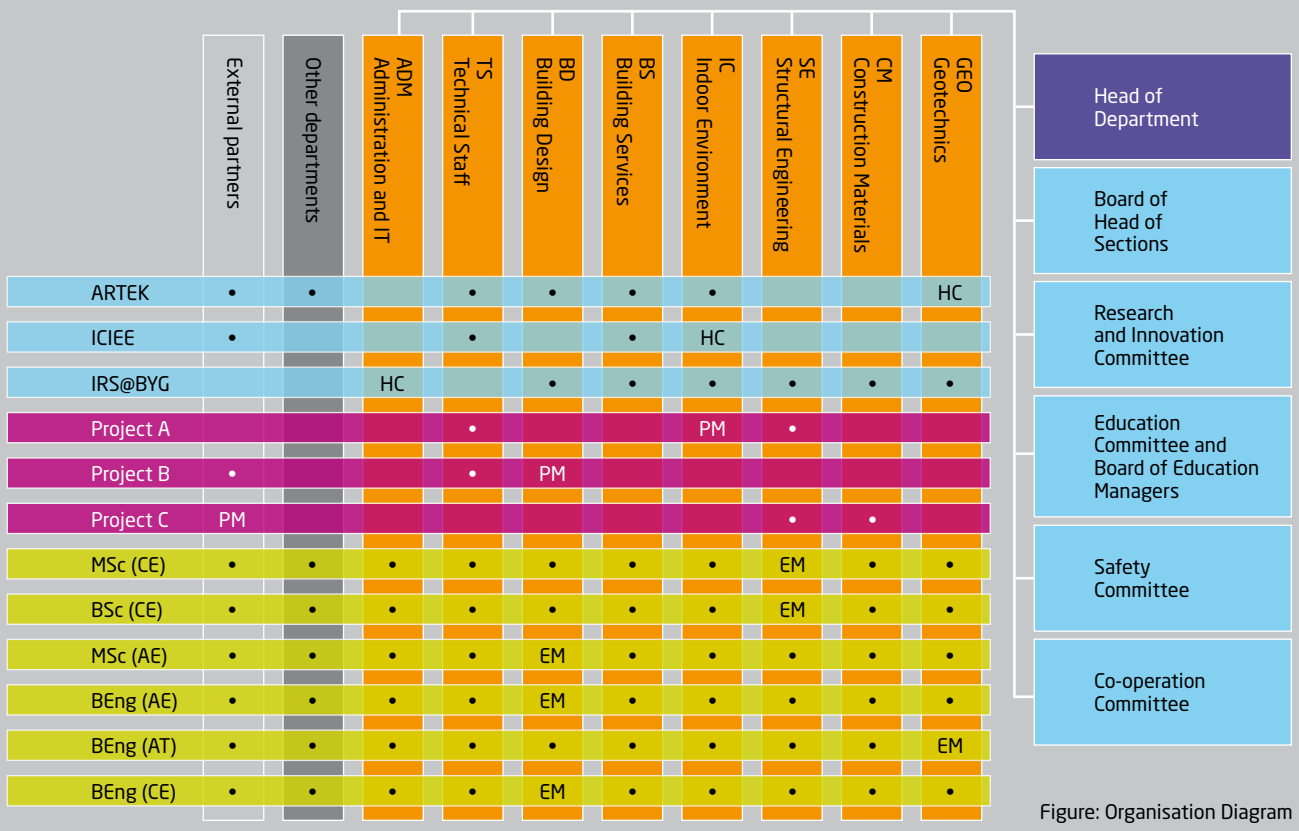


Figure: Organisation Diagram

HC: Head of Centre
PM: Project Manager
EM: Education Manager
• : Project/Education Participant

Sections:

- Building Design
  Professor Kristian Hertz
- Building Physics and Services
  Professor Carsten Rode
- Construction Materials
  Professor Ole Mejlhede Jensen
- Geotechnics
  Associate professor Ole Hededal
- Indoor Environment
  Professor Bjarne Olesen
- Structural Engineering
  Professor Henrik Stang
- Administration and IT
  Søren Burcharth
- The department for Laboratories and Workshops Jørgen Bjørnbak Hansen

Centres:

- IRS@BYG, The International Research School for Civil Engineering. Head of Department Jacob S. Møller
- ARTEK, Arctic Technology Centre. Professor Arne Villumsen.
- ICIEE, Centre for Indoor Environment and Energy Professor Bjarne W. Olesen.

Study Programmes and Education Managers:

- Civil Engineering (M.Sc).
  Associate Professor John Forbes Olesen
- Building Technology (BSc).
  Professor Per Goltermann
- Architectural Engineering (M.Sc).
  Professor Kristian Hertz
- Architectural Engineering (BEng).
  Associate Professor Lotte Bjerregaard
- Building Engineer (BEng).
  Associate Professor Egil Borchersen
- Arctic Technology (BEng).
  Associate Professor
  Hans Peter Christensen.

Advisory Board:

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- CEO Ingelise Bogason, ALECTIA
- Division Director Niels Kjeldgaard, MTHøjgaard
- Head of Office Lasse Sundahl, Danish Enterprise and Construction Authority
- Senior Vice President Carsten Winther Group Technology, Rockwool International.

Cable vibration research and the Fehmern crossing

"The Øresund Bridge cables." Photo: Christos T. Georgakis

Associate Professor Christos T. Georgakis
Section for Structural Engineering
cg@byg.dtu.dk

DTU Byg has assembled a world-class team of researchers to undertake a research project, which aims to provide design guidelines for the mitigation of wind-induced vibrations of cables on long-span cable-supported bridges.

The newly proposed crossing between Denmark and Germany will push the limits in engineering design. The selection of a cable-supported bridge will lead to one of the longest bridges of its type in the world. The challenges in designing a bridge are immense and the prospects of cable-vibrations will undoubtedly preoccupy both the bridge owners and designers. In this connection, Femern Bælt A/S is funding an €1.8 million collaborative research project to examine ways of reducing the probability of cable-vibrations on a bridge solution.

Danish Cable Vibration Group

In the fall of 2004, a group of engineers gathered at DTU to discuss the lingering problem of cable vibrations on structures. Cable vibrations have long affected many structures and the recent willingness of bridge owners and designers to openly discuss the vibrations afflicting their bridges made the meeting even more relevant. The group agreed on a path: collaboration with the goal of better understanding and controlling wind-induced vibrations of cables. The members - Sund & Bælt A/S, COWI A/S, Force Technology and the Department of Civil Engineering of the Technical University of Denmark, DTU Byg, - would later form the core of the Danish Cable Vibration Group.
Research activity within the group has since been rife. In response to ongoing hanger vibrations on the Great East Belt Bridge - connecting Jutland and Sealand, a COWI sponsored industrial PhD was initiated in 2005 with the title "Understanding and simulating wind-induced vibrations of iced vertical cables." The research work, currently being undertaken by Henrik Gjelstrup, has led to the development of a new theoretical model for the prediction of aerodynamic instabilities of cables – one that COWI has indicated they shall adopt for the future prediction of cable vibrations early in the design process of a bridge.

Fehmern Crossing

With the prospect of a choice of a cable-supported bridge for the Fehmern crossing, a larger collaborative research proposal on cable-vibrations was approved by Femern Bælt A/S in early 2008. To support the research project, a new state-of-the-art climatic wind tunnel was also approved. With the research contract signed in August 2008, DTU Byg, Femern Bælt, Sund & Bælt and Force Technology entered a collaborative research agreement for 5 years.

Wind-induced cable vibrations are predominately due to buffeting, vortex shedding, galloping or wake buffeting. DTU Byg will be coordinating an international team of researchers from the Universities of Bristol, Stavanger and Reggio Calabria to examine these vibration mechanisms and find ways of mitigating them. Furthermore, the dedicated climatic wind tunnel, capable of producing sub-zero temperatures and precipitation, will give the research team a quantum leap in capabilities for researching the excitation mechanisms and the means of vibration control.

