www.coinweb.no

SINTEF Building and Infrastructure

COIN Annual report 2010

SINTEF

SINTEF Building and Infrastructure

COIN Annual report 2010

2010

COIN Annual report 2010

Photo, cover: «Private house, Stavanger, Norway».
The architect: Jarmund/Vigsnæs AS Arkitekter MNAL, www.jva.no

Keywords:
Concrete

40 copies printed by AIT AS e-dit

Content: 100 g Scandia
Cover: 240 g Trucard

Address: Forskningsveien 3 B
POBox 124 Blindern
N-0314 OSLO
Tel: +47 22 96 55 55
Fax: +47 22 69 94 38 and 22 96 55 08

www.sintef.no/byggforsk
www.coinweb.no

Cooperation partners / Consortium Concrete Innovation Centre (COIN)

Aker Solutions
Contact: Jan-Diederik Advocaat
Email: jan-diederik.advocaat@akersolutions.com
Tel: +47 67595050

Saint Gobain Weber
Contact: Geir Norden
Email: geir.norden@saint-gobain.com
Tel: +47 22887700

Norcem AS
Contact: Terje Rønning
Email: terje.ronning@norcem.no
Tel: +47 35572000

NTNU
Contact: Terje Kanstad
Email: terje.kanstad@ntnu.no
Tel: +47 73594700

Rescon Mapei AS
Contact: Trond Hagerud
Email: trond.hagerud@resconmapei.no
Tel: +47 69972000

SINTEF Building and Infrastructure
Contact: Tor Arne Hammer
Email: tor.hammer@sintef.no
Tel: +47 73596856

Skanska Norge AS
Contact: Sverre Smeplass
Email: sverre.smeplass@skanska.no
Tel: +47 40013660

Spenncon AS
Contact: Ingrid Dahl Hovland
Email: ingrid.dahl.hovland@spenncon.no
Tel: +47 67573900

Norwegian Public Roads Administration
Contact: Kjersti K. Dunham
Email: kjersti.kvalheim.dunham@vegvesen.no
Tel: +47 22073940

Unicon AS
Contact: Stein Tosterud
Email: stto@unicon.no
Tel: +47 22309035

Veidekke Entreprenør ASA
Contact: Christine Hauck
Email: christine.hauck@veidekke.no
Tel: +47 21055000

Summary

The vision of COIN is creation of more attractive concrete buildings and constructions. Attractiveness implies aesthetics, functionality, sustainability, energy efficiency, indoor climate, industrialized construction, improved work environment, and cost efficiency during the whole service life. The primary goal is to fulfil this vision by bringing the development a major leap forward by more fundamental understanding of the mechanisms in order to develop advanced materials, efficient construction techniques and new design concepts combined with more environmentally friendly material production.

The focus areas are:

- Environmentally friendly concrete
  - Low-carbon footprint binder systems
  - Insulating and energy preserving concrete
- Competitive construction
  - Robust highly flowable concrete
  - Ductile
  - High quality manufactured sand for concrete
- Technical performance
  - Crack free concrete
  - Service life
  - Structural performance

Almost 50 publications and presentations were produced in 2010 and one workshop was accomplished. 11 master students had their degrees within COIN, and three more PhD fellows have started. The international cooperation was extended with participation in a Nordic project and two German projects.

The Consortium has a Board of Directors, three Thematic Advisory Committees, TACs, a manager and a management group. The centre is located in Trondheim with SINTEF Building and Infrastructure as host institution. The Board has nine members; seven from the industrial partners, one from NTNU and one from SINTEF. All partners are represented in the TACs.

The consortium partners represent the value chain of the business sector; material suppliers, concrete producers, contractors and users. They represent leading multinational companies in the cement and building industry. The partners cooperate through the work in the projects (technical work and joint meetings) and in the TACs. One new subcontractor joint the centre in 2010.

The accumulated cost in 2010 was 29.3 million NOK.

"We see that COIN research furnish new and improved products and processes. Furthermore, the knowledge of the industry partners and the COIN researchers is increased. (…) COIN will provide a basis for recruitment to the industry, institutions and authorities. Held together, all these aspects will strengthen the Norwegian concrete industry considerably."

Knut Kjellsen
Chief engineer,
Norcem AS

Table of contents

1 Vision and goal

The vision of COIN is creation of more attractive concrete buildings and constructions. Attractiveness implies aesthetics, functionality, sustainability, energy efficiency, indoor climate, industrialized construction, improved work environment, and cost efficiency during the whole service life. The primary goal is to fulfil this vision by bringing the development a major leap forward by more fundamental understanding of the mechanisms in order to develop advanced materials, efficient construction techniques and new design concepts combined with more environmentally friendly material production.

The corporate partners are leading multinational companies in the cement and building industry and the aim of COIN is to increase their value creation and strengthen their research activities in Norway. Our over-all ambition is to establish COIN as the display window for concrete innovation in Europe.

Photo: The architect: Jarmund / Vigsnæs as arkitekter

2 Research plan - Social, environmental and industrial needs

The construction industry is one of Norway's largest, and concrete is the dominating construction material in buildings and infrastructure. COIN's research plan is based on social, environmental and industrial needs as described below.

Innovation potential
The construction industry is one of Norway's largest with an annual turnover of approximately EUR 45 billion. According to a strategy document[1], innovation can release an annual value creation potential of EUR 3-4 billion. Concrete is the dominating construction material in buildings and infrastructure with an annual volume of 7 million ton. The concrete industry has documented significant value creation for the industry and the society with a yield rate of 19 on R&D investments from 1980 to 2000[2]. In this period the Research Council provided essential funds triggering the R&D engagement of the industry. Again, there is a potential and a will in the industry to bring concrete innovation into a new era by development of; environmental friendly cementing materials, low energy building concepts, new high tensile strength cementing materials reinforced with fibres; fibres replacing steel re-bars in SCC; super light weight concrete in sandwiched elements revolutionizing not only the building industry but even the ship building and offshore industry; as well as by other feasible achievements addressed in COIN.

Image and customers needs
A major challenge facing the concrete industry is the paradox that it is an essential necessity but yet has a low public image. Hence, it is an important issue for the industry to create a more realistic and positive image of their products. It is likewise important to make concrete buildings more attractive in order to gain a stronger position among building owners, architects, contractors and in the public opinion, and thereby increasing the marked share especially on housings.

The traditional focus of the companies within the concrete industry has been on volume sales (i.e., cubic meters of concrete or tons of cement) and not sufficiently on the totality. In marked analyses, the industry is criticized by owners, architects and consultants for a lack of understanding of their customers' requirements and needs, and for not taking responsibility for the quality of their end products. These analyses also revealed a lack of confidence in the ability of the concrete industry to deliver products with predictable quality.

These challenges are not unique for the Norwegian industry but common to all modern countries and the industry has started to address them. The Concrete Centre in UK and byggutengrenser.no in Norway are examples on how the concrete industry joins forces to promote the benefits of concrete constructions addressing their customers' needs as well as providing easy access to information for their own members.

Alongside promotion there is also an urgent need for a major technology development in order to deliver more attractive buildings, improve the efficiency, reduce the construction and service life costs, and improve the work environment, in order to meet the need of customers and the society.

A goal is therefore to improve the quality of concrete products and to make it even more cost efficient and environmentally friendly.

[1] BAE/council> Research and development in the construction industry. Challenges and value creation potential. Part 1&2.Sept 2002
[2] Moksnes, J> What is the value creation from R^D in the concrete field in Norway in the period 1980/2000_ NCA Publ No 28, 2002

Productivity
As for the building industry as a whole, the concrete industry faces challenges with respect to productivity, quality, work environment (HSE) and recruiting skilled workers. These challenges interact as the skills influence the quality (e.g., faults, defects, progress) and hence, the productivity. The physically hard outdoor work makes it increasingly difficult to recruit young people while skilled workers retire early.

The productivity in the construction sector has during the past decade for several reasons had a negative development compared with other industries. Technical improvements may significantly reduce the required work force and counteract this trend. Self-compacting concrete (SCC) has the potential for such achievements but it is little used for ready-mixed concrete. Further development of SCC into a complete construction concept combined with fibres will significantly improve the efficiency. The working environment will also be improved due to less noise and strain injuries. In order to further improve the product quality, productivity and the work environment there will inevitably be an increased trend towards tailoring of properties and a higher degree of (indoor) prefabrication and premixed products.

A goal is therefore to develop more rational production and to increase the level of competence in this sector.

Sustainability
Sustainable development will still be emphasized by European and National politicians in the coming years. The sustainability of buildings and structures is strongly influenced by the choices made in design and construction, and it should be evaluated for the whole service life of the building. Concrete is a durable material offering a long service life and low maintenance costs. Recent studies reveal the possibilities for significant reductions (more than 50 %) in energy consumption for heating and cooling of buildings by adequate utilisation of the high thermal energy of concrete. This requires exposure of concrete surface and provides a potential for multifunctional construction elements with built in air storage for optimal air conditioning, surface textures and coatings to facilitate cleaning, and coloured concrete for improved aesthetics.

