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SINTEF Building and Infrastructure

COIN Annual report 2008

SINTEF

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2009

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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.

A main activity in 2008 was to select and detail the topics identified in the state-of-the-art-reports prepared in 2007 as need for further research. The project structure established in 2007 was maintained.

The projects are:
1. Advanced cementing materials and admixtures
2. Improved construction techniques
3. Innovative construction concepts
4. Operational service life design, and
5. Energy efficiency and comfort of concrete structures

The Consortium has a Board of Directors, an Advisory Committee, a manager and a management group. The centre is located in Trondheim with SINTEF Building and Infrastructure as host institution. The Board has eight members; six from the industry partners, one from NTNU and one from SINTEF. All partners are represented in the Advisory Committee.

The consortium partners represent the value chain of the business sector; various material suppliers, 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 Advisory Committee. The centre got a new partner in this first year.

No PhD students were engaged in 2008. One researcher was employed with SINTEF.

The accumulated cost in 2008 was NOK 33.6 mill.

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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.

2 Research plan - social, environmental and industrial needs

The research plan is based on the social, environmental and industrial needs referred below. These needs were addressed by the Consortium Partners in the application process and made more specific in a 2-days workshop at the start of COIN (March 2007), and in the ongoing ECO-serve thematic EU network, with main objective to identify the needs of the European Construction Industry in its endeavour towards sustainability of the industries' products and production processes involving cement, aggregate and concrete production.

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 20002[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; new high tensile strength cementing materials reinforced with microfibres; 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 still hardly used for ready-mixed concrete (2% of total volume). 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. These issues are addressed in the ongoing ECO-serve thematic EU network, with main objective to identify the needs of the European Construction Industry in its endeavour towards sustainability of the industries' products and production processes involving cement, aggregate and concrete production.

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.

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.