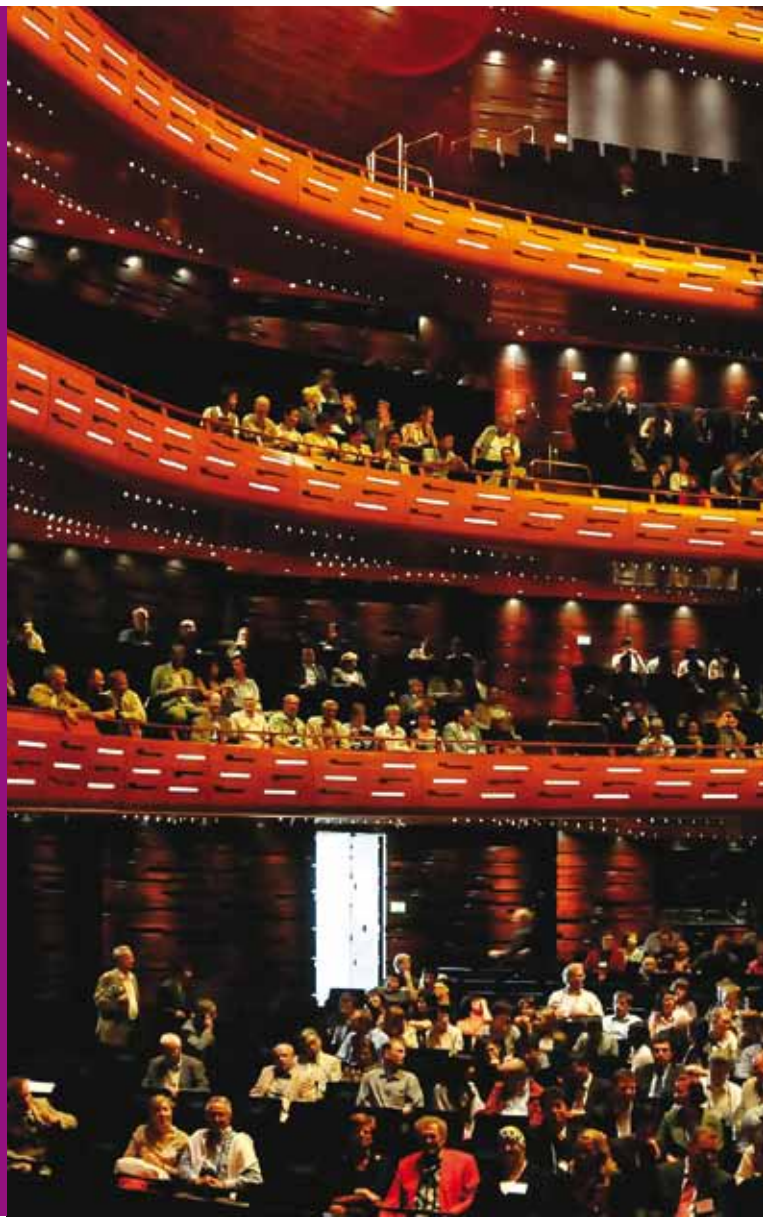
Large cumbersome external dampers and partially effective aerodynamic countermeasures are the only known means for mitigating cable vibrations. Nevertheless, investments in innovation for an engineering project of this size are generally limited due to the inherent risk associated with them. One of the main motivations for the research team will be its ability to suggest improvements and innovation in cable design early in the Fehmern Bridge design process. The current research could lead directly to design guidelines that the bridge's final design would have to adhere to.

In recognition of the current activity in the field, DTU Byg has been provisionally selected to co-host the International Symposium on Cable Dynamics in Copenhagen in 2011.

The conference president Prof. Bjarne W. Olesen opens the technical part of the conference at DTU. Photo: Andreas Szekacs

Conference on indoor air quality at DTU

Participants from around 50 countries met in Copenhagen in order to discuss how the researchers may help providing a healthy and comfortable indoor climate. 731 papers and 33 forums were presented and the evenings gave place to a number of social events.



Professor Bjarne W. Olesen
Section for Indoor Environment
International Centre for Indoor Environment and Energy
bwo@byg.dtu.dk

More than 1200 researchers from approx 50 countries participated in the 11th International Conference on indoor air quality and climate - 'Indoor Air 2008' - at the Technical University of Denmark (DTU). The conference returned to Copenhagen 30 years after the conference was held for the first time in 1978 with as few as 47 papers. The Technical University of Denmark holds a central place in the world for the advancement of the science and practice of providing healthy and comfortable indoor air and was at the previous Indoor Air 2005 in Beijing elected to organise the next conference.The conference took place 17-22 August and was at the previous Indoor Air 2005 in Beijing elected to organise the next conference and involved participants from medicine, engineering, architecture and related fields. 731 papers, eleven plenary presentations and 33 forums where presented and often, as many as eight events took place at the same time.

Latest research results presented

The congress was organised by the International Centre for Indoor Environment and Energy of DTU Civil Engineering with Professor Bjarne W. Olesen as president and Associate Professor Pawel Wargocki and Post doc Peter Strøm-Tejsen as Vice-chairs. The national organising committee included members of several Danish research groups from Aalborg University, Århus University, National Research Institute for Occupational Health, and Institute of Technology.The conference covered all aspects of indoor air and climate and its influence on peoples' health, comfort and productivity. We spend more than 90 percent of our time in indoor environments including our homes, our workplaces and our vehicles. More than 40 percent of all energy use worldwide is for buildings to provide an acceptable indoor climate. Therefore, it is essential to provide an optimal indoor environment in an energy efficient manner.The latest research results were presented at the congress, together with examples on how an optimal indoor environment is achieved in a sustainable manner. The congress addressed various types of indoor environment including residential buildings, offices, schools, industry, commercial, and transportation.

Excellent facilities

DTU provided excellent facilities for the participants with plenary sessions held in the sport halls and parallel sessions in Building

Most of the participants followed the opening ceremony and entertainment in the Opera. Photo: Rodney Aarup/Andreas Szekacs

306. In addition, poster sessions took place in 302, 303 and 101, where also a small exhibition took place. Ironically some of the meeting rooms had many of the same indoor air issues that the conference was intended to help address like too high temperature, odour and insufficient ventilation.

Most of the participants stayed in hotels downtown Copenhagen and used public transportation to get to DTU. Bus-train pass was included in the registration. Copenhagen provided excellent facilities for the social events like the registration and opening ceremony in the Opera, with a magnificent performance of the Royal Ballet and Opera. Copenhagen invited the participants to a reception at the City Hall followed by an evening in Tivoli, and the conference dinner took place in Wallmans Saloons including a fantastic show. As one of the participants accompanied by his wife said: "I have always told my wife about how boring it is to attend conferences; but now she does not believe me anymore".

It was only possible to organise this conference and to invite 11 top keynote speakers due to the generous support from several sponsors like Rockwool, Uponor, Halton, Lindab, System Air, Exhausto, Swegon, Danish Engineering Society, Real Dania and DTU.

Participants are networking at the reception in the Opera. Photo: Rodney Aarup

Research in international focus

An international technical committee "Electrokinetic processes in Civil and Environmental Engineering" chaired by DTU Civil Engineering is newly initiated. Increased fundamental understanding on the use of electrokinetics for e.g. removal of salt from sandstone and heavy metals from polluted soil is the aim of the committee.

Sandstone sculpture severely damaged by salts. Photo: Lisbeth Ottosen

Soil polluted from wood preservation. The vegetation is sparse due to the high concentration of heavy metals. Photo: Lisbeth Ottosen

Associate professor Lisbeth M. Ottosen
Section for Construction Materials
lo@byg.dtu.dk

Looking at these two photos - a sandstone sculpture where the face is lost due to salt decay and the soil, which is so polluted that the vegetation is limited to a few types of mosses - the apparent shared issue is damage. However, the two types of damages are so different that it is not obvious that the solution may be found within the same scientific area – electrokinetics.
In laboratory scale it has been shown that sandstone can efficiently be desalinated and heavy metal polluted soil can be remediated by means of an applied electric field. When an electric field is applied to a moist porous material different transport processes are obtained. On the contrary to mass transport in a pressure gradient, the transport processes obtained in the applied electric field includes transport in the smallest pores, even pores of nanometer size, and this fact is important when utilizing electrical fields for solving problems as those in the photos.

International committee

There are though important fundamental issues, which are not adequately understood in order to foresee the outcome when scaling up the methods. A new research project "Fundamental of Electrokinetics in In-homogenous Matrices" was funded in the autumn 2008 by the Danish Agency for Science, Technology and Innovation, and the aim of this project is to fill in the most important fundamental knowledge gaps to bring implementation of electrokinetic methods closer.
Increased fundamental understanding is also the focus of a newly initiated international technical committee "Electrokinetic processes in Civil and Environmental Engineering" (chaired by DTU Civil Engineering, DTU Byg). The committee is scientifically sponsored by RILEM and has participation of leading experts from 5 continents. The committee is the first wide collaboration between civil and environmental engineers who has in common the utilization of electrokinetic transport processes and it is anticipated that the interdisciplinary collaboration will be highly beneficial to both groups. Thus at DTU Civil Engineering the fundamental of electrokinetics is addressed through intense fundamental and applied research and international collaboration.

Huge problem

Salt decay of historic monuments is a huge problem worldwide and at the international conference "Salt Weathering on Buildings and Stone Sculptures" (organized by DTU Civil Engineering with co-organizers from other important Danish actors in the field) focus was set on fundamental and practical issues related to this type of decay.
Preliminary results for electrokinetic desalination of sandstone were presented at the conference. Systematic research in desalination of sandstone using electrokinetics has not previously been conducted and the interest in the DTU Byg results was huge because they showed very efficient salt removal from a high and problematic level to a harmless level. The electrokinetic desalination research with sandstone has been conducted in laboratory scale with different types of sandstone and no limit in relation to stone type has been seen so far. The research has been supported by Augustinus Fonden and Bergiafonden and due to the encouraging results, the research will continue towards implementation.

