Department of Civil Engineering

Annual Report 2006

BYG•DTU

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Printed in Denmark by
Gullanders Bogtrykkeri A/S
ISSN: 1601-8605 (SR 07-09)

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Front picture: Student project testing pedestrian induced vibrations on wooden suspension bridge

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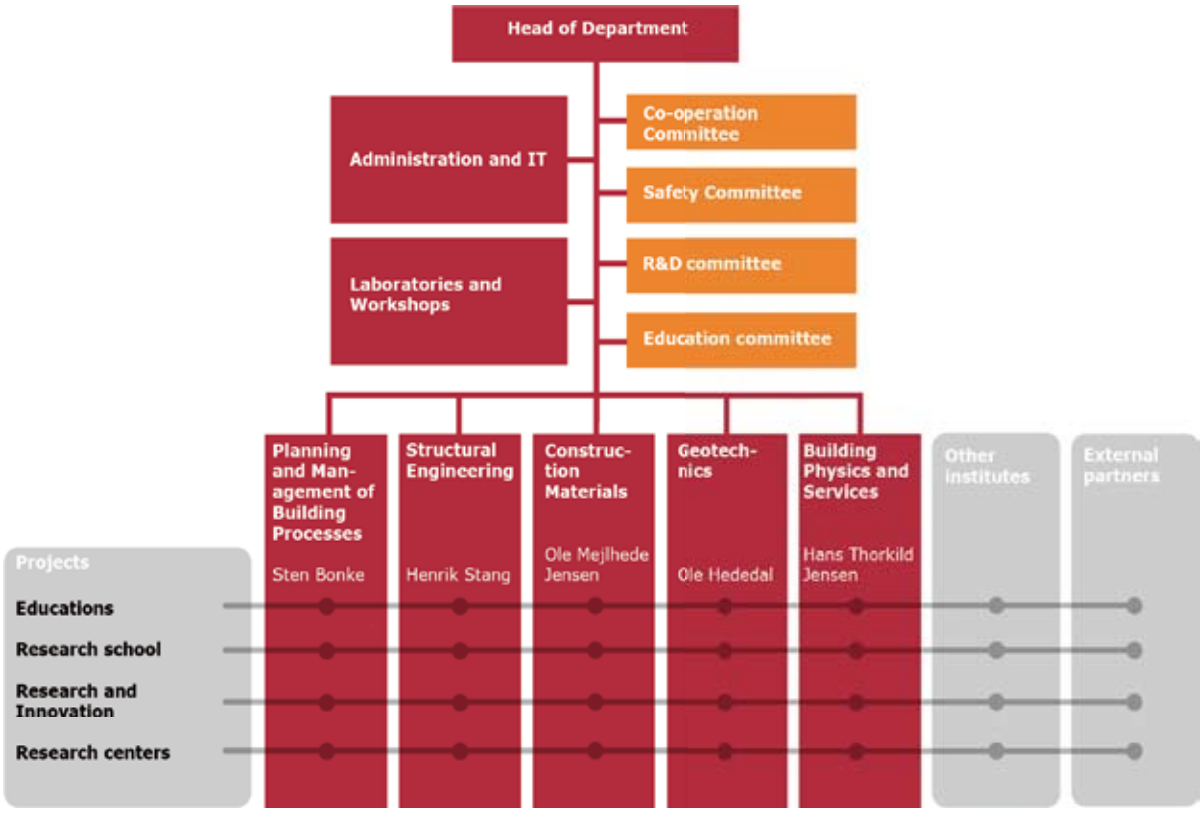


Study Programmes and Programme managers:

- 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

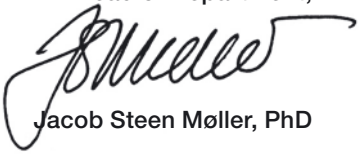
In 2007 the Department in collaboration with IPU has established an Innovation Centre in Civil Engineering. IPU is a DTU controlled company facilitating industry collaboration. The Innovation Centre will enhance the collaboration with industry and help to increase funding for our research infrastructure.

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

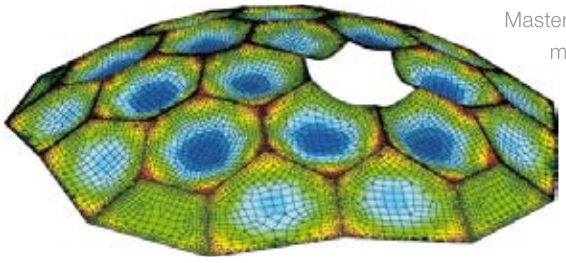
The establishment of the course has initiated a significant amount of Master and Bachelor projects dealing with many of the still unresolved problems related to the use of glass as structural material: the stress distribution and strength in adhesive joints and bolted connections, the long and short 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 facetted shell. The picture shows the largest principal stress for snowfall on a shell with a broken facet