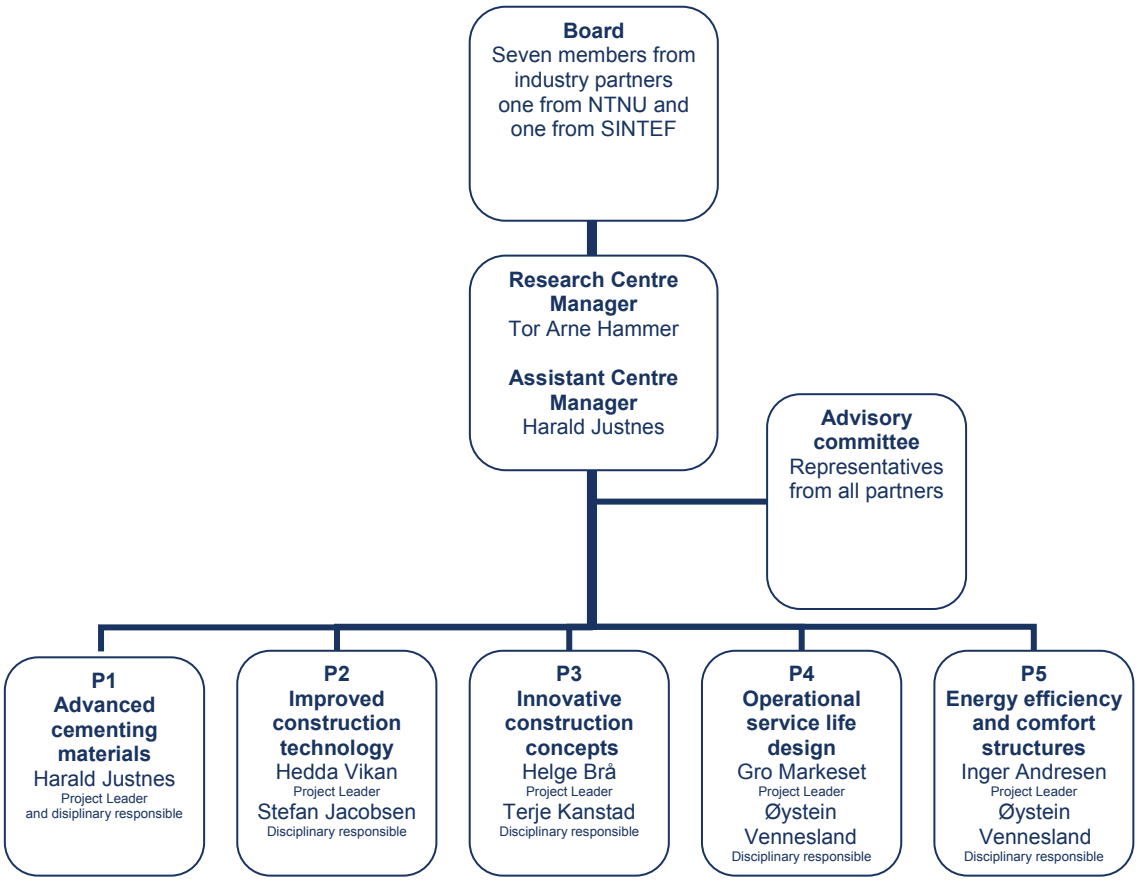
Fundamental approach

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

The Consortium has a Board of Directors, an Advisory Committee (AC), a manager and a management group. The Centre's manager reports to the Board. The centre is located in Trondheim with SINTEF Building and Infrastructure as host institution and with Senior Scientist Dr. T. A. Hammer as Research Centre Manager and Chief Scientist Professor H. Justnes as 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 AC, which act as a technical expertise group. AC considers and decides the annual work plan to be recommended for the Board.

The centre operates in close cooperation with NTNU Faculty of Engineering Science and Technology. Three professors at the Department of Structural Engineering (Kanstad, Jacobsen, and Vennesland) are disciplinary responsible for four projects. In addition three part time professors at NTNU are strongly involved in COIN: Justnes is project manager and disciplinary responsible for one project, Kjellsen is sub project manager and member of advisory committee, and Myrdal is project manager for one of the projects. The centre uses the laboratory facilities of NTNU and of SINTEF in Trondheim as well as in Oslo.



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

The consortium partners represent the value chain of the business sector; various material suppliers, contractors and users. They represent leading multinational companies in the cement and building industry. The centre got a new partner (Skanska) this second year.

Aker Solutions is one of the world's leading offshore technology companies and a part of Aker, a group of companies with a focus on energy, maritime and marine-resources industries.

Borregaard LignoTech is the world's leading producer of lignin-based products, i.a. as concrete admixtures, and is a part of Borregaard. They have their own laboratory and research staff.

maxit Group AB is the market leader in Europe on dry mortar, lightweight aggregates and building chemicals products. maxit Group is present in 25 countries. They have their own laboratory and research staff.

Norcem AS is Norway's sole producer of cement and a part of the Heidelberg Cement Group (DE), one of the world's leading producers of cement, and an associated company to the ready-mixed concrete company NorBetong and its subsidiary NorStone, Norway largest producer of concrete and aggregates. Norcem coordinates the Group cement-related R&D activities in Norway.

Rescon Mapei AS is a part of the Mapei Group (IT), one the world's leading producers of admixtures and additives for concrete as well as adhesives and chemical products for the building industry. Rescon Mapei has laboratory and research staff in Norway.

Skanska Norge AS is a part of Skanska which is one of the world's leading construction groups with expertise in construction, development of commercial and residential projects and public-private partnerships.

Spenncon AS is part of Consolis SAS (BE) which is one of the largest manufacturer of prefabricated concrete products in the world. Spenncon acts on behalf of the Scandinavian Branch of Consolis; Spenncon, Parma and Strängbetong, as well as of Consolis Technology.

Unicon AS is a part of Unicon A/S (DK), which is the largest ready-mix concrete producer in Scandinavia and a subsidiary of Cementir SpA (IT), a world leader in production of white cement.

Veidekke Entreprenør ASA is a part of Veidekke Group, a leading building contractor and property developer in Scandinavia.