Sustainable buildings can effectively **combat climate change**

Energy efficient houses play a decisive role in reducing CO2 emissions. Therefore the development and implementation of sustainable technologies must be accelerated. This was the conclusion of a climate workshop at the Technical University of Denmark in June.

New highly insulated low energy home with cavity wall with an inner and outer brick wall. Photo: Henrik Tommerup

Research assistant Henrik Tommerup
Section for Building Physics and Services
hmt@byg.dtu.dk

Insulation of existing exterior walls under construction in typical home from the 70's. Photo: Rockwool

Multi-storey property after a façade renovation with an improved insulation and a new rain shield. Photo: Henrik Tommerup

DTU Civil Engineering and DTU Management Engineering organized a workshop on Sustainable Buildings that took place on June 19 2008 at the Technical University of Denmark in Lyngby, Denmark, The workshop was the first of a series of workshops and conferences arranged by the DTU Climate Change Technologies programme (see www.dtu.dk/climate) leading up to the Climate Summit COP 15 in Copenhagen December 2009. The participants in the workshop were representatives from companies involved in the building sector and the authorities along with researchers. The companies that participated are vital to the Danish production of energy saving products, consultants in design and operation, and contractors.

In a key note speech, Claude Lenglet, Director of R&D at Bouygues Construction of France and Co-leader of the private-public-partnership on energy efficient buildings (E2B JTI) said that the scientific community agrees that all countries must drastically and rapidly reduce their CO2 emissions and that energy efficient houses play a decisive role in this. He further stated that buildings use 40 percent of the total EU energy consumption and that the built environment generates 1/3 of Green House Gasses in Europe. Replacement rate remains very small (1 to 2 percent per year) and new buildings are still far from being really energy efficient. Therefore, we should now provide solutions at a large scale. Business as usual is not an option.

As the replacement rate in Europe is very small it is especially energy renovation of the existing building stock and also energy supply systems that can contribute to solve climate change problems. To a large extent, the technologies to lower the energy requirement of the building stock are there, they just need to be implemented appropriately.

Urgent action is needed

To accelerate the development and implementation of sustainable technologies and strategies for reducing CO2 emissions from buildings, efforts in the following areas are needed:

- A revitalized energy planning with planning in different scales and solutions reflecting the local context
- Innovative organizations, e.g. new ways of handling energy savings etc, Energy Service Companies, public-private partnerships etc.
- Closer cooperation, updated education and more research based knowledge in the built environment
- Strengthened technical educations, more ”knowing generalists”, training of craftsmen
- Focus on Life Cycle Cost, i.e. operation and maintenance and the environmental impact during the lifetime
- Periodic energy certification of building – like the Danish scheme for cars (e.g. every 5 years). Could be relevant to make one integrated certification scheme including both the energy and physical condition aspects.
- Better building energy requirements: differentiated requirements (worthy of preservation, age etc.), general simplification, control and inspection schemes
- Incentives: cheap loans, investment subsidies, tax advantages, and the providing of standard solutions, off-the-shelf renovation packages, broad energy advising for private house owners and good examples on energy efficient new and renovation of existing buildings

The general attitude at the workshop was that we face large and serious climate change problems that need urgent action. The built environment is an obvious area to put effort into because of the large and cost-effective energy saving potential and potential for Renewable Energy-based supply systems for buildings.

The recommendations from the workshop will be presented at a high-level conference in September 2009, where industrial, governmental and scientific perspectives on climate change issues will be addressed.

A new partnership between engineers and architects

A collaboration between DTU Civil Engineering and Henning Larsen Architects aims at investigating the possibilities and effects of implementing technical knowledge in the early sketching process in order to design energy efficient, functional and aesthetically beautiful buildings and cities.

PhD student Jakob Strømann-Andersen
Section for Building Physics and Services
jasta@byg.dtu.dk

PhD student Martin Vraa Nielsen
Section for Building Physics and Service
mavni@byg.dtu,dk

PhD student Michael Jørgensen
Section for Building Physics and Services
mijo@byg.dtu.dk

1.

How shall we design our future cities and buildings so that they become both energy effecient, functional and at the same time aesthetically beautiful? This question is three new PhD projects at DTU Civil Engineering trying to answer though studies of the way we design and organize our surroundings. The projects startet in fall of 2008.

The projects are sponsored by the foundation Realdania and carried out in collaboration with Henning Larsen Architects. In their motivation Realdania writes: The present projects have a good possibility of becoming the spearhead for how the collaboration between the two trade groups (architects and engineers, red.) can evolve. It will also contribute to a softening of the rigid professional demarcations – which will benefit the building of a sustainable environment."
The projects revolve around the same hypothesis: it is possible to qualify the basis of decisions when designing future cities and buildings through technical scientific sustainability analyses. All projects have energy efficient buildings as a focal point, but try to determine the potential within three different scales.

Scale

The underlying basis is a realization of the close relationship between urban planning, the building and the façade that, not only require technical knowledge, but also a new design process.

Large scale – integrated Energy Design in Uban Planning.

Jakob Strømann-Andersen does research in the design of future urban plans and their influence on the buildings energy consumption. So far focus has been pointed at the optimization of the individual building and its systems, their operation and maintenance. However, the design of the individual building and its contextual placement should always be a result of the urban geometry.
By considering the building as an isolated unit, the interaction between the surroundings and the buildings energy performance is neglected.
The study is morphological and every considered parameter is related to the urban geometry. The project does not have a fully diagnostic goal. Furthermore the goal is not to supply exact measurements of the energy consumption at the urban level, but to set up comparable values that dynamically can be used in an integrated design process.

Medium scale – Integrated Energy Design of larger Buildings.

Michael Jørgensen does research in the design of future buildings with focus on the problematics that arise between building physics, climate, geometry, component and system solutions. The thesis is that if one is able to analyze and optimize the organization of rooms in regard to the energy consumption, one can improve the basis of decision for the building geometry and thereby contribute to the development of a new type of architecture where the spatiality itself is optimized in relation to low energy consumption.
The goal is that the method and the model should function as an "intelligent" tool to aid the creative process through a basis of dynamic analyses at the early stages of the design process.

2.

3.

1. The proposal for the extension of FIH-bank headquarters shows a façade that has been designed with respect to minimizing direct sunlight impacts on the thermal and visual environment in the building, without limiting the view of the surroundings. This results in optimal daylight conditions plus good indoor thermal environment and since no external screening is needed, a reduction I maintenance costs.

2. In proposal for the new school in Ørestaden the façade is optimized with respect to strict demands for both functionality, energy and indoor environment. The division of windows with regards to view and especially daylight, minimizes the over-all glass area which in combination with a number of other initiatives, results in a building that meets the demands for class 1 in terms of both low-energy-building and indoor environment.

3.The proposal for the new urban area Västra Dockan in Malmö operates with a holistic and technical scientific vision for the urban spaces and buildings. This results in unique possibilities for the outdoor comfort level and energy reductions, because the effects from, for example; shade from surrounding buildings can be taken into account, as the impact of wind and daylight conditions from the varying urban landscape designs is considered.

Integrated design works across scales. The understanding that the façade, the building and the masterplan are closely tied provides the basis for Integrated Energy Design (IED) and means that a variety of parameters are considered throughout the design process."

Small scale – Integrated Energy Design of the Building Envelope.

Martin Wrå Nielsen does research in the design of future facades and their dynamic potential and subsequently their impact on the buildings overall energy consumption and indoor climate. The thesis is that a great potential exists in considering the dynamic possibilities of the façade through involvement of engineerical knowledge. Thus will a greater degree of adjustment and adaptability result in a more optimal utilization of the present resources in form of daylight and solar energy.

A dynamic façade can furthermore, in collaboration with architects, become a source of development regarding aesthetics and design with technical knowledge as design facilitator. Thereby the purpose of the project becomes partly a clarification of the facades problematics and potential including the known solutions, partly an investigation of conventional design methods and their problem areas and subsequently suggestions for a solution.

A new Design Process

All three PhD studies deal with energy efficient buildings and have great focus on the process. Consequently a parameter such as Integrated Energy Design (IED) runs like a red thread throughout the research projects. It is done because of the realization that the preliminary design choices, such as the width of the streets and the orientation, geometry and the overall expression of the building have great effect on the overall energy consumption of the building. Parameters, which engineers rarely have an opportunity to have an influence on the traditional design process because of their late involvement when a number of crucial decisions already have been made.

The concept behind IED is a closer cooperation between engineers and architects. Therefore the research is carried out in collaboration with Henning Larsen Architects, which gives an opportunity to investigate the possibilities and the effect of implementing technical knowledge already in the sketching process. Fundamentally the aim is to advocate a more rational approach, where design choices are analyzed technically in regard to energy consumption and indoor climate thus obtaining a more informed process so that the designer or architect makes the informed and "correct" decisions from the start.