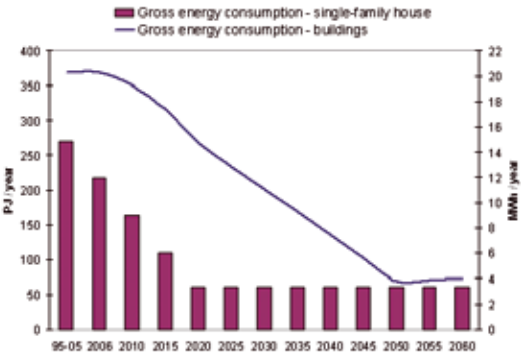
Professor Henrik Stang and Professor Jeppe Jönsson, Responsibles for the course in Glass and Glass Structures

www.kurser.dtu.dk 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 (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 renovated 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.

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).

Highly insulated and airtight low-energy house in Kolding (Seest). The house has a mechanical ventilation system with high efficient heat recovery.

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

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.

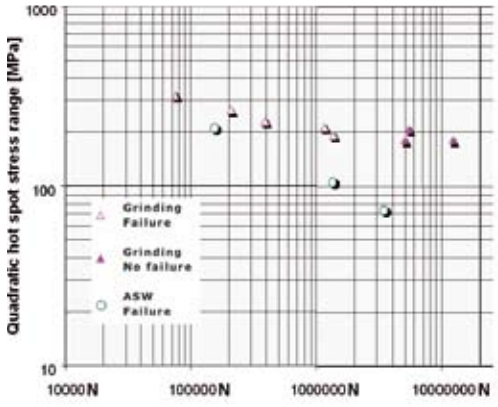
BYG•DTU has for a period of almost 20 years been involved in a series of quite large Nordic research projects on fatigue in welded steel structures. These projects have had strong industry participation and financing by leading Nordic companies and Universities. All projects have had a considerable economical 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.

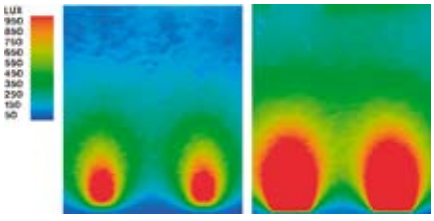
Professor Henning Agerskov, using BYG•innovation

www.byg.dtu.dk/english/byginnovation

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

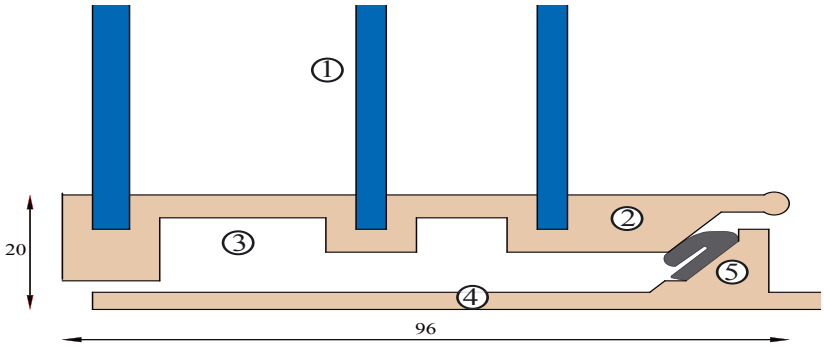


The influence of the smaller frame for the inflow of light to a room with a depth of 3,5 meters

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 coorperation with Fiberline A/S, a leading company in the production of fibre-glass reinforced polyester profiles.

The energy savings in a 180m2 house

Window type	Glazing	Glass area of Window	Net energy contribution	Annual energy use of building
Traditional	2-layer glazing unit	73 %	-47 kWh/m²	87 kWh/m²
Slim alu/ wood	2-layer glazing unit	82 %	-39 kWh/m²	85 kWh/m²
Passive house	3-layer glazing unit	66 %	-4 kWh/m²	74 kWh/m²
BYG•DTU	3 single panes	94 %	15 kWh/m²	69 kWh/m²

The new energy demands BR-95 lists that the energy use per m2 heated room space must be no more than 82 kWh/m2 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

www.byg.dtu.dk/english/bps

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 apprixmately 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 at almost 12 MN the bridge failed and the load went back to zero.