A goal is to develop designs and construction systems for significant reductions in energy consumption for heating and cooling of buildings by adequate utilisation of the high thermal energy of concrete.

With respect to sustainability the concrete industry also faces challenges related to environmental impact, depletion of resources and energy consumption. Being a “natural” material, utilization of concrete implies consumption of a vast amount of raw materials. Thus, the industry is facing rapidly increasing challenges related to global environmental requirements and supply of resources that force the concrete industry to look for alternative solutions. The main challenges are to significantly reduce raw material consumption, energy demand and emissions, while maintaining the market share. |
A goal is therefore to improve the sustainability through development of technologies for reduced raw material and energy consumption and for low emissions, while maintaining the market share.

Environment
Aggregates for concrete have been quarried from natural resources. Now, an increasing amount is produced from crushed rock (but also secondary raw material, demolition waste, etc) because the natural resources are emptied or rejected for environmental reasons. However, even rock quarries meet environmental restrictions all over Europe. Production of cement is associated with high CO_2-emission. Although considerable progress has been made in optimisation and utilization of alternative materials and fuels, it still accounts for

about 5 % of the world's total CO_2-emissions. The Cement Sustainability Initiative (CSI), a program of the World Business Council for Sustainable Development has been formed to help the cement industry to address the challenges of sustainable development, and it provides regular up-dates on status.

To meet these environmental challenges the concrete industry needs to reduce material consumption, develop alternative and more robust materials, lighter products, and new construction and design techniques.

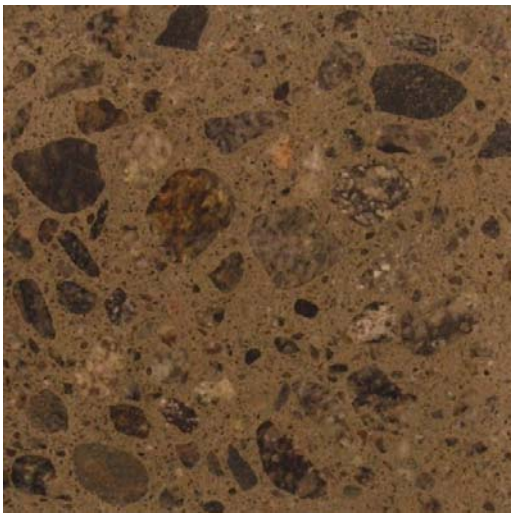


Photo: Tone Østnor

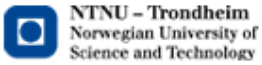
High performance concrete for harsh climate

The offshore industry pushed the limits for concrete application with the development of high strength and also LWA concrete in Norway in the 1980 and -90s. Technologies that later were applied also in onshore construction. Today natural gas transport on huge water depths, offshore storage tanks for liquefied natural gas and oil production in cold climates again push the limits for high performance concrete with respect to material composition and execution. Opening up the Barents Sea for oil production will challenge material and structure performance in this harsh climate, where ice abrasion is a decisive factor, and push the development further.

Fundamental approach

Research areas like SCC, fibre reinforcement and blended cements are not new, but the research have up till now been to a large extent empirical. A more fundamental understanding of the mechanisms is required in order to bring the development a major leap forward. As an example, traditional steel reinforcement may be completely replaced by fibre reinforced SCC and light composites. However, this requires a fundamental understanding of the interaction of cement paste and fibres and on how it can be optimized.

3 Organising



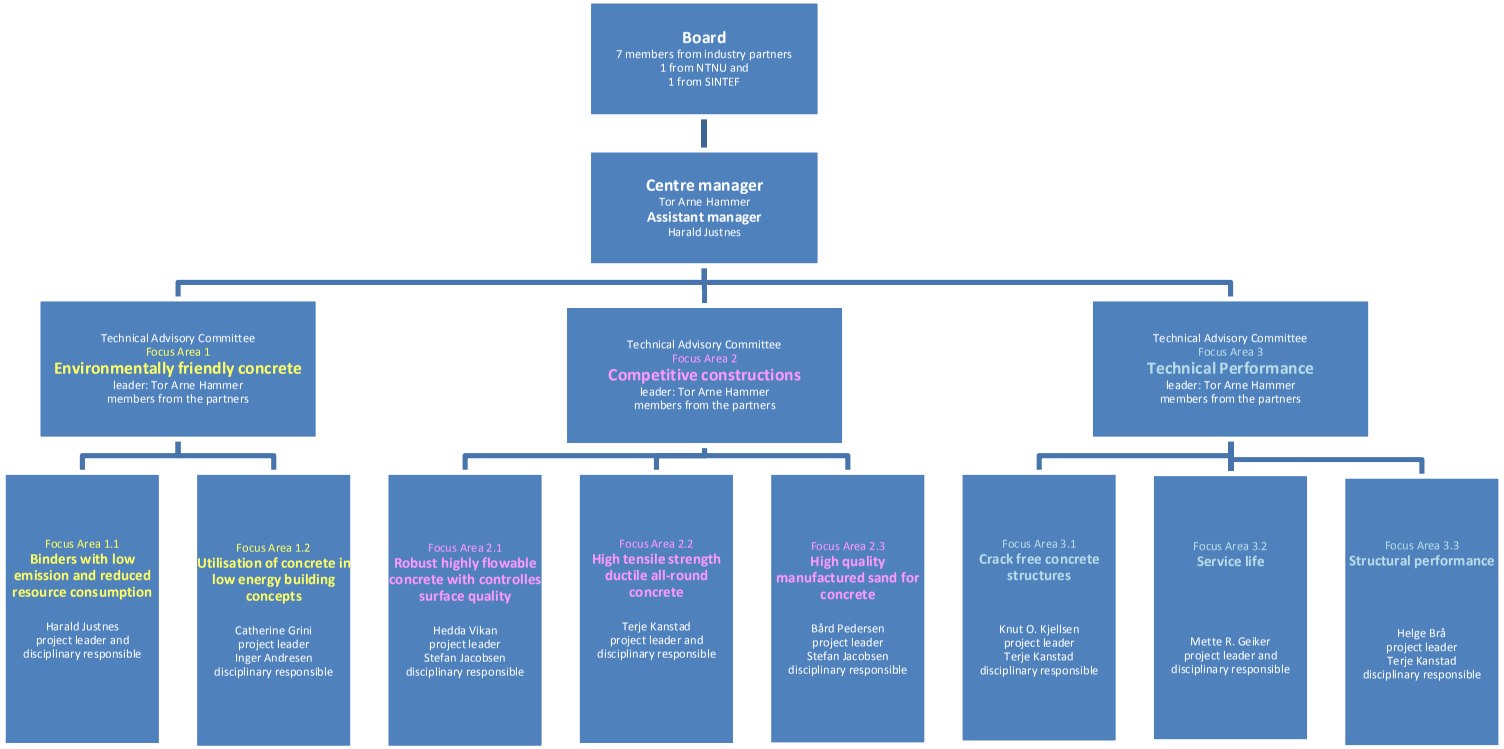
COIN has 11 partners and is located in Trondheim with SINTEF Building and Infrastructure as host institution. In addition to SINTEF, NTNU is research partner and 9 partners are representing the whole value chain of the Norwegian concrete industry. The Consortium has a Board of Directors, an Advisory Committee, three Thematic Advisory Committees (TAC - one for each focus area), a manager and a management group. The Centre's manager reports to the Board. Senior Scientist Dr. T. A. Hammer is Research Centre Manager and Chief Scientist Professor H. Justnes is Assistant Centre Manager. The Board has nine members; seven from corporate partners, one from NTNU and one from SINTEF. All partners are represented in the TACs, which consider and decide the annual work plan to be recommended for the Board.

The technical activities are organized in 3 focus areas (FA), with belonging projects (presently 2-3 projects per FA), as shown below:

Focus area FA1: Environmental friendly concrete structures
Focus area FA2: Economically competitive construction
Focus area FA3: Technical performance

Furthermore, each FA has a Thematic Advisory Committee (TAC) with members from the Partners, headed by the Centre manager, with the responsibility to establish the innovation objectives and criteria, prioritizing and reporting. The TACs also break down the overall objectives into manageable and adequate action plan and tasks.

The senior personnel are made of the management group and the disciplinary responsible persons at NTNU.



COIN organization 2010

The centre operates in close cooperation with NTNU Faculty of Engineering Science and Technology. Three professors at the Department of Structural Engineering (Jacobsen, Kanstad and Geiker) are disciplinary responsible for seven projects, and the two latter are also project managers for two projects. In addition three adjunct professors at NTNU are strongly involved in COIN: Justnes is project manager and disciplinary responsible for one project, Kjellsen is project manager and member of two Thematic Advisory Committees and Helge Brå is project manager.