Perspective

Joined, the projects therefore search to necessitate solutions, which can fulfil the increasing demands for energy efficiency and sustainability, which have also become very important parameters in architectural competitions. The close collaboration between engineers and architects is therefore essential in order to obtain a more open and rational process, which can meet the stricter demands of the future for low energy consumption and good indoor climate, without compromising the architecture.

Need to strengthen **road engineering in research and education**

A report from DTU Civil Engineering and the Danish Road Directorate shows that university research and education in road engineering have been neglected in recent years. Following the report DTU Civil Engineering has strengthened the field at the department and the relations to the Danish Road Institute.

As the pictures suggest, the need for road engineers is great, since the traffic load is increasing and decaying of roads is expanding; resulting in a greater need for constructing and renovating roads. Photo: Danish Road Directorate

Assistant Professor Maj-Britt Quitzau
Section for Planning and Management
of the Built Environment
DTU Management Engineering
maqu@man.dtu.dk

The road sector is of high socio-economic priority in Denmark. Heavy investments are made in road infrastructure in order to ensure mobility in the Danish society. However, little emphasis has been put on ensuring research and education in the field of road engineering, although this is a prerequisite for professional advancement and recruitment of qualified candidates within the road sector. As a result, road engineering has to a great extent been phased out at Danish universities, with severe effects on the road sector.

The Department of Civil Engineering of the Technical University of Denmark, DTU Byg, in cooperation with the Danish Road Directorate has worked out a report of the necessity to strengthen research and university education within road engineering at Danish universities. The report was published in January 2008, and based on a number of qualitative interviews with central stakeholders in the Danish road sector (including authorities, advisors and developers) and Danish universities.

The report shows that stakeholders in the Danish road sector express concerns about recruitment of candidates, especially at master and PhD levels. The stakeholders bemoan the little interest shown for road engineering among newly qualified candidates. They feel that it is both necessary to strengthen the knowledge development in road engineering (in terms of research) and to expand the basis of recruitment of qualified candidates. This need of strengthening research and education in universities is substantiated by conversations with scientists at Danish universities.

A strengthened education

The report recommends a strategic focus on re-establishing a strong research environment in road engineering in Denmark in order to close the current gap in knowledge and lack of human resources. Such a research environment not only ensures further research, but also an improved basis for the higher education of road engineers.

Three necessary initiatives are pointed out:

1. Greater acknowledgement of research and innovation in road engineering
2. Establishment of strong research environments in road engineering
3. Assure a greater share of synergy and cooperation between stakeholders in the field.

Following the report, DTU Byg has taken initiatives to strengthen research and education in road engineering at the department. Besides continuing a close dialogue with stakeholders in the road sector, the section of Geotechnics at DTU Byg in 2008 had a visit from a renowned specialist in road pavements, Professor Hosin Lee from the University of Iowa, in order to formulate a research vision and to strengthen the relations to the Danish Road Institute. Also, the Arctic Technology Centre of the Technical University of Denmark has established a road laboratory both at DTU Byg and in Greenland, sponsored by the Greenlandic home rule government, in order to support research and education activities in road engineering under arctic conditions. Finally, a new position as associate or assistant professor in road construction has been advertised to be filled in during spring 2009.

With the launch of these activities, DTU Byg is pushing for a revival of the field of road engineering, but such a revival can only be successful, if the initiatives are supported by stakeholders in the road sector and by political initiatives, the report concludes.

IRS@BYG **is alive and prospering**

2008 was a good year for The International Research School for Civil Engineering with a continuously growing number of new PhD students.
The future looks bright for the school with international collaboration and several co-financed PhD projects.

PhD student Anne Bagger, 32 years, from the Section for Structural Engineering is one of 56 PhD students at DTU Civil Engineering. She studies facetted shell structures in glass and joined the department in 2006. Anne Bagger graduated from DTU Civil Engineering in 2001 and came to the Technical University of Denmark from a position in the engineering company Rambøll Danmark A/S where she designed steel and glass structures. Today she has her own company. Photo: Simon Klein Knudsen/MAKWERK

Associate Professor Hans Janssen
Deputy manager of IRS@BYG
haj@byg.dtu.dk

The International Research School for Civil Engineering (IRS@BYG) was launched on January 1st 2005. Since its launch in 2005, the research school has steadily grown and currently gathers 56 PhD students. Of these, 18 have started in 2008, compared to on average 14 starting students in 2006 and 2007. The International Research School for Civil Engineering is hence living up to the growing expectations of the Technical University of Denmark, DTU, concerning the education of PhD students.
A lot has happened for the research school in 2008 and evolutions can be seen on many fronts: internal and external collaboration, internal and external communication, and financial support to school and student

Internal and external collaboration

At the start of 2008 the Section of Planning and Management of Building Processes left the Department of Civil Engineering DTU Byg, to join the new Department of Planning Engineering. The section however remains part of the research school, and we hope for a rewarding further collaboration. At the same time, the Section and Centre for Indoor Climate and Energy joined the research school, permitting us to collaborate more closely on themes like indoor climate and sustainable buildings.
The same theme is the driving force for the newly founded Graduate School for Sustainable Energy, in which the research school collaborates with similar schools from the Technical Universities of Munchen (Germany) and Eindhoven (Netherlands). This Graduate School is one of the first particular results of the European University Alliance between DTU, TUe and TUM.

Internal and external communication

Internally, the 'departmental PhD days' have been succeeded by 'sectional PhD seminars'. These allow the PhD students to present their current results to their peers, from which they can receive more in-depth feedback. The first such seminar in the Section of Building Physics and Services was considered a success by both the presenters and the audience.
Externally, the merits of obtaining a PhD degree have been presented to future potential PhD students through the 'Become a PhD in Civil Engineering' event. At this info seminar, some 25 Master students were introduced to the many aspects of a PhD project by staff from DTU's PhD office, by current DTU Byg PhD students, and by PhD's from the 'field'. Some of the participants are at present in the starting phase of their PhD, and the event will certainly be repeated in 2009.

Support to school and PhD students

In November 2007, the International Research School for Civil Engineering was awarded with a 1.200.000 DKK Quality Enhancement grant by Forskings- og Innovationsstyrelsen. This grant has enabled the research school to support the organisation of several PhD summer schools and the 'pre-doctoral' hiring of promising PhD students.
Finally, in May 2008 the research school submitted its application 'Enhanced Research and Synergy in the Built Environment' to the Samfinansierede Stipendier call from Forskings- og Innovationsstyrelsen. That application was awarded with 2.475.000 DKK in November 2008, allowing the research school to start four co-financed PhD projects in 2009.
As you can see, a lot has happened for the research school in 2008, and we aim at continuing this trend in 2009.

A good start at **DTU creates better students**

The experience at DTU Civil Engineeing, DTU Byg, is that a good start for the new students with an intense mix of social and teaching activites, leads to happy, hard-working, enthusiastic students with a good network – and to students who are a pleasure to teach in the courses.

Students enjoying the high view from 12th floor – nice view of the site. Photo: Per Goltermann

Professor Per Goltermann
Education Manager
pg@byg.dtu.dk

At the Department of Civil Engineering, DTU Byg, the BSc-students are offered an introduction RUS-tour a week before the official semester start. This tour is 100 percent organized by the students association and provides detailed information about DTU, the rules of the university, dormitories etc.. During the tour the students are organised in vector-groups of 8-10 new students, headed by a vector (an older student on 3rd or 5th semester).

The vector group will be the core group in the beginning of the studies and will normally be used as study group in the courses in engineering mathematics and physics on the first semesters. The group meets weekly with the vector, who guides the freshmen in their studies in the first semester and brief them about the aspects of living a new life. The group typically meets once a week. The vector also invites the students to social activities, followed by a weekend tour in the mid-semester so that the students will be able to build a strong network in the class.

The vector is supported by a tutor (an associated professor). The group tutor is introduced to the students and the group before the RUS-tour. The tutor meets the individual student a number of times during the semester and he has the responsibility for guiding the students in selection of courses or other aspects beyond the vectors experience.

Two independent surveys carried out in 2008 showed that 96-98 percent of the students thought that the semester start from a purely professional point of view had been good or very good while 85 percent were content or very content with the semester start from a social point of view.

A nice surprise

The actual study at DTU Byg begins with an initial course "Engineering work", which is an introduction to the study and later life as a civil engineer. The students work in changing groups on 4-5 problems, ranging from the design, construction, testing and autopsy of a bridge over testing and analyzing building materials, estimating bridges with building mechanics and optimization of the design, free hand drawing and CAD to the building energy design of a house. These problems do not only act as introduction to different

Introduction to the construction site, safety and the building process with alls its challenges in high-rise structures. Photo: Per Goltermann

technical areas, they also show the new students, that they are actually able to understand and solve more problems, than they expect – which comes as a pleasant surprise for many.

The course contains also excursions to building sites, lectures by young engineers from private companies (role models) and introductory lectures to different specialization areas in order to facilitate the later choices of courses.

This approach to the study and the social life as a student at DTU leads to a very strong network in the class already in the first semester, where all students have worked together with approximately 35 percent of the class and met the whole class in a number of social events.