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 failure the CFRP rod reached a strain of approximately 8000 microstrain 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

www.byg.dtu.dk/english/se

Greenlandic permafrost conditions – a geotechnical perspective

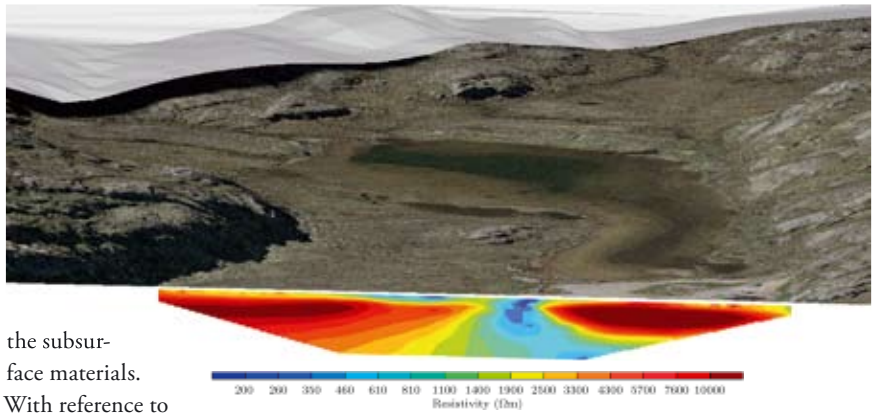
Permafrost is a section of the subsurface in which the temperature is continually below 0°C year round. Research helps with risk assessments for urban areas with respect to the predicted climatic changes

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.

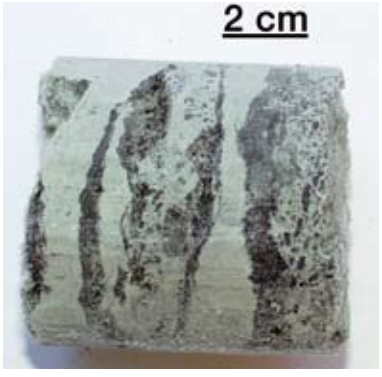
Permafrost mapping with geophysical methods

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 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.

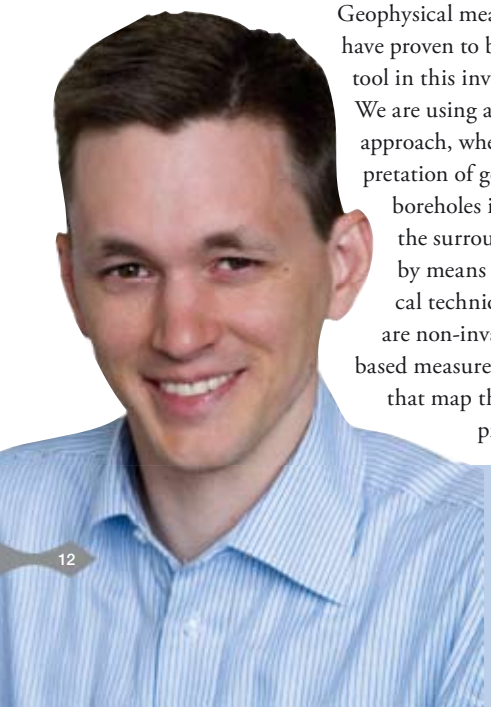


Resistivity profile obtained near Sisimiut. The highly resistive areas (red) correspond to frozen sandy and silty sediments, whereas the low resistive area (blue) is an unfrozen section of the same sedimentary unit. The unfrozen "talik" is caused by a small river, which drains the lake visible in the 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).

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,
Section for Geotechnics

www.byg.dtu.dk/english/geo

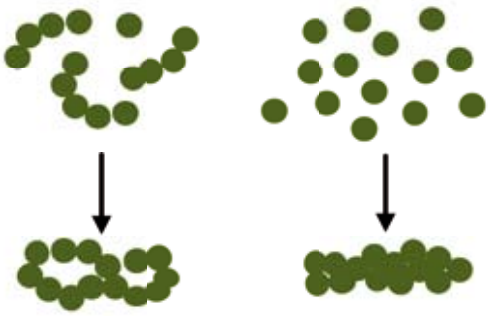
Bringing the use of concrete to its fullest potential?

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 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.

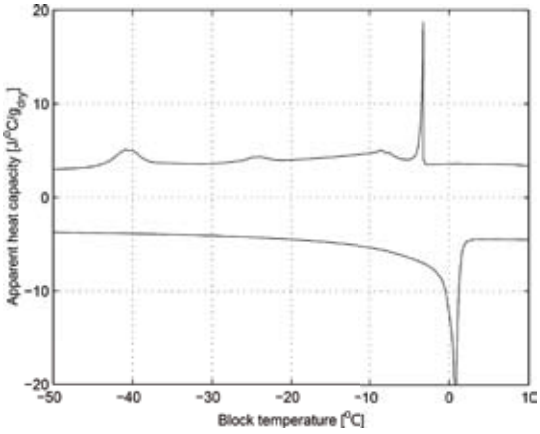


If the net inter-particle force is highly attractive, the particles will tend to agglomerate in a loose network (left). Reducing the attractive inter-particle forces by means of absorbing polymers can therefore facilitate a closer packing of the constituent particles (right).