Norwegian Public Roads Administration (NPRA) is an autonomous agency subordinated the Norwegian Ministry of Transport and Communication. They have their own research staff and laboratories, and provide guidelines for design, construction and maintenance of roads, tunnels and bridges.

The **Norwegian University of Science and Technology** (NTNU) represents academic eminence in technology and the natural sciences as well as in other academic disciplines.

The **SINTEF Group** is the largest independent research organisation in Scandinavia with more than 90 % of its income from contract research.

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

4 Technical activities, results

A main activity in 2008 was to select and detail the topics identified in the state-of-the-art-reports prepared in 2007 as need for further research. The project structure established in 2007 was maintained, representing the previous mentioned social, environmental and industrial needs. Also, the projects are organised to cover every partner's main interest. The projects are:

4.1 Project 1: Advanced cementing materials and admixtures

- Cements with lower CO_2 emission during production
- Admixtures to control hydration development
- Cements and admixtures to prevent cracking
- Alternative pozzolanes
- Cements with lower porosity

Industry partners with main interest in this project are Borregaard, maxit, Norcem, NPRA, Rescon Mapei, Skanska, and Spenncon There is one PhD student on the first sub-project.

Some main results in 2008:
The ongoing PhD-work in sub-project 1.1 shows a promising approach to develop a new kind of "all-round" cement with significantly reduced CO_2-emission, based on a combination of Portland-cement, limestone filler and fly ash (waste product from coal fired power plants). The principle of activating the limestone by the pozzolanic product from fly ash (or any other alumina containing pozzolan) has been proven in the publication at the conference in Nanjing (see Table 9.1), both by presence of predicted new mineral and that more chemical bound water is created. Furthermore, it has also been shown (unpublished data) that replacing cement with 30% fly ash and 5% limestone filler gives higher compressive strength for mortars than replacing with 35 % fly ash alone (respectively 54 MPa and 47 MPa). Thus, this chemical synergy results in physical effects.

The second major finding is in sub-project 1.4, where it has been thoroughly documented that ordinary "blue" clay (more rich in illite than kaolin) can be made a very reactive pozzolan just by calcining shortly at about 700°C. Such low temperature may be achievable by using fuel with low net CO_2 emission (i.e. waste or biofuel). The calcined clay lumps formed easily falls apart to 3-5 μm particles upon light grinding. The pozzolan activity measured according to ASTM C311 is better than the well-known silica fume. The industrial partner maxit is so excited by this finding that they have granted extra cash to increase the volume of further research.

Both findings in P1 described briefly above can make a significant contribution to reduction of the carbon footprint of the cement and concrete industry in Europe.

Project reports 2008:
- Low water permeability through hydrophobicity
- Quality improvers in cement making – State of the art

4.2 Project 2: Improved construction techniques

- Concretes with rheology adapted to rational production methods
- Concretes with high fibre content to be used in load carrying structural parts
- Concretes and production techniques to give good looking surfaces
- Technology for production of optimal crushed aggregate

Industrial partners with main interest in this project are maxit, Norcem, NPRA, Unicon and Veidekke. One PhD student is engaged in this project.

Some main results in 2008:
A calculation tool for one-way slabs has also been developed for comparison of different one-way slabs dependent on actual calculation model and maximum load evaluating span length, cross section and costs. Requirements to airborne and stepborne sound are also implemented in this tool.

Traditional reinforcement of concrete structures is a time consuming and resource demanding process. Hence, fibre reinforcement is a temping alternative. An important assumption for design of fibre-reinforced structures is that the fibres are evenly distributed and oriented in an optimal way. Åse L. Døssland finalized her PhD thesis "Fibre reinforcement in load carrying concrete structures: laboratory and field investigations compared with theory and finite element analysis".

To fulfil the vision of aesthetic concrete buildings, the volume stability should be increased and crack tendency reduced. Guomin Ji has finalized the PhD thesis "Cracking Risk of Concrete Structures in The Hardening Phase".