This package of social and teaching activities forms an intense and interesting start for the students at DTU – and is essential in creating the right attitudes to teaching among students and teachers, a thing which will maintain and improve the high levels at DTU.

Preliminary test loading of our designed and build bridge: It actually works very well. Photo: Egil Borchersen

A new Geeenlandic industrial PhD programme

The Arctic Technology Centre of DTU Civil Engineering and Greenlandic companies cooperate in the effort to develop new geophysical survey schemes, which will be of benefit for the Greenlandic society.

PhD student Mojmir Choma
Arctic Technology Centre
mocho@byg.dtu.dk

PhD student Inooraq Brandt
Arctic Technology Centre
inbra@byg.dtu.dk

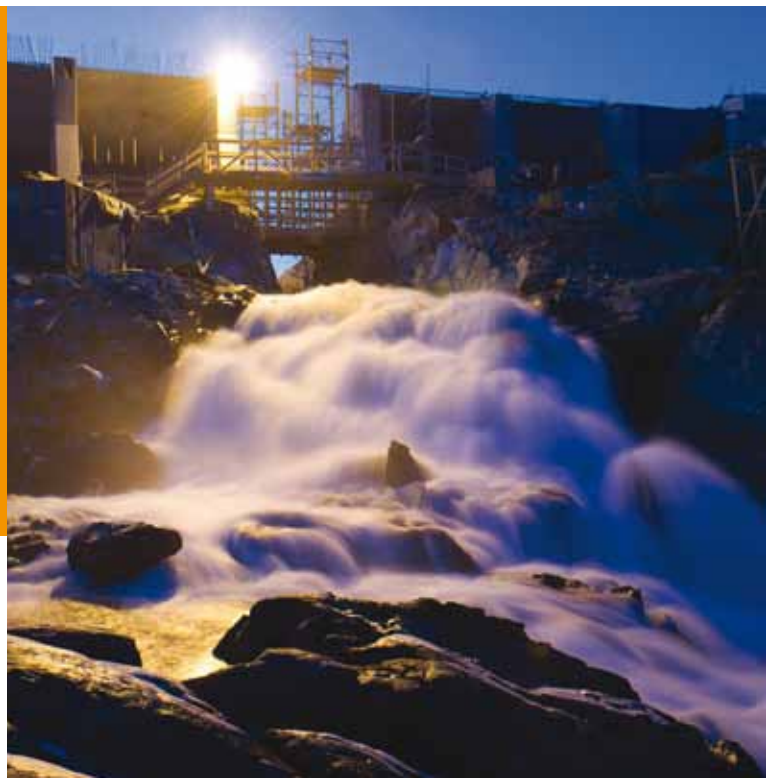
A new Greenlandic Industrial PhD programme was introduced in 2008. The programme has established a frame for cooperation between Greenlandic companies and academic institutions as the Arctic Technology Centre of the Department of Civil Engineering, ARTEK. As chief executive officer Keld Hornbech Svendsen from Asiaq puts it:

"Asiaq finds that the new Industrial PhD programme provides great possibilities for cooperation with DTU and ARTEK in regards to development of new geophysical survey schemes, which we expect will be of benefit for the Greenlandic society. E.g. in relation to development of new and improved survey methods which in return will provide an enhanced knowledge base for Greenlandic construction design."
The two first PhD students following the programme have based their research at ARTEK in cooperation with Asiaq – Greenland Survey respectively and the Greenlandic energy company Nukissiorfiit.

"Integrated Geoscience Study of Extend and Effects of Permafrost Change in Greenland" is carried out by Inooraq Brandt, M.Sc. Civil Eng., in cooperation with Asiaq in Nuuk, Greenland. Inooraq seeks to determine the applicability of geophysical methods to mapping of permafrost and ice content in frozen deposits through field surveys at different localities in Greenland and correlation with geotechnical information. Focus is on the use of Ground Penetrating Radar, seismic measurements, DC resistivity methods, Electro-Magnetic methods and microgravity. Due to anisotropic features in different types of permafrost, the methods are not always conclusive when used individually.

Climate amelioration

Inooraq will benefit from experiences at relevant research facilities through participation in courses on Svalbard and cooperation with researchers in the Alps and/or Alaska. The results will serve as basis for an evaluation of the effect of climate induced changes in permafrost conditions and the effects on infrastructure and constructions. Development of databases regarding permafrost distribution and physical properties near urban areas in Greenland will contribute to necessary adaptation and mitigation procedures in relation to the ongoing climate amelioration in the Arctic, which typically results in structural damages of buildings and roads due to subsidence in ice rich soils.

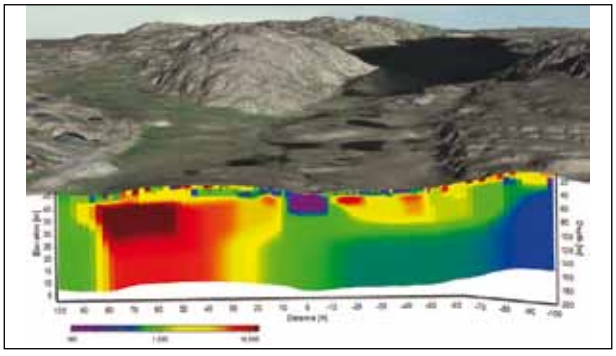


Dam construction at Qorlortorsuaq; power supply for Narsaq and Qaqortoq in South Greenland. Photo: Nukissiorfiit.

"Hydro Power Potentials in Southern Greenland" is carried out by Mojmir Choma, M.Sc. The main focus of the project is to determine areas best suited for efficient production of hydro power energy in Greenlandic towns and small settlements. This is to be done through surface and hydrological modelling based on data measured in relevant areas. Different commercial software programs are to be implemented, e.g. ArcGis and Surfer, for 2D and 3D surface modelling, and Matlab and Python, for hydrological modelling. Measured data include determinations of run-off areas, description of geological conditions, precipitation amounts and other hydrological parameters. The models are to produce an overview of water quantities and stability over time which is to be used in calculations of production potentials.

Green energy

Arctic areas are important in terms of present and particularly future hydro power potentials. Due to the geology, ice coverage and today's global warming, Greenland has some of the world's best conditions for producing high volumes of green energy. During the project Mojmir is to collaborate with Professor. Eng. Jan Szolgay, PhD from the Department of Land and Water Resources Management at the Slovak Technical University and with the Department of Hydrogeology at Comenius University.



Electrical resistivity profile and digital terrain model of the Thermokarst valley in Sisimiut, West Greenland. Photo: Thomas Ingemann-Nielsen, ARTEK

CDIO

- learning by doing

80 students at DTU Civil Engineering built small scale houses in order to demonstrate which factors influenced the energy consumption for heating houses. The course is a part of a new educational concept at the Technical University of Denmark.

After construction the small houses were placed outside in the cold November weather. Photo: Egil Borchersen

Associate Professor Egil Borchersen
Education Manager
eb@byg.dtu.dk

By the start of the autumn term the new educational concept CDIO was implemented in the programme of Bachelor of Engineering at the Technical University of Denmark, DTU. "Design and build a small scale house and demonstrate which factors that influences on the energy consumption for heating houses" was the task for one of the courses. The 80 students were worried and their teachers a bit in doubt about how to manage this new way of "lecturing a course" but we succeeded and ended up with 21 small houses.

The CDIO concept also consists of a number of other initiatives which have to be implemented in the curriculum. The international CDIO organisation initiated by MIT in Boston and Chalmers in Gothenburg has set up 12 standards to be fulfilled by a CDIO based curriculum. However the DTU central committee for CDIO implementation decided to start with fewer standards. Among these was the demand on setting up learning objectives for all DTU courses and working out learning outcomes in detail on course level. Though most courses previously have formulated objectives we now obtained a more clear and comparable wording. Another task was to introduce a cross disciplinary project on each semester. For those who have been involved in teaching at DTU during the last decades this is not a new wish. May it succeed this time.

Designing houses on paper

In the curriculum for the Bachelor of Engineering in Civil Engineering the interdisciplinary project this autumn was Energy Consumption in Building and the Build Design course (11701) was combined with the theoretical course Building Energy (11738), in which the thermal design of buildings is handled. I the beginning of the semester the students were forced to make decisions about their design without the necessary theoretical background.

The process was divided in four periods. First one month one day a week for conceiving the assignment and designing the small house on paper. Then the second month for building the house in the new established workshop in Building 117. In the implement phase - the small houses were placed outside in the experimental area. Each house contained an electrical heater with a thermostat securing that the temperature inside was kept in the interval from 18-22 degree Celsius. Furthermore a small data logging device was place inside each house logging the time the heater was active. There were only few sunny hours during the measuring period in November, and the outdoor temperature passed below zero some of the nights so the houses were really tested for their energy saving ability.

Time for the final report

The last period (the operate phase) was used for handling the data and making the final report. In the meantime the students have learned in the parallel energy course how to theoretically calculate the expected energy consumption. So now the measurements were compared with the expected energy consumption. The huge amount of data was reduced to a few significant numbers and as a whole the measured consumptions showed up to be about 70-90 percent of the theoretical value.