The centre uses the laboratory facilities of NTNU and of SINTEF in Trondheim as well as in Oslo. Several of the industrial partners also have research facilities which are being used by the PhDs and in other research performed within the centre.

The partners cooperate through the work in the projects (technical work and joint projects meetings) and in TAC. Four partners or more are represented in all projects, and four partners have personnel taking part in the Master of Science education at NTNU.

3.1. Industry partner Norcem's experiences from four years in COIN

Norcem AS is one of the nine industrial partners in COIN. Norcem is part of Heidelberg Cement, and the subsidiaries Norbetong and Norstone perform work in COIN. Metso, the Finnish manufacturer of machines to produce crushed aggregates, is a subcontractors to Norcem in COIN. Norcem is active participant in 6 of the 8 focus areas, holds chairmanship of the board, is represented in all 3 TACs, has management in two projects, adjunct professorship at NTNU and supervises two COIN PhD students. We have asked Knut O. Kjellsen, chief engineer in Norcem R&D, to tell about their involvement in COIN as a centre.

What are your main interests in COIN?
Norcem's main interest in COIN is to contribute to a strong and united national effort to strengthen research and development of cement based materials in Norway, and to strengthen the concrete industry.

What –if any- impact has COIN had on Norcem's position in the Heidelberg Cement corporation?
COIN is an important part of the R& D strategy of Heidelberg Cement Group Norway. COIN is well anchored in Heidelberg Technical Center (HTC) in Germany, and is well regarded at HTC. We inform and discuss COIN with HTC, and COIN strengthens our position towards HTC. In association with Klaartje De Weerdt's COIN PhD work, Dr Maciej Zajac of HTC joined several meetings, and Klaartje was invited to HTC in Germany to present her work.

What does it mean for Norcem to hold the position as chairman of the COIN board?
The chairmanship is an important position, and membership in the board possesses an opportunity for us to take initiative and influence the direction of COIN. All board members have equal opportunity to influence COIN, as decisions are made in consensus.

Norcem has contributed with more in-kind and considerably more cash funding than the agreement. What is the reason for this?
The research plan and the increased joint activities have enabled us to include more of our research tasks into COIN than planned. In addition, other companies within Heidelberg Cement Group Norway, have seen the opportunities of participating in COIN. Thus, NorBetong and NorStone have joined the team.

Norcem does research directly with other industrial partners within COIN. Could you tell a little more about this?

COIN has been an important incubator for the direct co-operation with other industrial partners; for example the activities we have with Rescon Mapei and Consolis/Spenncon within Focus Area 1.2 was initiated within the COIN project. We have also co-operation with Skanska and the Norwegian Road Directory within sub-projects in COIN. COIN has strengthened this co-operation.

From Norcem's point of view: What does COIN mean for the Norwegian concrete industry as a whole?

As a member of COIN we appreciate the enthusiasm and dedication of the COIN research team. This positivism and optimism that COIN brings about, shall not be underestimated. We see that COIN research furnish new and improved products and processes. Furthermore, the knowledge of the industry partners and the COIN researchers is increased. Several of the COIN PhD students will afterwards have specialist positions in the concrete business, thus COIN will provide a basis for recruitment to the industry, institutions and authorities. Held together, all these aspects will strengthen the Norwegian concrete industry considerably.

4 Technical activities, results

The main activities in 2010 were according to the plan established in 2008 and a continuation of the work performed in 2009. A number of research breakthroughs were reached as can be seen from the project presentations below, and a milestone was reached as the first COIN PhD-student delivered her thesis; Klaartje De Weerdt (defence 3 Feb 2011). Her work on ternary blended cements contributed to the new environmental friendly cement that Norcem brought to the market in 2010.

The projects are organised to cover every partner's main innovation ideas. The projects are:

4.1 Focus Area 1: Environmentally Friendly Concrete

The objective of the research is to show the potential of concrete to be the environmentally friendly material. The work is divided into to projects: *Low-carbon footprint binder systems* and *Insulating and energy preserving concrete*.

4.1.1 Focus Area 1.1: Low-carbon footprint binder systems

The objective of the project is to establish the basis to develop all round alternative low-carbon footprint binder systems. Activities in 2010 have been:

- Cements with lower CO_2 emission during production
- Admixtures to control hydration development
- Admixtures to entrain air and reduce shrinkage
- Alternative pozzolanes
- Concrete with lower permeability

Project manager is Professor Harald Justnes, chief scientist in SINTEF. PhD student Klaartje De Weerdt did her thesis on cements with low CO2 emissions and PhD Kien Hoang is working on admixtures to control hydration development

Some research achievements in 2010:

The synergy between limestone and fly ash enhancing strength in ternary blended cement has been well proven as the PhD of Klaartje De Weerdt draws to an end. The optimum combination found in her study was 65% cement, 30% fly ash and 5% limestone with respect to strength, and fulfills the COIN target of finding and overall cement with at least 30% reduction in CO_2 emissions. De Weerdt received the Norwegian Concrete Association's research award for her work, and Norcem also launched "low carbon cement" with the same composition that was used to build the new center for the Norwegian Meteorological Institute. Her study has also been SINTEFS partner project contribution to the European research network Nanocem, where it has caused considerable interest among the partners. The principle that limestone can be activated by aluminate containing products from the pozzolanic reaction of fly ash has been followed up by EPFL using metakaolin instead of fly ash and referring to it as the "SINTEF method".

Replacing cement clinker with large amounts of supplementary cementing materials will give low early strength, especially at low temperatures. The objective of the PhD of Kien Hoang is to find an accelerator blend that fulfills the European standard for hardening accelerators, meaning at least 30% increase in compressive strength after 2 days at 5°C and at least 20% increase after 1 day at 20°C relative to reference concrete. At the same time the 28 days strength should be at least 90% of reference. This has now been fulfilled for a mixture of 3 common chemicals at a total dosage of only 0.35% of cement mass. The mother

company (MAPEI) of the COIN partner Rescon/Mapei has found this so interesting that they are asking to keep the exact composition secret for the world outside COIN for the moment, indicating that we are on the cutting edge of innovation. The next step is to document why this mixture is so effective.

Hydrogen peroxide was tested as combined "air-entrainer" and "shrinkage reducer" in 2010. The concept is to form oxygen chemically in the concrete water. The water will then be saturated with oxygen, form very small bubbles that may coalesce to larger. This is an alternative to emulsifiers where air is dragged into the concrete in the mixing process and stabilized to bubbles, and may be a way of avoiding the residual carbon-tenside incompatibility in for instance fly ash cements. Since the water will be (over)saturated with respect to oxygen, gas will be released as the pore water pressure falls and can thus counteract shrinkage (mitigates vacuum in contraction pores). Both these features ha been tested, but the evaluation of the data has yet to be done and reported. However, it has been proven that the "air-entrainer", or rather "bubble creator" concept is working in concrete, with small void with high surface as result.

Calcined "marl", or rather calcareous clay (clay contaminated with calcium carbonate) as alternative pozzolan has proven to be extremely efficient. 50% cement can be replaced by calcined marl in mortars and still the 28 days strength of the reference with 100% cement can be maintained, and at the same time the 50/50 blend achieve sufficient strength after 1 day allowing removal of formwork in practice. "Marl" is an unexploited resource for the clay industry as it is unsuitable for bricks and light weight aggregate etc, and have create significant interest within the COIN partner Saint Gobain Weber. Calcined "marl" fulfills the criterion for "calcined natural pozzolan" in the European cement standard, and opens up for the creation of CEM IV/B (pozzolan cement) where up t o 55% cement can be replaced, reducing CO_2 emissions further.

Concrete with lower permeability has been tried to be created by intermixing 0.75% of the cheap bio admixture rapeseed oil of cement mass, following up the success of previous mortar tests. A significant reduction in water suction was obtained as expected, but the strength was unexpectedly lowered since this was not observed for mortars with up to 1% addition of rape seed oil. The chloride ingress was not significantly reduced either using the test set-up in the spraying/drying chamber with sea water simulating splash zone. The activity will be terminated after final reporting.

4.1.2 Focus Area 1.2: Insulating and energy preserving concrete

The objective of the project is to establish the basis for concrete to be an insulating and energy preservative material.

Project manager is researcher Catherine Grini, SINTEF, who will be replaced with researcher Kjersti Folvik, SINTEF, from 1 April 2011.

Some research achievements in 2010:
The workshop "Concrete Ideas for Passive House" was held in Oslo 26-27 January, 2010. The workshop focused on the possibilities and challenges of using new materials or constructions (i.e.Phase Change Materials, Vacuum Insulation Panels, Nano Insulation Materials, Thermal Active Building Systems) in combination with concrete for achieving Passive House or Zero Emission Building. The group discussions concluded with research topics that COIN should approach. As a result of the workshop, new research activities got initiated. An atlas of good construction details for concrete structures for use in the passive house concept has been written. Collaboration with the Zero Emission Building Research Center on possibilities offered by mixing nano materials and concrete got started.