A simple technique has been developed to visualise the flow of pumped concrete. Experiments and literature review have shown that the pumpability of concrete can be quantified as being better the lower the necessary pressure to obtain a given flow. The pressure gradient over the pipe length is thus suggested as a measure of pumpability for a given pump set-up. The flow is found to be approximately proportional to pump-frequency, while the resulting pressure is found to depend on the rheological properties of the concrete. Results indicate that the Bingham plastic viscosity is a rheological parameter affecting pumpability. No such relation could be made with the Bingham yield stress and pumpability.

With natural sand/gravel resources being rapidly depleted all over Europe, the needs of the construction industry will have to be met increasingly from crushed/manufactured aggregates. Production technology, equipment and characterisation methods have, moreover, to be developed. Fields of application for leftover materials will also be determined in order to develop a non-waste technology. The project has arranged the international workshop "Manufactured Sand" in Stavanger, October 2008.

Project reports 2008:
- Means of improving concrete construction productivity – State of the art
- Pumping of concrete and mortar – State of the art

4.3 Project 3: Innovative construction concepts

- Design and verification basis for utilization of fibres in load carrying structures
- Development of superlight high performance aggregate and concrete
- Hybride structures – development of new material combinations, e.g. to be used in arctic environment

Industry partners with main interest in this project are Aker Solutions, maxit, NPRA, Spenncon, UNICON, and Veidekke. Four PhD-students are engaged in the project.

Some main results in 2008:
There has been established a project group working deliberately towards design rules and verification methods for a safe utilisation of fibre reinforced concrete in load carrying structures. A preliminary study on available European design guidelines will be reported early 2009. Effects of fibre reinforcement in a lightweight concrete was started.

There has been made extensive progress in developing a new high strength light weight aggregate for concrete, based on pure blue clay. And more ideas for significant improvement have been discussed, and a plan for investigating the ideas has been made. A study on fibre reinforced lightweight aggregate has been started with promising results.

It has been established an international network between research organisations dealing with design of concrete structures in artic regions and with ice abrasion in particular. The PhD study on the topic shows good progress and a rig has been developed for laboratory testing.

Project report 2008:
- Diffusion tight concrete – Preliminary study

4.4 Project 4: Operational service life design

The main objective of the project "Operational service life design" is to develop operational and reliable service life models and methods applicable for new design as well as for redesign of concrete structures based on a fundamental understanding of the different mechanisms involved in the deterioration processes.

The main focus is on deterioration of concrete structures caused by chloride-induced corrosion and well as alkali-aggregate reaction. The following topics are studied:
- Modelling of chloride transport and corrosion process
- Study of governing durability related parameters like chloride diffusion, critical chloride content and concrete resistivity
- Efficiency of preventive measures to increase service life (surface treatments, inhibitors, low corrosive reinforcement, etc)
- Performance based testing concept for alkali silica reaction

Two PhD candidates are involved in this project.

Industrial partners with main interest in this project are: Norcem, NPRA, Rescon Mapei, Skanska and Spenncon.

Some main results in 2008:
Reliable service life modelling need reliable input parameters. So far the focus has been on the quantification of the input parameters "chloride diffusion coefficient" and "critical chloride content" (for depassivation of the reinforcement). From a field site in Trondheim concrete samples have been tested after ten year of exposure in sea water. Systematic investigation of chloride profiles shows that the achieved chloride diffusion decreases with time and that the diffusion coefficient depends on the type of pozzolan blended in the cement.

COIN organised a workshop "Critical Chloride Content (CCC)" in Trondheim with a broad participation from all over the world, and with some of the most reputed researcher within the field. A main conclusion is that the test methodology to determine CCC is very important. It is shown that the calculated service life is very sensitive to this parameter. For instance, CCC for one and the same concrete may vary within a power of ten depending on the methodology used. The main objective of the present PhD-study is to find such a reliable method.

COIN-workers are central in the international pre-standardisation work (RILEM) within alkali-aggregate-reactions in concrete (AAR). The PhD-study constitutes a major part of the work. It has been established a cooperation with North-American institutions, from which one professor is a supervisor for the PhD-student.