Above the successful part of the new curriculum is described. Of course there are also less successful parts. During the course some students chose to drop out. We did not succeed to find out why. A number of other CDIO initiatives have not yet been implemented in the curriculum because the working group concentrated on getting the first semester ready in time. The first semester students have in the meantime continued to the second semester in which the interdisciplinary project is more a theoretical project.

Prediction of reinforcement corrosion in concrete structures

A collaborative PhD project takes place between DTU Civil Engineering, Sund & Bælt Holding A/S and Femern Bælt A/S to establish a numerical model for corrosion of reinforcement taking into account cracks and other defects. Such model will both facilitate the assessment of existing structures and support the design of new reinforced concrete structures.

Associate Professor Mette Geiker
Section for Construction Materials
mge@byg.dtu.dk

Professor Henrik Stang
Section for Structural Engineering
hs@byg.dtu.dk

Associate Professor John Forbes Olesen
Section for Structural Engineering
jffo@byg.dtu.dk

Much emphasis is placed on means of ensuring a long service life of reinforced concrete structures, and the possible impact of cracks is an area of major concern. Concrete has a high compressive strength, but a low tensile strength and is therefore reinforced for structural purposes. Typically, black steel is used for reinforcement, and the steel is well protected by the alkaline concrete. However, aggressive ions as chloride from sea water or deicing salt may penetrate - in particular through cracks - and cause premature steel corrosion.

Large sums are used to ensure the durability of concrete structures, especially to protect against reinforcement corrosion. Durability considerations are thus an integrated part of the design, construction, and operation phases of important infrastructure structures such as the Great Belt Link and the planned connection over Femern Belt.

Improved durability leads to increased structural reliability, less maintenance and repair, and overall increased sustainability. Possible solutions improving service life, however, are difficult to evaluate, since current service life models are not based on detailed descriptions of the corrosion process. Also they do not take into account the presence of cracks and other defects.

New prediction tool

For a comprehensive evaluation of the service life, models based on physio-chemical concepts are needed. These models should - besides a description of the electro-chemical corrosion process itself - include description of the structural detailing, the materials properties (including defects and cracks) as well as aging and deterioration.

Development of such models is the focus area of an ongoing research project. The models will, among others, support the selection of materials, including possible nanotechnological solutions. The project is undertaken by PhD student Alexander Michel together with supervisors from two sections of the Department of Civil Engineering, namely the Section for Construction Materials and the Section for Structural Engineering, as well as supervisors from the large infrastructure owners Sund & Bælt Holding A/S and Femern Baelt A/S. In addition, the project benefits from, among others, two recent PhD projects undertaken in close collaboration with Professor Per

The Great Belt Link. Photo: Sund & Bælt Holding A/S

Møller, DTU Department of Mechanics. PhD student Andre Küter, now COWI A/S, adapted available thermodynamic principles to the area of reinforcement corrosion and established a thermodynamically consistant description of diverse corrosion states of steel in concrete. Former Industrial PhD student Peter Vagn Nygaard, Force Technology, provides, among others, data on the impact of temperature and relative humidity.

Initially, a two phase model (Figure 1a) will be established based on current literature. This initial model will include transport and selected electrochemical processes to allow simulation of the propagation of macro-cell corrosion in a homogeneous defect-free system. After evaluating the ability of the model to simulate the corrosion process, the model will be extended to include varying surface conditions and cracks. Based on this deterministic multiphase model (Figure 1b) for macro-cell corrosion, a probabilistic service life model for the propagation phase of cracked reinforced concrete will be established.

Fig. 1a: Two phase corrosion system

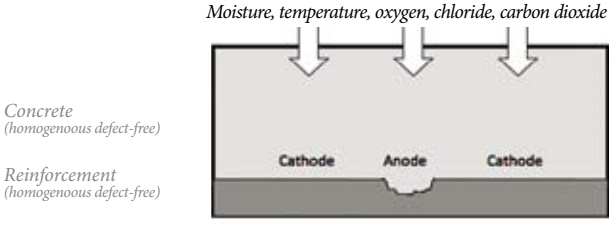


Fig 1b: Multiphase corrosion system

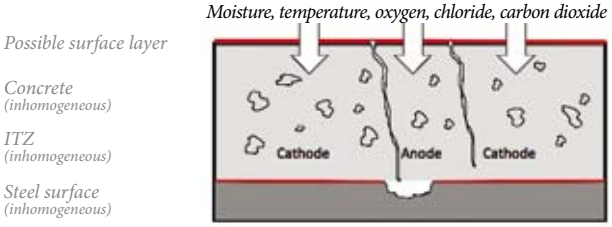


Fig. 1: Concrete-steel systems to be modelled. Illustration: Alexander Michel

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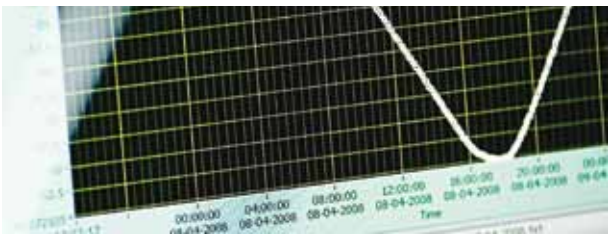

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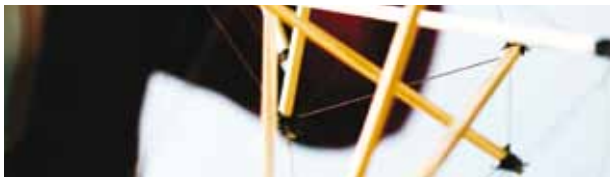

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Bjarne Poulsen
Permeability testing of Cementitious Materials by Beam-bending Method
Arsen Krikor Melikov

Avdo Fetahagic
Strengthening of Reinforced Concrete Beams with Carbon Fiber Reinforced Polymers (CFRP) - Application of the Crack Sliding Theory. Björn Täljsten

Kristinn Pétur Skúlarson
Thin High Performace Concrete Structures Reinforced with CFRP - Investigation of Fire Properties Björn Täljsten, Gregor Fischer

Helgi Þór Guðmundsson
Applications of Mineralbased Repair System Björn Täljsten, Gregor Fischer

Matar Ali Muttar Al-Badri
Thin High Performace Concrete Struc-tures Reinforced with CFRPre-inforcement
Björn Täljsten, Katalin Orosz

Pedro Natário
Interlaminar Peeling in Concrete Beams Repaired with CFRP
Björn Täljsten, Piotr Rusinowski

Christian Wolf
Tension of RC Concrete Prisms Strengthened with CFRP Plates
Björn Täljsten, Piotr Rusinowski

Ruben Murargi, Jorge Lopes
Seismic Analysis of the New Icelandic Conference Centre. Christos Georgakis

Morten Møller van Gils Hansen
Examination of Forced Cable Vibrations and Their Decay - A Case Study on The Øresund Bridge Christos Georgakis, Holger Koss, Allan Larsen (ex)

Esben Ehrenreich Thorup, Michael Krolykke
Cross-beam Configuration in Multi-check Cable Supported Bridges. Christos Georgakis, Lars Jensen (ex)

Abbas Abdallah
Structural Design of Multistorey Building. Egil Borchersen

Søren Udengaard Johansen
Consequences in Implementing a Digital Building Process. Flemming Vestergaard

Jesper Ege Rasmussen
Analyse af DBK som klassifikationssystem. Flemming Vestergaard

Niels Treldal
Integrated Data and Process Control during BIM Design
Flemming Vestergaard, Carsten Rode

Frederik Emil Nors, Thomas Berend Nielsen
Identification of Indoor Environmental Factors and Technical Systems that Safeguard Children's Health in Day Care Facilities. Geo Clausen

Þorunn Sigurdardóttir
Utilization of Recycled Glass in Concrete . Gregor Fischer

Lárus Helgi Lárusson
Detailed Design of a Composite Floor Deck Element Gregor Fischer, Jeppe Jönsson

Asger Pervez
Office Building in Six Storeys; Structural Analysis of Main Structure, Concrete Elements and Connections According to Eurocode. Gregor Fischer, Per Kjærbye

Dorte Bøge Jensen, Pernille Karstoft Bak-Jensen
Forum Horsens Stadium - Structures. Henning Agerskov, Henrik Tinning (ex)

Sorin Antonio Susnea Raftopol
Bygningsprojektering, stål. Henning Agerskov, Per Kjærbye

Sara Møller Jakobsen
Bæreevne af pladedragere med hensyn til tværkræfter
Henning Agerskov, Peter Noe Poulsen, Jesper Gath (ex)

Ida Lysbeck Madsen
Financial Updating at the Contractor Skanska. Henrik Buhl, Sten Bonke

Thomas Groth Harpsøe, Andreas Conrad Lundsteen
Diaphragm Action in Skandek Roof Ele-ments. Jeppe Jönsson