Post-occupancy evaluations of office buildings using fair-faced concrete ceilings are on-going.

4.2 Focus Area 2: Economically Competitive Construction

The objective of the research is to achieve a 20 % improved productivity with minor environmental costs. This is sought through the three projects *Robust highly flowable concrete*, *High tensile strength allround concrete*, and *High quality manufactured sand for concrete.*

4.2.1 Focus Area 2.1: Robust highly flowable concrete

The objective of the project is to establish the fundamental knowledge enabling design of concrete to control its rheology and stability. Activities in 2010 have been:

- Reliable design and production of stable, robust and highly flowable concrete with controlled surface properties
- Develop methods and systems for the classification of concrete surface quality

Project manager in 2010 was senior researcher Dr Hedda Vikan, SINTEF. From 2011 researcher Dr Klaartje De Weerdt, SINTEF, will be project manager.
PhD student Ya Peng is working with issues correlated to both this project and focus area 2.3 High quality manufactured sand for concrete.

Some research achievements in 2010:
The use of self-consolidating concrete leads to increased productivity. Controlled stability (i.e. resistance to segregation) and thus constant quality from delivery to delivery is, however, one obstacle to increased use of this material. Self-consolidating concrete can be stabilized by aid of admixtures and/or fillers. The influence of these two proportioning methods on the rheological properties and castability of concrete and equivalent matrix were compared. Thixotropy is of special interest since it is believed to influence stability, form-filling ability, the migration and evacuation of entrapped air bubbles and thus the final surface quality.

Two unstable reference self-consolidating concrete were prepared using two superplastizer types. The stabilizing capacity of two different chemical stabilizers and three types of filler was tested on each of these unstable concretes. The effect of the stabilizers depends strongly on the plasticizer type and dosage: increased dispersion is linked to decreased structural build-up. The two chemical stabilizers increased the thixotropy of the matrix. However, additional filler had a stronger effect. The higher the fineness of the filler the larger is the increase in viscosity and thixotropy.

Further research will be conducted on the effect of the combination of both additional filler and chemical stabilizers on the stability of both matrix and concrete. The final aim of the project is to develop robust recipes for SCC with materials available in Norway, and additionally to link the rheological properties with quality of the finished surface.

Concrete is often considered in connection to grey and dull architecture by the public. Focus on architecture and design that utilizes the unique formability of concrete can however result in fantastic constructions. An important basis for good design and productivity is that concrete surfaces with predictable esthetical expression can be obtained. There are currently no Norwegian tools that describe concrete surfaces for use in design, production and assessment phase of a project. The lack of a specification tool can result in misunderstandings between architect and contractor as well as unrealistic expectations to the final result.

In cooperation with SINTEF ICT, an image analysis programme was designed: BetongGUI. The program analyses pictures of the concrete surface and gives as output statistical data concerning pores, greyscale and grayscale variations. A range of challenges were met concerning the procedures of photographing the concrete walls and determining the relevant output of the program.

In 2011, the aim is to tackle the before named challenges and to finalize the BetongGUI software and validate it by testing it on different concrete surfaces. The database of images which thereby will be obtained, will form the basis to determine the different concrete surface categories used in future guidelines.

4.2.2 Focus Area 2.2: Ductile high tensile strength concrete

The objective of the project is to establish the basis for developing all-round concrete with 15 MPa tensile strength as well as the basis for structural design with this concrete. Activities in 2010 have been:

- Materials development
- Guideline for design and execution
- Field - and full scale laboratory testing

Project manager is Professor Terje Kanstad, NTNU.

PhD students within the project are Sindre Sandbakk and Giedrius Zirgulis.

Some research achievements in 2010:

Materials development: The sub project is related to the objective development and verification of ductile high tensile strength concrete, and consists of the following three activities:

- Development of ductile high tensile strength concrete where an initial test series with promising results has been carried out and reported, and two more series have been initiated. For further development a broader group is active (including structural behaviour, standard test methods, general mix design principles and fibre packing theory). Parts of this work are included in a PhD thesis which will be fulfilled in 2011.
- Fibre reinforced LWAC in which a master thesis on superlight FRC (>350kg/m^3) was finished in June 2010, and the work is planned to continue within a separate activity denoted “Ductile LWAC”. Furthermore fibre reinforced LWAC was used in the hybrid concrete structures project (PhD-thesis etc) where materials testing also has been carried out.
- Structural properties of flowable concrete where a master student was writing her thesis on this topic last autumn. The work included fresh concrete testing (aggregate segregation vs flow length) in a new test method denoted the LCPC-box, and effects of the flow process on the fibre orientation and residual tensile strength.

Guidelines for design and execution: The guideline is in good progress and will be published as a COIN-report early in 2011. The work covers the topics: Material documentation, Test methods, verification and execution, design methods, and reinforcing rules. Special attention has been paid to verification of the shear design formula in the guidelines (1 master thesis), and the test method investigations which will be fulfilled in

2011 (PhD-thesis). A joint Norwegian-Belgian round robin test program has been carried out and completed (COIN-report).

Field - and full scale laboratory testing: Rambøll started a field test program on fibre reinforced post-tensioned flat slabs in Ålesund, and the testing and evaluation will be fulfilled in 2011. The project is financed by Rambøll and local industry partners. However, NTNU is responsible for the instrumentation work on contract, while COIN carries out supplementary testing to validate the field test and relate the results to previous laboratory tests (1 master thesis). Field testing is continuously also being carried out by Veidekke, who considered several interesting aspects, for instance verification of fibre content in fresh concrete (1 Master thesis). Within the project "Hybrid concrete structures" fibre reinforced LWAC are being used in beams produced by Weber (4 master students in 2010). The major objective by all the field tests is to verify the guideline proposal.

4.2.3 Focus Area 2.3: High quality manufactured sand for concrete

The objective of the project is to develop manufactured sand giving equal properties as natural sand.

Project manager is Dr. Bård Pedersen, Technology manager of Norstone.

PhD student Ya Peng is working with issues correlated to both this project and rheology, focus area 2.1.

Some research achievements in 2010:
In addition to particle shape, some of the most important questions of manufactured sand are related to filler. Generally speaking, the "price" we have to pay in order to make cubical or even rounded particles is very high filler content. There are available techniques for filler reduction and even modification of the filler itself by only removing particles below a certain size. However, it is not obvious what filler level or what filler characteristics are the most suitable for concrete. Actually, this is a very complex field that involves concrete mix design philosophy and interactions with the type of cement and the type of plasticizer.

An extensive test program involving 7 different fillers was run in 2010 in order to investigate some of the rheological aspects related to filler and mix design. Advanced rheology testing was performed both on filler modified cement paste (matrix) and on self compacting concrete. The results are to be fully reported during 2011.

One major achievement in 2010 was the agreement with Metso Minerals. Metso is a world leading manufacturer of crushers and other equipment to the mining and aggregate industry. Their extensive expertise in the field of crushing technology and air classification gives a great contribution to the team. In addition to their expertise within this field this agreement has given access to the Metso test field in Tampere with possibilities of pilot crushing using different crusher setups. The first pilot crushing experiments with Norwegian aggregates was performed in mid 2010. An extensive program of pilot crushing of several Norwegian rocks is planed for 2011.

4.3 Focus Area 3: Technical Performance

The objective of the research is to improve and predict aesthetic qualities and service life. The focus area is divided into three projects: *Crack free structures*, *Service life* and *Structural performance.*

4.3.1 Focus Area 3.1: Crack free structures

The objective of the project is to establish the basis for mix design and execution to get "defect free surfaces".

Project manager is Dr Knut O. Kjellsen, chief engineer at Norcem.

PhD student Anja B.E. Klausen is working within the project.

Some research achievements in 2010:
2010 have focused on establishment and verification of testing equipment and methods. The verification phase of the seven new shrinkage rigs is finished, and the results are proven to give reasonably good agreement to the SINTEF standard method for shrinkage measurements. A major effort has been devoted to update the stress-rig (Temperature Stress Testing Machine = TSTM), which now is working satisfactorily. Some verification tests on basic features and reproduction of test results still remain. Two successful quasi-adiabatic tests were carried out in the new TSTM in 2010. Considerable resources have also been spent on the quality and reliability of the test method for relative humidity within concrete. Knowledge is transferred from Lund University, still some work remains before this test method has sufficient reliability.

The new shrinkage rigs were in 2010 used for two experimental series, with various concretes where both the cement type and the fly ash content has been varied.

4.3.2 Focus Area 3.2: Service life

The objective of the project is to establish the basis for exact control of the life time by prevention of water suction, sufficiently high electric resistivity and exact knowledge about the chloride threshold value.

Project manager is Professor Mette Geiker at NTNU, who took over the job after Roar Myrdal, SINTEF, in September.
PhD student Ueli Angst has been working on critical chloride content, Karla Hornbostel is working on electrical resistivity and Jan Lindgård's thesis is on alkali aggregate reactions.