Project reports 2008:
- Critical chloride content in reinforced concrete. COIN workshop, 5-6 June 2008, Trondheim, Norway –Workshop report
- Effect of surface treatment on chloride ingress and carbonation in concrete structures – State of the art
- Experience and results in connection with AAR -4.1 Testing 60°C
- Modelling of reinforcement corrosion in concrete structures – State of the art
- Stainless steel reinforcement in concrete structures – State of the art

4.5 Project 5: Energy efficiency and comfort

This task focuses on utilization of the passive thermal mass of concrete to reduce the need for cooling/heating of buildings, and its consequence for the indoor climate.

Unicon is the industrial partner with main interest in this project.

Calculations using improved models show that the energy consumption for local cooling in office buildings may be eliminated by utilisation of the thermal mass. To maintain an acceptable level of acoustic insulation is a challenge when the acoustic ceiling is removed for exposure of concrete slab. Acoustic issues are then in focus in task 5. Pilot buildings using passive thermal mass will be followed through COIN, from the design and construction stage until the use stage. COIN's goal is to describe and analyse the energy concepts that are chosen during the design stage. Later on, during the use stage, analysis of energy consumptions and interviews on indoor climate will be realized for each pilot building.
During the design stage, detailed calculations of energy consumptions and indoor thermal climate can also be made by COIN.

5 International cooperation

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 is shown below.

5.1 National and international committees

Committee	Description/ additional information	Time span	COIN member
Cembureau TF 5.6	”Product standards & regulations”	Ca 2000 -	Terje F. Rønning
CEN 51& 104 joint WG 12	Cement – test methods (Norwegian delegate)	Ca 1995 -	Terje F. Rønning
	Cement-frost testing	Ca 1990 -	
CEN TC 51	Cement (Norwegian delegate)	2004 -	Terje F. Rønning
CEN TC 104	Concrete and related products	1990 -	Steinar Helland
SC1	Concrete - Specification, performance, production and	2000 -	Steinar Helland
SC2	conformity”	1998 -	Magne Maage
	Execution of concrete structures	2008	Steinar Helland
SC8		2000	Magne Maage
	SC8 Repair and maintenance of concrete structures	1990	
EFC WP 11 - TG 5	European Federation of Corrosion; Work Party 11 “Corrosion in Concrete”; Task Group 5 ”Reference Electrodes for Concrete” (chairman)	2001 -	Roar Myrdal
EFC WP11 TG	Evaluation and planning of Corrosion Surveys and Monitoring of corrosion of steel in concrete	2007 -	Øystein Vennesland
FABEKO –	Norwegian Ready Mixed Concrete Organisation: Environmental committee	Ca 2000 -	Terje F. Rønning
FARIN	Forum for Alkali Aggregate Reactivity in Norway	Ca 2006 -	Terje F. Rønning
fib	Research and Innovation within the Building and Construction industry	2004 -	Terje F. Rønning
	Technical council	1988	Steinar Helland
Commision 5	Structural Service Life Aspect	2000 -	Øystein Vennesland Gro Markeset
Commission 5	Norwegian Concrete Association Preparation of publication “Instrument surveillance of concrete structures"	2008 -	Claus K. Larsen
Commission 8	Concrete	1986 -	Steinar Helland
Magazine	“Structural Concrete”	2005 -	Steinar Helland (deputy editor)