Mikkel Christiansen
Pedestrian Induced Vibrations in Pedestrian Bridges
Jeppe Jönsson, Einar Thor Ingolfsson

Helle Krogsgaard
Investigation of a Joint for Plane-based Shell Strucures of Glass
Jeppe Jönsson, John Forbes Olesen, Anne Bagger

Andreas Breum Øl-gaard
Application of an Adhesive in an Mechanically Reinforced Glass Beam
John Forbes Olesen, Jens Henrik Nielsen, Henrik Stang

Sine Gustavsen
Indeklima i skoler. Jørn Toftum

Finn Larsen
Light Concrete Structures. Kristian Hertz

Jesper Prip Bonnesen
Prestressed Concrete Structures and Fire. Kristian Hertz

Thomas Bo Frederiksen
Investigation of Evacuation in High Rise Buildings
Lars Schiøtt Sørensen

Jesper Scott Johnsen
Vandtågeanlægs slukningseffekt belyst ud fra forsøg
Lars Schiøtt Sørensen, Carsten Palle (ex)

Karen Ravn
Undersøgelse af reaktions- og beslutningstid
Lars Schiøtt Sørensen, Morten B.S. Valkvist (ex)

Peter Engkilde
Load Capacity of Reinforced Concrete Shells. Leif Otto Nielsen

Anja Josefine Hansen, Mette Thyregod
Determination of Corrosion Initiation of Steel in Concrete
Mette Rica Geiker, Peter Vagn Nygaard, Per Goltermann

Cecilia Raae Støvel-bæk
A Critical Analysis of Citizens's Attitude to their Personal Mobilities
Morten Elle

Rikke Munch Bendtsen
Innovation of Sustainable Building. Morten Elle

Ikhlas A Ali
Development of Water Supply in Erbil. Morten Elle

Ina Sybille Hertz Karlsen, Iben Lyck Froberg
An Urban Development Project in Copenhagen. Morten Elle, Kristoffer Weiss (ex)

Srinivasa Raghava Tharimela
Advanced Rock Mechanical and Physical Studies of Saltwash Sand Stone
Niels Nielsen Foged, Katrine Alling Andreassen, Ida Lykke Fabricius

Niclas Grønkjær Rasmussen
Shear Strength of AAC Beams. Per Goltermann

Anders Ole Stubbe Solgaard, Mikkel Wyrtz
Inplane Shear Test of Fibre Reinforced Disks. Per Goltermann

Kristin Islev Knudsen
Plates in Fibre Reinforced Concrete. Per Goltermann

Claus Madvig Nielsen
Bæreevne og levetid af en betonbro. Per Goltermann

Peter Lind
Fiberarmerede bjælker. Per Goltermann

Jonas Sejersbøl Jacobsen
Mixed Mode plasticitetsanalyse af betonkonstruktioner
Peter Noe Poulsen, Leif Otto Nielsen

Julie Malbæk
Static and Dynamic Analysis of Ca-blestayed Pedestrian Bridge
Peter Noe Poulsen, Niels Jørgen Gimsing

Jacob Maare Pedersen
Study of the Failure Properties of Treated Wood with Focus on Brittleness
Sigurdur Ormarsson, Staffan Svensson

Roberto Gimenez Mata
Inlet Stratifiers for Solar Tanks. Simon Furbo, Elsa Andersen

Kim Obel Nielsen, Mathias Gjendal
Experimental Methods for Determening the Longterm Strength of Wood
Staffan Svensson, Tho-mas Astrup

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Use of Risk Management in the Danish Construction Industry. Sten Bonke

Morten Elleskov Christensen
Planning and Management Principles in Construction
Sten Bonke, Henrik Sørensen (ex)

Sarah Leenknegt, Jonas Vandermaesen
Methodology of Integrated Design of Low Energy Office Building
Svend Svendsen

Gonzalo Obrador Sánchez
Heating System for Low-Energy Houses. Svend Svendsen

Louise Finnerup Wille
Integreret design af bygninger med fokus på dagslys og belysning
Svend Svendsen

Maja Heiede
Development and Investigation of Passive Ventilation Systems
Svend Svendsen, Christian Anker Hviid

Michael Jørgensen, Jakob Strømann-Andersen
Use and Development of Integrated Design Method for Large Buildings. Svend Svendsen, Lotte Bjerregaard Jensen

Inooraq Brandt
Geofysiske undersøgelser af permafrostrelaterede strukturelle skader på veje og landingsbaner i Thule, Grønland. Thomas Ingeman-Nielsen, Niels Foged

Lars Lehn Rasmussen, Camilla Dyring
Supply of Makeup Air in Mechanically Ventilated Low Energy Houses
Toke Rammer Nielsen

Anne Kirkegaard Meibom
Demand Controlled Ventilation in Single Family Houses. Toke Rammer Nielsen

Tina Bull Kipper
Energirenovering af enfamiliehuse. Toke Rammer Nielsen, Jesper Engelmark

Lina Wikstrøm, Martin Vraa Nielsen
Analyse af indeklima og brandsikkerhed for den danske pavillon til Expo 2008 samt efterfølgende konvertering til kontorareal
Toke Rammer Nielsen, Lotte Bjerregaard Jensen, Lars Schiøtt Sørensen

BEng theses

Anders Christian Pinholt Kancir
Structural Design of Building. Per Oluf H Kjærbye, Per Goltermann

Mads Devantier Dysted Nielsen, Henrik Peter Møller
Urban Development and Planning
Susanne Balslev Nielsen, Vibeke Møgelvang Nielsen

Jonas Eik Jacobsen
Day Light in Office Buildings. Svend Svendsen

Christoffer Anton Plesner-Petersen, Steven Ipsen
The House based on Kyoto 2020 - Energy Consumption of 2020
Toke Rammer Nielsen

Lene Westh
Lavenergi-enfamiliehus hævet på pæle. Toke Rammer Nielsen

Tina Vickie Aagesen, Kristjana Ósk Birgisdóttir
Sustainable School Building
Toke Rammer Nielsen, Per Oluf H Kjærbye

Kim Eriksen, Henrik Gunnar Pedersen
Materials for Arctic Road Construction. Arne Villumsen

Mette Hersom Hansen
Tagboliger. Egil Borchersen

Christian Jøns Nielsen, Jesper Jøns Nielsen
Projektering af fleretagers betonelementbyggeri. Egil Borchersen

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Projektering af fleretagers betonelementbyggeri. Egil Borchersen

Stefan Gregers Brandt Johansen, Bjarke Stenaa Ørvad
Digital Architecture - Computer Modelling as basis for Design and Production with Developable Surfaces. Hans Peter Nielsen

Trine Vibeke Bay, Kaja Stenrød Paulsen
Innovative Material and Assembly Method - Test of Adhesive Joints between Composite Profiles of Glass Fibre Reinforced Polymers
Kurt Kielsgaard Hansen, Lotte Bjerregaard Jensen

Navid Sidiqi, Anders Hornshov Jakobsen
Styrke- og holdbarhedsundersøgelser af hvid plastfiberarmeret beton til LightHouse-projektet. Kurt Kielsgaard Hansen, Lotte Bjerregaard, Gregor Fischer

Christian Møller Nielsen, Rune Jon Andersen
New Tile with Aggregate of Expanded Sintered Clay Used for Cladding. Tile Mortar Fixing Tests and Design for Mounting
Kurt Kielsgaard Hansen, Teresa Surzycka, Snorre Stephensen

Louise Stubtoft Kærgaard, Eva Kirstine Fabricius
Charcoal Boards - Material Properties and Design
Lotte Bjerregaard Jensen, Kurt Kielsgaard Hansen

Brigitte Andersen, Katrine Hauerslev
Car Park in Ørestad. Lotte Bjerregaard Jensen, Palle Sehested (ex)

Nina Pagh Koch, Jacob Jul Sørensen
Sustainability as a Basis of Architectural Design. Morten Elle, Teresa Surzycka

Lill Bjerregaard Christensen, Casper Gullach
Urban Planning and Urban Development. Morten Elle, Vibeke Møgelvang Nielsen

Niels Andreas Castberg
Bus Shelter - An Interplay between Materials, Constructions and Design in City Furniture, Per Goltermann, Per Oluf H Kjærbye, Teresa Surzycka

Jeremias David Elleby Sørensen
Implementation of Digital Construction in Small Companies
Flemming Vestergaard

Dennis Kristensen, Martin Krogh Hansen
Investigation of the Stress-crack Opening Behaviour of Hybrid Fiber Reinforced Concrete, Gregor Fischer

Pernille Grønnegaard Pedersen, Mette Blond
Structural Improvements of Composite Deck System
Gregor Fischer, Jeppe Jönsson

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Process and Financial Control in Construction. Henrik Buhl

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Plasticity and Plate Buckling. Jeppe Jönsson

Mads Nørgaard, Joseph Quoc Thanh Nguyen
Forbedring af produktivitet i moderne kontorbyggeri. Jørgen Erik Christensen