Some research achievements in 2010:
Studies on chloride induced reinforcement corrosion were in its final phase and the PhD thesis will be defended May 2011. One part of the research efforts aimed at improving the state of the art regarding measurement methods to determine critical chloride contents. Both based on experimental results as well as a literature review, recommendations were made for a realistic test setup for the critical chloride content; These include the use of ribbed steel in as-received condition, chloride exposure by cyclic wetting and drying as well as leaving the rebar at its free corrosion potential rather than subjecting it to potentiostatic control. These suggestions recently entered the work of RILEM committee CTC that aims at making recommendations for a widely accepted test method to determine critical chloride contents. While it was in the present project from experimental work concluded that even in rather small laboratory specimens, the cathode is sufficiently large to provide realistic conditions for (early) pitting corrosion, probabilistic considerations have illustrated that the specimen size is likely to significantly influence the measured critical chloride content.

A second part of the present project addressed the stage after corrosion onset: Measurements after depassivation provided insight into the mechanism of early pitting corrosion and lead to the conclusion that the corrosion kinetics is at this stage dominated by anodic diffusion

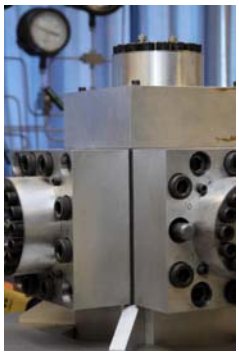
control. Furthermore, experiments with respect to the effect of defects at the steel/concrete interface revealed the presence of a bleed-water zone on the underside of horizontally oriented rebars. These weaknesses appeared to play an important role in corrosion initiation. On the other hand, the presence of comparatively large entrapped air voids at the steel surface was regarded as harmless as long as the concrete is not water-saturated.

Based on preliminary results on impact of alkali leaching on ASR expansion presented March 2010 two of the three RILEM concrete prism tests were withdrawn.

4.3.3 Focus Area 3.3: Structural performance

The main objectives of the focus area Structural Performance are to develop and utilize new concrete material combinations and applications. Activities in 2010 were:

- Super LWA development – Fibre reinforcement of clay based pellets
- Hybrid structures - Performance of advanced concrete materials and combinations
- Ice abrasion - Concrete in arctic marine environment
- Material modelling – Focus on LWAC
- High Performance concrete - UHPFRC



Project manager is Dr Helge Brå, senior researcher in SINTEF.

PhD students within this project are Markus Bernhard, Egil Møen, Linn Grepstad Nes and Håvard Nedrelid.

All activities except the latest are mainly driven by PhD studies.

Some research achievements in 2010:
The activity on super LWA were stepped up due to a summer job and start-up of a PhD study. Previous findings on strength increase from fibre reinforcement were confirmed and based on these findings steel fibres were identified as the most promising. Initial tests in concrete were performed.

Experiments on layered slab elements (different concrete mixes/reinforcement types) were analysed with good results by advance FE modelling.

Findings from the ice abrasion study were implemented in real design by Aker Solutions.

4.4 PhD project on chloride induced reinforcement corrosion in concrete

Interview with PhD student Ueli Angst, NTNU

Ueli Angst moved to Norway from Switzerland and started the work on this PhD project in April 2007. The work was carried out at NTNU Trondheim with ETH Zurich, Switzerland, having been involved in the form of an agreement on supervision. The thesis was completed for submission in the end of January 2011. The public defense at NTNU Trondheim is scheduled for Tuesday, 3rd May 2011. His work has already received international attention through 8 papers in international scientific journals, 5 papers presented at conferences, and co-authorship of one book chapter. Moreover, he was awarded the Norwegian Concrete Association's Research Prize 2009.

Can you briefly describe your PhD work?

There is a general consensus that chloride induced reinforcement corrosion is the most common degradation mechanism for reinforced concrete structures. My PhD work approached the topic from several angles: Firstly, a technique for the non-destructive measurement of the chloride concentration in the concrete pore solution was studied. Secondly, the concept of the so-called critical chloride content, viz. the chloride content in the concrete at which corrosion is believed to start, was reviewed. A third focus area of my studies comprised laboratory experiments in order to study the mechanism of chloride induced corrosion. The work was supervised by Prof. Øystein Vennesland (NTNU), Dr. Claus K. Larsen (Norwegian Public Roads Administration), and Prof. Dr. Bernhard Elsener (ETH Zurich, Switzerland).

The experimental and theoretical work related to the non-destructive chloride sensors revealed error sources that have to be considered when applying this technique. It was concluded that non-destructive monitoring of the concentration of chloride ions dissolved in the concrete pore solution is possible in a laboratory environment, but becomes more difficult under real world conditions. Moreover, the identified error sources appeared not only to be sources of error, but also sources of information as they allowed characterization of properties of the concrete pore system regarding transport of ionic species.

The critical chloride content is a decisive parameter for service life predictions or condition assessment. In general, the variable is nowadays still based on experience dating back to the 1960s–1980s. A thorough literature review has shown that although a lot of research efforts have worldwide been made during the last fifty years, the present state of the art does not allow improving current practice. Moreover, values for the critical chloride contents used by consulting engineers (and scientists) are based on experience with Portland cement; critical chloride contents for modern binder types (compare other activities within COIN and numerous research groups all over the world) are in general unknown. My experimental work indicated how measuring setups for the critical chloride content can be improved so that the results are more reliable and realistic. On the basis of theoretical, probabilistic considerations we suggested how laboratory results might be transferred to practice.

What implications do results of your work have for the research community?

It is widely recognized that in order to gain experience with modern binders and their effect on the critical chloride content, a generally accepted test method for the critical chloride content is required. In this regard, a RILEM committee has recently been established that aims at providing recommendations on such a test method (RILEM TC CTC). Experience from my experimental work and theoretical considerations on the concept of the critical

chloride content are highly relevant for this committee work. As my supervisors and me are all members of this committee, we had and have the opportunity to provide significant input to the committee and the test method to be recommended.

Dataloggers and concrete specimens used for the experimental work on chloride induced corrosion. Photo: Ueli Angst

Can you tell a little about the cooperation with ETH?

The cooperation was mainly in the form of Prof. Dr. Bernhard Elsener from ETH being my co-supervisor. During the duration of the project, he travelled to Norway twice, and I travelled several times to Zurich. During the last stage of my PhD project, I spent one month at ETH to discuss and evaluate some of my experiments. As the Institute of Building Materials at ETH has very good scanning electron microscopy facilities, part of these investigations were undertaken there.

In what way have the industrial partners been involved in your work?

The Norwegian Public Roads Administration was involved by Dr. Claus K. Larsen being my co-supervisor. One of the benefits from this was that Claus Larsen represented an owner. As scientists from academia and owners from real life often have different interests, this ensured that the valuable practical perspective was not lost during the work.

How will the results from your work be continued within COIN?

In the third focus area of my work, the mechanism of chloride induced reinforcement corrosion was addressed. One aspect of this was the early stage of corrosion propagation once the steel had started corroding. My experiments gave insight into the rate limiting mechanism during the first few weeks of corrosion propagation. At present, service life predictions in general only consider the initiation stage, viz. the time until corrosion starts. The propagation stage can with today's knowledge not be modeled in a reliable manner. To be able to predict the rate at which corrosion proceeds, viz. the rate at which steel cross section is lost, a better understanding of the corrosion mechanism is required. In the end of 2009, Karla Hornbostel started working on her PhD project at NTNU that aims at experimentally studying the corrosion propagation phase beyond the stage that was covered by my experiments.

What will you be working with when you have defended your PhD work?
I always thought that by the end of my PhD work I will be able to decide whether I wish to continue as a researcher in academia or working as a consulting engineer in practice. However, I still feel very uncertain about this matter. On the one hand, I highly enjoy research, but on the other hand, I am aware of the fact that particularly in my research area, the relation to practice is extremely important. I am thus very happy that I got offered two part time positions that complement one another perfectly: I will continue in research in a part time postdoc position at ETH in Zurich and gain practical experience in a private consulting company in Switzerland dealing with various aspects of corrosion related problems.

Do you have any advice for the COIN PhDs to come?
I encourage everyone to participate in international research activities such as conferences, workshops, or – if available – committees and work groups. I also think it is extremely valuable to publish articles in international peer-reviewed journals in order to get the work and ideas reviewed by experts from outside the research environment one belongs to.

Sensor for non-destructive measurement of chloride concentration in the concrete
Photo: Ueli Angst

5 International cooperation

5.1 Institutions and projects

Partners and key persons represent broad international cooperation by virtue of local networks within the multinational partners, personal networks and of committees. An overview of the latter shows that 17 COIN researchers participate in more than 30 such bodies.