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.

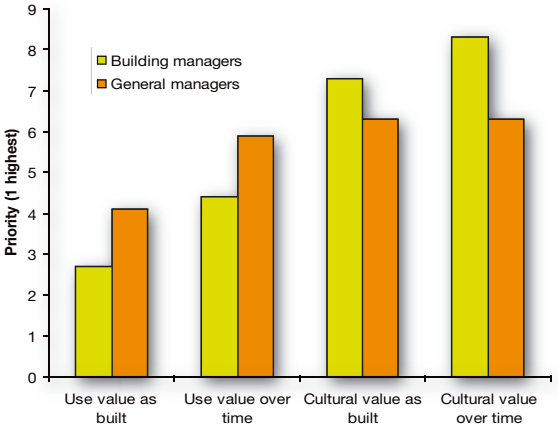
Facilities Management (FM) is a new discipline and has recently been included in BYG•DTU's research agenda. To understand how FM has originated, this research project has focused on the historical development of the roles as building client and building operator, and how these functions within the last 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 be implemented and developed. These theories concerns real estate strategies and values of buildings.

Studying DR

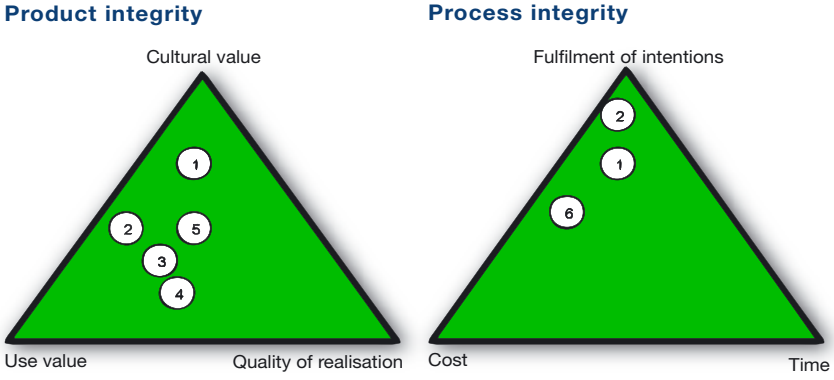
The empirical basis of the project has been a longitudinal case study of the buildings of DR (Danish Broadcasting Corporation) during the corporation's 80 years history as a public service broadcaster of radio and television in Denmark. The researcher had personal experience from 14 years of employment 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.



1. *Stærekassen* 2. *Radiohuset* 3. *TV-byen*
4. *R/TV-huset and Distiktshuse* 5. *DR Byen* 6. *TV-byen, R/TV-huset, Distrikshuse 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.

Associate professor Per Anker Jensen, Section for Planning and Management of Building Processes

www.byg.dtu.dk/english/pmbp

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Feasibility of carbon-fibre cables on long-span cable-stayed
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Hansen, Kurt Kielsgaard, Bent Grelk, Rambøll

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Modelling of ignition and flame spread phenomenaes in thin and thick materials
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Burgos, Christian Gomez
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Furbo, Simon, Alexander Thür

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Statically and cyclically loaded monopiles in soft clay
Hededal, Ole, Caspar Thrane Leth

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Jönsson, Jeppe, Leif Otto Nielsen

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Schwarz, Frank, Daniel Eeg Lyng Justesen
Structural Design and Modelling of High Rise Buildings
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Corrosion Monitoring of Concrete Structures – Evaluation of Methods
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Reused material in cold asphalt – the road of the future?
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Gottlieb, Sara Wisbech, Rasmus Tofte Klinkvort
Bubiyan Sea Port Roads
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Hansen, Stine Stensby, Signe Raymond Arnklit
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Munk Plum, Anders Munck

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Tile, Leca etc. Utilized in Greenlandic Building Industry
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Marcher, Jens C.A., Mikkel H. Cordtz
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Mauz, Clements E.
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Brock, Niels, Niels Foged and Greenland Contractors

Molter, Jens Christian
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Rasmussen, Claus Oved
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Skifte, Hans-Ulrik T.
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Tindbæk, Jonas, Lars Færch K. Hansen
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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
	Total	109	112	114
Technical and Administrative	Academic	11	11	10
	Clerical	13	12	12
	Technician	18	22	22
	Other TAP	5	5	4
	Total	**47**	**50**	**48**
Total department staff		156	162	162

Education

STÅ[1] – 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
	Total	87.689	84.046	81.094
Expenditures	Wages	63.021	62.725	62.917
	Other expenses	26.420	19.628	16.445
Total		89.441	82.353	79.362
Result		-1.757	1.693	1.732
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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