Mette Tranberg Werehmeister, Trine Kræmer
Hydraulic Limes for Restoration. Kurt Kielsgaard Hansen

Christian Nerup Sørensen, Mathias Haase
Possible Influcence of Casting Height on Properties and Microstructure of Hardened Self Compacting Concrete. Kurt Kielsgaard Hansen, Peter Laugesen (ex)

Jens Nørhave Kastvig
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Morten Nymark, Thomas Blok
Copper Electrodes for Wood Preservation
Lisbeth M. Ottosen, Iben Vernegren Christensen

Marius Bruus-Jensen, Jonas Damgaard Sørensen
Introduction of TrimByg in the Work of Craftsmen. Niclas Andersson

Thor Ugelvig Petersen, Anders Plesner Bruun
Scheduling - Development, Utilization and Distribution of the Time Schedule
Niclas Andersson

Rasmus Louis Christian Meldal Kolding, Jimmy Bloch Sørensen
Anvendelse af beton til slidlag på veje. Ole Hededal, Jan Jansen, Finn Thøgersen (ex)

Nicolai Kragh-Hansen
Risikostyring i en entreprenørvirksomhed. Per Anker Jensen

Søren Heron, Rasmus Juul Jensen
Transversely Loaded Lightweight Concrete Columns. Per Goltermann

Naseer Fattah Mohammed
Kontorhus, betonelementer. Per Goltermann, Per Kjærbye

Zeki Yilmaz
Kontorhus, betonelementer. Per Goltermann, Per Kjærbye

Sarfaraz Khan, Mustafa Moussa el-Cheikh Hassan
Bygningsprojektering, boliger. Per Kjærbye, Per Goltermann

Mikkel Kjærvig Broe
Row Houses

Tim Mansour, Christian Kaiser Oldenburg
Økonomiske, stabile og let-opsættelige konstruktioner i den tredje verden
Per Kjærbye, Per Goltermann

Faruk Kurtis, Rasmus Louis Frederiksen
Housing Construction in 1 to 1½ Levels - Planning, Designing and Construction

Christian Lærke Pedersen, Martin Steen Svensson
New Bridge by 'Kvæsthusmolen'. Peter Noe Poulsen, Jesper Gath (ex)

Anders Niklas Dobson Mørk
Shinking Mesurement on Treated and Untreated Wood
Staffan Svensson, Kurt Kielsgaard Hansen, Emil T. Engelund

Niclas Biel Olsen, Tine Ninn Løjstrup
Strategic Partnering in Construction. Sten Bonke

Esben Leth Jacobsen, Patrick Dehn
Concepts in Construction. Sten Bonke

Jesper Feldthaus, Nicklas Girel
Management of Precast Concrete Deliveries
Sten Bonke, Knud Christensen

Johannes Martin Utoft Christensen, Martin Wilhelm Øckenholt Larsen
Integrated Design of Energy Efficient Glass Facades and Lighting Systems
Svend Svendsen

Torben Seemann
Energy Renovation of Apartment Block. Svend Svendsen

Peter Rydahl
Buckling of Wood Based I-beams. Søren Traberg, Sigurdur Ormarsson

Troels Grønbech Petersen
Investigation of Beams with Thin Web. Søren Traberg, Sigurdur Ormarsson

Morten Hjalmar Thomsen, Morten Kamuk Tafdrup
Energirigtig renovering. Toke Rammer Nielsen

Paninguak Petersen
Materials for Roads in Greenland. Arne Villumsen, Kristian Lennert

Torkild Narud
Steel Structures in Greenlandic Houses. Egil Borchersen

BSc theses

Lars Hagsted Rasmussen, Sebastian Schjelde Ebbe
Moisture Transport and Sorption in Cement Based Materials - Measurement and Theoretical Analysis
Björn Johannesson, Kurt Kielsgaard Hansen

Ask Tonsgaard Andersen
Insulation with Drainage Capabilities
Carsten Rode

Simon Sigurd Henriksen, Amalie Gunner
Temperaturstabilisering med faseændringsmaterialer
Carsten Rode, Geo Clausen

Andreas Claus Hansen
The Engineer's Management Functions in Relation to Social and Psychological Working Environment
Elsebet Frydendal Pedersen

Dorte Partov
Indeklima i danske boliger
Geo Clausen

Christopher Just Johnston
Sammenhæng mellem luftskifte i boliger og astma/allergi
Geo Clausen, Jørn Toftum

Miki Kobayashi
Gitterdrager i træ og stål
Henrik Almegaard

Anne Lolk Jensen, Lise Nygaard Jensen
Konstruktive løsninger til fremtidens lavenergitypehuse
Henrik Almegaard, Svend Svendsen

Henrik Mehlsen, Kristian Schmidt Bertelsen
Undersøgelse og modellering af bulingsdrevet delaminering
Henrik Stang

Cecilie Vej-Hansen
Optimization of Steel Fibre Reinforced Concrete
Henrik Stang, Mette Geiker

Mohammad Muhsen, Charlie Boye Svensson
Udvikling af beslag til samling af glastværsnit
Jeppe Jönsson

Mads Højmark-Jensen
Revnevidder i armerede betonbjælker/søjler
John Forbes Olesen, Peter Noe Poulsen

Ricardo Antonio Barbosa, Sidsel Juhlin
Investigation of Salt Deterioration of Natural Stones
Kurt Kielsgaard Hansen, Bent Grelk (ex), Poul Klenz Larsen (ex)

Christian Bacher Hjorth
Elektrokemisk fjernelse af salt fra murværk
Lisbeth M. Ottosen

Mads Mønster Jensen, Jon Jakobsen Høj
Permeability Testing of Cementitious Materials by Beam-bending Method
Mette Geiker, Björn Johannesson

Daniel Per Skaarup, Michael Julsbo Nygaard
Optimering af fiberarmeret beton
Mette Geiker, Henrik Stang

Martin Kuld
Højere ordens Finite Elementer - for skiver og plader inden for bygningsmekanik
Peter Noe Poulsen

Jacob Herold Høgh, Jacob Paamand Waldbjørn
Analyse af stålkonstruktioner under hensyntagen til rummelig udknækning
Peter Noe Poulsen, Jesper Gath

Ole Kruse, Eyðbjørn Dal Jakupsson
Undersøgelse af hjørnesamling med dæmper
Sigurdur Ormarsson

Ulf Gjendal
Public Private Partnership in Denmark and Germany
Sten Bonke

Søren Marienlund Andersen, Jan Vig Nielsen
Udformning og analyse af spærfodsamling
Søren Traberg, Sigurdur Ormarsson

Søren Nykjær Boje
Geotechnical and Geophysical Investigations at Itinneq, Sisimiut, Central West Greenland
Thomas Ingeman-Nielsen, Arne Villumsen

Staff

As of December 31 2008		2008	2007	2006	2005	2004
Scientific	Professor	7	7	7	9	11
	Associate Professor	40	40	46	38	44
	Assistant Professor	8	7	10	15	15
	Other VIP	9	9	9	6	4
	PhD Students	51	42	37	44	40
	Total	115	105	109	112	114
Technical and Administrative	Academic	9	9	11	11	10
	Clerical	11	13	13	12	12
	Technician	21	20	18	22	22
	Other	9	7	5	5	4
	Total	50	49	47	50	48
Total Department Staff		165	154	156	162	162

Education

STÅ[1]-total		494	514	483	508	519
Projects (students)	MSc	74	88	85	92	74
	BSc	34	51	31	36	56
	BEng	84	119	130	62	82
Admission (students)	BSc (Building Technology)	65	58	62	72	60
	BEng (Architectural Engineering)	45	47	50	52	42
	BEng (Civil Engineering-summer)	82	84	75	63	58
	BEng (Civil Engineering-winter)	39	29	38	30	32
	BEng (Arctic Technology)	19	18	8	9	8

Research

Refereed papers	Total	50	67	45	61	63
	Of these in ISI	47	48	30	43	37
PhD theses		3	13	5	8	10
Doctoral theses		0	0	0	1	0

Finances

Revenues	DTU-grant	66.718	59.827	56.656	53.184	52.523
	External revenue	46.489	30.326	31.033	30.862	28.563
	Total	113.207	90.153	87.689	84.046	81.094
Expenditures	Wages	68.846	66.782	63.021	62.725	62.917
	Other expenses	31.933	23.954	26.420	19.628	16.445
Total		100.779	90.736	89.441	82.353	79.362
Result		12.428	-583	-1.757	1.693	1.732
Available amount	January 1	7.839	6.200	7.957	6.264	4.532
Carried forward	December 31	9.054	5.617	6.200	7.957	6.264

STÅ[1]: 1 STÅ is one student annual work (1 STÅ=60 ects points)


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χ^2
$\Sigma!$

DTU Civil Engineering
Technical University of Denmark, Brovej, Building 118
DK-2800 Kgs. Lyngby

Phone +45 4525 1700
Fax +45 4588 3282
byg@byg.dtu.dk
www.byg.dtu.dk