Cooperation activities in 2010:

Institution / project	Activity 2010
Aberdeen University	Mutual visits to discuss sustainability and durability issues with Professor Fred Glasser.
Minbas. Swedish project (Cementa/CBI)	Mutual exchange of knowledge on aggregate research, through meetings/seminars
Metso Minerals, Finland	Subcontractor to Norcem (Norstone) in Focus Area 2.3 High quality manufactured sand for concrete
EMPA Dübendorf	PhD exchange to EMPA (Klaartje de Weerdt)
ETH, Zürich	PhD-supervision (Ueli Angst)
Helsinki University of Technology (TKK) and VTT, Finland	Joint project, "Duraint" (Ice abrasion)
IBMB Braunschweig	Exchange student Maria Pauluhn to perform work at SINTEF/NTNU on early age cracking
ICI Iceland	Agreement about collaborationon Rheology/SCC
Kobe University	Associate Professor Yutaka Takashina, guest researcher at NTNU
Leuven University	Joint project on testing of FRC
Crackfree. Swedish Consortium (Luleå Univ.)	Active coordination of common activities between COIN and Crackfree, through common project meetings and project planning.
Nanocem, European network	SINTEF is partner with COIN projects (Focus area 1.1 Low-carbon footprint binder systems)
New Brunswick University	PhD supervision (Jan Lindgård)
Freiburg University	Exchange student Lisa Wieghardt on super-LWA
EPFL, Lausanne	Tor Arne Hammer is Guest Academic
TU Dresden	Participating in "Structural Health- and Corrosion Monitoring", which is funded by the European Support program EFRE-TNA.

5.2 EU-funded projects

In regards of materials technology, EU's Seventh Framework Programme (7FP) has not announced any specific calls meeting the needs of our business sector, and we have not found themes in other calls that fit the themes of COIN. One exception is FP7-2011-NMP-ENV-ENERGY-ICT-EeB, where SINTEF was a part of the proposal from the Spanish AIDICO, "LOW-ENERCRETE - "Product development and application of cementitious building materials with low embodied energy for a sustainable construction. However, the proposal was rejected.

We are continuously evaluating the possibilities of participation in or preparing proposal for relevant EU-funded projects (i.a. through participation in EU "partner search" meetings).

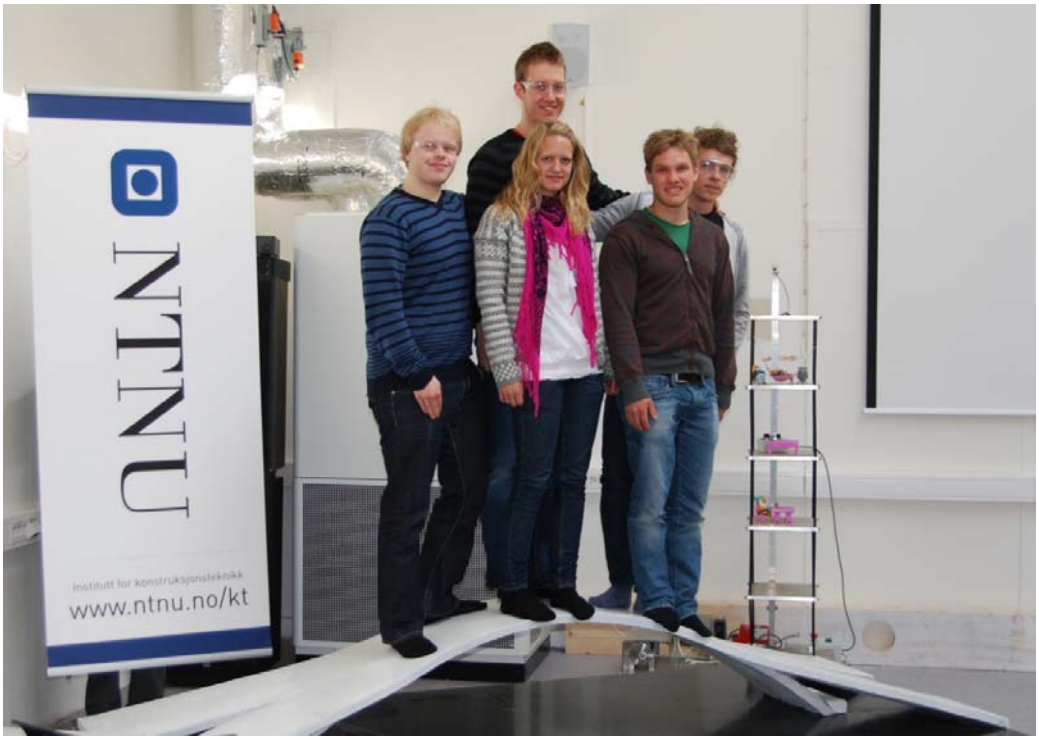
6 Recruiting

6.1 Master students

COIN is involved in the education of master students in science at the Norwegian education institutions NTNU, UMB and Oslo University College. In 2010 11 students have written seven master theses within the centre. Three master students from foreign institutions have stayed at NTNU to work with their master thesis within COIN. The industrial partners are also involved in supervision of master students, and personnel in both Veidekke and Saint-Gobain Weber have been supervisors to the master students.

SINTEF Building and Infrastructure employed one of the master students from NTNU spring 2010, and she has continued working with COIN activities.

At NTNU, COIN is involved in several levels of the master programme. In 2010 Terje Kanstad (NTNU) and Mari Bøhnsdalen Eide (SINTEF) were responsible for a village called "Concrete Innovation" in NTNUs compulsory course "Experts in Teamwork". The intention of the course is to provide students in their fourth year with practical skills in interdisciplinary teamwork. 30 students from several different disciplines signed up for COIN's village, and 5 out of 6 student groups ended up making a product in concrete, while the last group chose to write a report about Eurocode 8.



Da Vinci bridge made of super high-strength concrete, reinforced with steel fibres. The concrete was measured to have a compressive strength of 113.7 MPa.

6.2 PhD students

Three new PhD fellows started in 2010: Ya Peng from China, who is working with SCC and fillers, Markus Bernhard from Germany, who is working with superlight LWA, and Giedrius Zirgulis from Latvia, who came from COIN's partner Consolis to make a PhD study on

fibres. In addition Saint-Gobain Weber employed a PhD student, working at NTNU but outside COIN, to follow up the work performed in COIN on calcined clay.

Both Spenncon/ Consolis, Saint-Gobain Weber and Norcem have increased their financing of COIN to support laboratory work of the PhD fellows. Rescon Mapei has made investments in new laboratory equipment which is being used by one of the PhDs.

6.3 Interview with PhD student Giedrius Zirgulis

Giedrius Zirgulis moved to Trondheim, Norway and started his PhD study in September 2010. While Ueli Angst (chapter 4.4) represents the first four years of the centre, Giedrius Zirgulis represents the next four years.

Why did you start a fellowship at COIN/ NTNU?

After getting a diploma I started to work in a precast concrete elements factory which is a company of Consolis. Everything is interesting when you are freshly graduated. And practical experience knowledge I got while working in industry helps to see issues (studied in the university) in different point of view. But after some time the need to broaden your knowledge appears again. So I used my chance and started to work in Consolis' research and development laboratory Consolis Technology, located in Finland. This was a very good start in research field. Now I can see that practical experience and material knowledge do supplement each other. So when I got proposal to study in NTNU I didn't think long. That is another step for me in broadening knowledge.

Can you briefly describe your PhD work?

Generally speaking my PhD work is concentrated on fibre concrete. Before I started getting into this topic I had some doubts if it is possible to find something new about a material which has been around concrete industry for decades already. But even after few weeks when I have started to know more about it, it have become clear how many unsolved issues about fibre concrete there still exist. At this stage of research my supervisor Terje Kanstad proposed me to concentrate on possibility of using fibres together with ordinary reinforcement in load bearing elements. To research the opportunity of reducing reinforcement by using steel fibre reinforced concrete. Of course it is not possible to replace steel rebars with fibre reinforced concrete. But when it comes about production of precast elements, in some cases they can be very heavily reinforced. It takes a lot of time and steel to produce such reinforcement (a beam for example). In this context fibre reinforced concrete looks very attractive. Even if small amount of rods can be reduced it can give a major labour and steel savings in the long run, same time indirectly contributing to reduction of CO2 emission due to steel production.

What is your relation to the industrial partners within COIN?

As I mentioned above I have come to NTNU from Consolis Technology, and Consolis is one the industry partner in the COIN project. Though I am employee in NTNU now, I still keep close contacts with Consolis Technology (Finland) and other Consolis business units like Spenncon (Norway), Betonika (Lithuania) and 25% of my study time I work for small projects for Consolis. This relation is great support in my research since I can have discussions on topics with my supervisor, professors and colleagues in NTNU as well as with experts in Consolis. Same time full scale factory castings can be planned in Spenncon

factory in Verdal which brings test results closer to reality. I think access to full scale testing is very important in a research like this.

Which advantages do you experience by doing your PhD study within COIN?
I like being part of COIN as a centre. Lots of things are going on here and everything is organised so that you will get as much information as possible. Various meetings and presentations are held where you can present your work and get to know what others are working on. This really helps to see the big picture and not to be captured in your own thesis only.

The biggest advantage, however, is the close collaboration of COIN and industry partners. In my opinion this can be a key factor for breakthrough in developments or new discoveries. Industry always needs a research in order to continue development and universities are strong in fundamental knowledge, which sometimes is not treated properly by industry. So doing PhD within COIN gives a high chance that the research will contribute for society. Besides this project is very international, I can meet and work with PhD students from other countries, which give strong background for future collaborations.

Photo: Giedrius Zirgulis

7 Communication

COIN has published 40 scientific papers and held more than ten presentations in 2010. Amongst these are 7 articles in journals with referees, ten reports, including one state of the art report and a number of oral presentations of COIN.

Both the centre manager and the assistant manager have been invited key note speakers at three international conferences in 2010, of which one was cancelled due to fly ash and restrictions to airborne traffic.

Klaartje de Weerdt received Norwegian Association's research prize 2010 for her work on blended cements.

COIN puts effort in informing the Norwegian building industry of its research and results. In 2010 two oral presentations were given, and eight articles were published in trade magazines.

In May more than 50 persons involved in COIN gathered at a seminar presenting findings achieved so far within the centre. In addition to presentations of work within the projects, Fred Glasser from University of Aberdeen and Emmanuel Denarié were invited to give lectures on respectively *Inhibitors as problem solving* and *Engineering of UHPFRC and applications for rehabilitation.* The seminar was inspiring for all COIN members present, and offered an excellent opportunity for networking.

Photo: Kjersti Kvalheim Dunham

Key personnel

Center manager
Tor Arne Hammer, SINTEF
Phone: +47 930 58 686
e-mail: tor.hammer@sintef.no

Assistant center manager
Harald Justnes, SINTEF
Phone: +47 930 58 688
e-mail: harald.justnes@sintef.no

Project leaders
Harald Justnes, SINTEF e-mail:
harald.justnes@sintef.no

Kjersti Folvik, SINTEF
Phone: +47 229 65 865
e-mail: kjersti.folvik@sintef.no

Klaartje De Weerdt, SINTEF
Phone: +47 99 60 43 30
e-mail: klaartje.de.weerdt@sintef.no

Terje Kanstad, NTNU
Phone: 47 73 59 45 19
e-mail: terje.kanstad@ntnu.no

Bård Pedersen, Norstone AS
Phone: +47 97 53 96 78
e-mail:bard.pedersen@norstone.no

Knut O. Kjellsen, Norcem AS
Phone: +47 97 56 95 02
e-mail: knut.kjellsen@norcem.no

Mette R. Geiker, NTNU
Phone: +47 73 59 45 29
e-mail: mette.geiker@ntnu.no

Helge Brå, SINTEF
Phone: +47 970 95 277
e-mail: helge.bra@sintef.no

Disciplinary responsible
Stefan Jacobsen, NTNU
e-mail: stefan.jacobsen@ntnu.no

Terje Kanstad, NTNU
Mette R. Geiker, NTNU
Harald Justnes, NTNU

PhD
Kien Hoang, NTNU
kien.hoang@ntnu.no

Anja B. E. Klausen, NTNU
anja.klausen@sintef.no

Sindre Sandbakk, SINTEF
sindre.sandbakk@sintef.no

Giedrius Zirgulis, NTNU
giedrius.zirgulis@ntnu.no

Ya Peng, NTNU
ya.peng@ntnu.no

Egil Møen, NTNU
egil.moen@ntnu.no

Linn Grepstad Nes, NTNU
linn.g.nes@ntnu.no

Håvard Nedrelid, NTNU
havard.nedrelid@ntnu.no

Jan Lindgård, SINTEF
jan.lindgard@sintef.no

Karla Hornbostel, NTNU
karla.hornbostel@ntnu.no

Ueli Angst, NTNU
ueli.angst@ntnu.no

Markus Bernhardt, NTNU
markus.bernhardt@material.ntnu.no

Board
Terje F. Rønning, Norcem *chairman*
Jan-Diederik Advocaat, Aker Solutions
Kjersti K. Dunham, Norwegian Public Roads Administration
Terje Kanstad, NTNU
Trond Hagerud, Rescon Mapei
Berit Laanke, SINTEF
Lars Bjerkeli, Skanska Norge AS
Ingrid Dahl Hovland, Spenncon
Stein Tosterud, Unicon

Administrative manager
Randi I. Henriksen, SINTEF
Phone: +47 73 59 52 62
e-mail: randi.henriksen@sintef.no

COIN Personel 2010

Visiting researcher

- Associate Professor Yutaka Takashina, Kobe University, Japan, stayed three weeks at NTNU

Visiting students and PhD

- PhD student Michaela Wirthova, University of BRNO, Tsjekkia, 3 month's stay
- PhD student Tatyna Uvarova, Far East State Technical University, Vladivostok Russia and
- PhD student Egor Pomnikov, Far East State Technical University, Vladivostok Russia, visit in November/ December working on Ice Abrasion
- Summer internship Rolands Cepuritis (master student) 3 months working within Focus Area 2 (SCC, Rheology and fiber)
- Student Maria Pauhlun, IBMB Braunschweig, Germany, stayed in March and April working on fibre
- Lisa Wieghardt, Technical University Bergakademie Freiberg, Germany, stayed two months working on fiber reinforced superlight aggregates

Master students

1. Tor Øystein Bjerve (male): *Hybride betongkonstruksjoner* (NTNU)
2. Anders Hansson (male): *Hybrid Concrete Structures – Experimental testing and numerical simulation of structural elements* (NTNU)
3. Simon Hanson (male): *Støpetrykk ved bruk av selvkomprimerende betong* (UMB)
4. Runar Heggen (male): *Ground bearing concrete slabs subjected to…* (NTNU)
5. Gunrid Kjellmark (female): *Superlett betong* – (NTNU)
6. Hans Andreas H. Moe (male): *Hybrid concrete structures. Experimental testing and determination of shear capacity* (NTNU)
7. Eirik Nikolaisen (male): *Fordeling av fiber i fiberarmert betong* (UMB)
8. Andre Schmidt (male): *Støpetrykk ved bruk av selvkomprimerende betong* (UMB)
9. Frode Seglem (male): *Ground bearing concrete slabs subjected to…* (NTNU)
10. Ole Georg Skjølberg (male): *Hybrid Concrete Structures – Experimental testing and numerical simulation of structural elements* (NTNU)
11. Martin Strand (male): *Støpetrykk ved bruk av selvkomprimerende betong* (UMB)

Annual accounts COIN 2010

(All figures in 1000 NOK)

Funding

The Research Council	11.272
The Host Institution SINTEF	480
Research Partner NTNU	5.864
Aker Solutions	421
Saint-Gobain Weber	1.159
Norcem	4.130
Rescon Mapei	1.022
Skanska	694
Spenncon	835
Norwegian Public Roads Administration	1.587
Unicon	663
Veidekke	1.175
External funding	25
	29.327

Costs

SINTEF Building and Infrastructure	12.584
NTNU	8.610
Aker Solutions	220
maxit Group	853
Norcem	2.691
Rescon Mapei	901
Skanska	401
Spenncon	446
Norwegian Public Roads Administration	1.185
Unicon	261
Veidekke	1.175
	29.327

COIN Publications 2010

Articles in journals

1. Helland, Maage and Aarstein: “In-field performance of North Sea offshore platforms with regard to chloride resistance”, Structural Concrete, pp 15-24, Vol 11 2010, ISSN 1464-4177
2. Angst, Elsener, Myrdal and Vennesland: “Diffusion potentials in porous mortar in a moisture state below saturation”, Electrochimica Acta 55 2010, pp 8545-8555, ISSN 0013-4686
3. Angst, Elsener, Larsen and Vennesland: “Potentiometric determination of the chloride ion activity in cement based materials”, Journal of Applied Electrochemistry, pp 564-573, Vol. 40, No. 5 2010, ISSN 1572-8838
4. Lee and Jacobsen: “Sample preparation, image acquisition and image analysis on interfacial transition zone of steel fiber-reinforced mortar”, Nordic Concrete Research 2010 ;Volum 41.
5. Lee, Wang and Jacobsen: “Mix design and the effect of silica fume and steel fiber on rheological and mechanical properties of mortars”, Nordic Concrete Research 2010, Vol. 41, ISSN 0800-6377
6. Nguyen, Melandsø and Jacobsen:”Time dependant surface heat transfer in light weight aggregate cement based materials”, Engineering 2010 Vol. 2, pp 307-317, ISSN 1947-3931
7. Lindgård, Nixon, Borchers, Schouenborg, Wigum, Haugen and Åkesson: “The EU “PARTNER” Project — European standard tests to prevent alkali reactions in aggregates: Final results and recommendations”, Cement and Concrete Research, pp 611-635, Vol. 40 2010, ISSN 0008-8846
8. Lindgård, Pedersen, Bremseth, Dahl and Rønning: ”Experience using the Norwegian 38°C CPT to evaluate the alkali reactivity of aggregates, concrete mixes and binder combinations”, Nordic Concrete Research, December 2010, pp 31-50, ISSN 0800-6377
9. Haha, De Weerdt, Lothenbach: “Quantification of the degree of reaction of fly ash”, Cement and Concrete Research, pp 1620-1629, Vol. 40, Issue 11 2010, ISSN 0008-8846
10. De Weerdt, Sellevold, Kjellsen, Justnes: “Fly ash -limestone ternary composite cements: Synergetic effect at 28 days”, Nordic Concrete Research, Vol. 2 2010, ISSN 0800-6377
11. Justnes: “Acceleration by retardation”, Journal of Chinese Ceramic Society, pp 1618-1622, Vol 38, No 9 2010, ISSN 0454-5648
12. De Weerdt: ”Separate grinding versus inter grinding”, Cement, No 5 2010, pp 113-116, ISSN1607-8837
13. De Weerdt: “A comparison of separate and joint grinding of cement and additives. A review of literature”, Cement, No 6 2010, pp 82-87, ISSN1607-8837
14. Wang, Jacobsen, Lee, He and Zhang: ”Effect of silica fume, steel fiber and ITZ on the strength and fracture behavior of mortar”, Materials and Structures 2010; Volum 43.(1-2) pp. 125-139
15. Nguyen, Melandsø and Jacobsen: *“Capillary suction in concrete with analytical pipe model - part 1: numerical study of flow conditions”*, Nordic Concrete Research 2010, Vol 42 pp. 71-87
16. Nguyen, Melandsø, Jacobsen: *”Capillary suction in concrete with analytical pipe model - part 2: expansion-, contraction- and random sized sections compared with experiments”*, Nordic Concrete Research 2010 (42-06) s. 89-107

COIN Publications 2010

Article in books / COIN reports

1. Jacobsen, Vikan and Haugan: *"Flow of SCC along surfaces"*, Springer, pp 163-173:Design, Production and Placement of Self-Consolidating Concrete", ISBN 978-90-481-9663-0
2. Berg and Jacobsen: *"Packing and aggregate/ fibre – void saturation to proportion self compacting fibre reinforced concrete"*, 2nd International conference on sustainable construction materials and technologies – proceeding of honorary sessions, pp 265-276, Italy: Universita Politecnica delle Marche 2010 ISBN 978-1-4507-1487-7
3. Grini (editor): "*Concrete ideas for passive houses*, COIN report No. 20, 2010, ISBN 978-82-536-1141-9
4. Vikan and Jacobsen: *"Influence of rheology on pumpability of mortar"*, COIN report No. 21, 2010, ISBN 978-82-536-1158-7
5. Myrdal: *"Corrosion Inhibitors – State of the art"*, COIN report No. 22, 2010, ISBN 978-82-536-1168-6
6. Sandbakk, Kanstad, Bjøntegaard, Vandewalle and Parmentier: *"International Round Robin Testing of Circular FRC slabs: Reporting and Evaluation of Test"*, COIN report No. 23, 2010 ISBN 978-82-536-1172-3
7. Kjellmark: *"Autogenous deformation and relative humidity in concrete"*, COIN report No. 24, 2010, ISBN 978-82-536-1184-6
8. Vikan and De Weerdt: *"Stability of SCC - chemical stabilizers versus filler"*, COIN report No 25, 2010 ISBN 978-82-536-1185-3
9. Klinski: *"Gode detaljer for betongkonstruksjoner i passivhus"*, COIN report No 26, 2010, ISBN 978-82-536-1195-2

Key-note conference presentations

1. Justnes: *"Durability research in the Norwegian Concrete Innovation (COIN) Centre"*, Proceedings of 3rd Asian Conference on Ecstacy in Concrete (ACECON 2010) Chennai, India, 5-9 December 2010, pp 9-35, ISBN 978-93-80689-02-9

Conference publications

1. Angst, Elsener, Larsen and Vennesland: *"Considerations on the effect of sample size for the critical chloride content in concrete"*, Proceedings of 2nd International Symposium of Service Life Design for Infrastructure, Delft, The Netherlands. Vol. 1. Ed: van Breugel K et al. RILEM Publications S.A.R.L., 2010, pp. 569-576. ISBN 978-2-35158-113-1
2. Østnor, Justnes and De Weerdt: *"Calcined Marl as Alternative Pozzolan"*, Proceedings of the Cement and Concrete Science Conference, Sept. 13-16 2010, Birmingham, UK, pp 37-40, ISBN 978-070442-797-6
3. Jacobsen: "*Moisture flow into concrete exposed to frost and ice*: *Freeze-thaw testing of concrete - input to revision of CEN test methods*." Denmark: Nordic Concrete Federation 2010 ISBN 978-82-8208-020-0. pp 119-132
4. Jacobsen, Vikan and Haugan: *"Flow of SCC along surfaces"*, SCC 2010, Montreal 26-29 September 2010
5. Vikan, Hammer and Kjellsen: "*Drying shrinkage of SCC – influence of the composition of ternary composite"*, SCC 2010, Montreal 26-29 September 2010
6. Angst, Larsen, Vennesland and Elsener: *"Influence of casting direction on chloride induced rebar corrosion"*,Concrete under Severe Conditions, Environment and Loading, Volume 1. Ed: Castro-Borges P et al. CRC Press, 2010, pp 359-366. ISBN 978-0-415-59316-8.

COIN Publications 2010

7. Angst, Larsen, Vennesland and Elsener: "Concrete under severe conditions, environment and loading", Mexico: Published in Proceedings (not presented)
8. Justnes: *"Acceleration by retardation"*, Proceedings of the 7th International Symposium on Cement and Concrete, May 9-12, Jinan, China
9. De Weerdt: *"Ternary cements containing limestone powder and fly ash"*, 3rd GEMS Workshop on Thermodynamic Modelling in Cementitious Systems, Dübendorf, Switzerland 28-29 June 2010
10. De Weerdt and Justnes: *"The synergetic interaction between limestone powder and fly ash in ternary cements – evaluation over time and temperature"*, Cement and Concrete Science Conference, Sept. 13-16 2010, Birmingham, UK
11. Markeset and Skjølsvold: *"Time dependent chloride diffusion coefficient – field studies of concrete exposed to marine environment in Norway"*, Service Life Design for Infrastructure, Delft, The Netherlands 4-6 October 2010

Articles in trade magazines/ presentations to the industry

1. Grepstad Nes: *"Experimental and numerical comparison of test methods for fibre reinforced concrete"*, 7th international DIANA Users Meeting 17-18 June 2010, Italy
2. Lindgård: *"Recent developments in AAR"*, RILEM TC 219-ACS, 11 March 2010, Azores, Portugal
3. Justnes: *"Calcined marl"*, Norsk Betongdag, Oct. 21 2010, Stavanger, Norway
4. Vikan: *"Innovasjonssenteret COIN: Utvikling av mer attraktive bygninger og anlegg i betong, hva har vi oppnådd"*, Byggenavet/ Næringsforeningen, Trondheim, Norway 2 Nov 2010
5. Haugan and Kjellmark: *"Rissfrie betongkonstruksjoner"*, Byggeindustrien 2010, No. 13, ISSN 0332-7086
6. Myrdal: *"Vannavvisende betong lever lenge"*, Rust og Råte 2010
7. Vikan, Eide and Hegseth: *"Spesifikasjon av forskalte betongoverflater"*, Mur + Betong 2010, No. 2
8. *"Bjørvika-betongen sparer miljøet: Brenner sement med søppel"*, Vegen og vi No 4 2010
9. *Betre på betong. Betongbransjen brukar 200 millionar på å utvikle betong som både er bra for miljøet og lommeboka"*, Vegen og vi No. 62010
10. *"Hva er betong?"*, Teknisk Ukeblad 2010, No 32, ISSN 0040-2354
11. *"Sement+ mergel"*, www.bygg.no, published 2010-10-21
12. *"God stemming på betongdagen"*, www.bygg.no, published 2010-10-21

SINTEF Building and Infrastructure is the third largest building research institute in Europe. Our objective is to promote environmentally friendly, cost-effective products and solutions within the built environment. SINTEF Building and Infrastructure is Norway's leading provider of research-based knowledge to the construction sector. Through our activity in research and development, we have established a unique platform for disseminating knowledge throughout a large part of the construction industry.

COIN – Concrete Innovation Center is a Center for Research based Innovation (CRI) initiated by the Research Council of Norway. The vision of COIN is creation of more attractive concrete buildings and constructions. The primary goal is to fulfill this vision by bringing the development a major leap forward by long-term research in close alliances with the industry regarding advanced materials, efficient construction techniques and new design concepts combined with more environmentally friendly material production.