Committee		Description/ additional information	Time span	COIN member
fib	TG 1.5	"Concrete for the Arctic" The merits of concrete structures for oil & gas fields in hostile marine environments	2009	Jan-Diederik Advocaat
	TG 8.3	Design of fibre reinforced concrete structures	2009 -	Terje Kanstad
	TG 8.5	Silica fume in concrete	2006 - 2010	Øyvind Bjøntegård Knut Kjellsen
	TG 8.8	Structural design with Flowable Concrete	2009 -	Terje Kanstad
ICCC 2011		International committee for ”13th International Congress on Chemistry of Cement”	2008 -	Harald Justnes
ISO TC 71	SC3	Concrete, reinforced concrete and prestressed conctere / concrete production and execution of concrete structures”	1995 - 2005 -	Magne Maage Steinar Helland
	SC 3 WG4	Durability – working out coming ISO standard Service life design of concrete structures	2004 -	Steinar Helland
	SC7	Maintenance and repair of concrete structures	2004 -	Magne Maage
NCTP		Norwegian Technology platform (chairman)	2006 -	Terje F. Rønning
Norwegian Concrete Association		Cathodic protection of concrete structures	2003 -	Øystein Vennesland
		Preparation of publication “Instrument surveillance of concrete structures”	2005 -	Roar Myrdal
		Scientific committee in symposium "Sprayed Concrete", Tromsø, Norway 12-15 September 2011	2008 - 2011	Øyvind Bjøntegaard
		Sprayed Concrete Committee	2007 -	Øyvind Bjøntegaard
		Board	2002 -	Terje F. Rønning (chairman 2008-09) Helge Brå Kjersti K. Dunham Sverre Smeplass
		Concrete and environment		Stefan Jacobsen Knut Kjellsen
		International work		Tor Arne Hammer
		Research and development		Terje F. Rønning Hans Stemland
		Committee for Design and execution of durable structures in marine environment	1998	Magne Maage
		Permanent committee for competence, profession and standardisation	1998	Magne Maage

Committee	Description/ additional information	Time span	COIN member
NRCTP	Nordic Technology platform (one of three Norwegian delegates)	2007 -	Terje F. Rønning
RILEM TC 219 ACS	"Alkali Aggregate Reaction in Concrete Structures"	2006-2011	Jan Lindgård Hans Stemland Terje F. Rønning Harald Justnes
RILEM TC 213- MAI		2005 -	Øystein Vennesland Claus Larsen
SCC '09	International committee for SCC'09 in Beijing	2008 -	Harald Justnes
Standard Norway	Reference group for concrete	2005 -	Magne Maage Steinar Helland
	Representative of Norwegian Producers of Materials for Construction in sector board	2001 -	Terje F. Rønning

In 2008 COIN formalized cooperation with:

Nanocem	SINTEF BF is partner with COIN projects (P1)
Aberdeen University	Letter of agreement
IBMB Braunschweig	Visit from IBMB and an agreement to find common activities within FRC
EMPA Lausanne	Visit to EMPA and an agreement for PhD exchange (Klaartje de Weerdt)
Luleå Univ.	Verbal agreement about collaboration on shrinkage activities
Cementa/CBI	Verbal agreement about collaboration on manufactured sand
New Brunswick University	Agreement of PhD supervision (Jan Lindgård)
ICI Iceland	Verbal agreement about collaboration on rheology/SCC
Leuven Univiersity	Visit to Leuven and agreement to participate in a joint project (FRC)

5.2 EU-funded projects

5.2.1 Ice Abrasion Resistant Concrete structures (IceARC)

In March Stefan Jacobsen submitted a proposal under the call FP7-NMP-2008-SMALL-2. The project was mainly related to the topics in the area "Using engineering to develop high performance knowledge-based materials" and the call NMP-2008-2.5-1 "Functionally graded materials for improved mechanical performance". The project was intended to be linked to ongoing activities in the COIN. This includes a PhD-student at NTNU presently working full time with ice abrasion on concrete as well as a Task Group with an activity dedicated to ice abrasion on cement based materials. The project was declined, but a new attempt together with VTT in Finland is under consideration.

5.2.2 Reducing the Environmental Footprint of Cement-based Materials (REFCEM)

In October Roar Myrdal participated in a NANOCEM-Workshop in Lausanne, Switzerland, starting the process of proposing a project for FP7: Reducing the Environmental Footprint of

Cement-based Materials (REFCEM). The main objective REFCEM is to reduce Europe's CO_2 emission by drastically increase the levels of substitution of Portland cement clinker with by-products and wastes produced by European industries, beyond those already widely used, and develop new cementitious materials, e.g. activated clays and natural pozzolans. To obtain this the project will develop a systematic, science-based understanding of cementitious processes and materials at the nanoscale, and extend this knowledge across all the scales involved in cement and concrete production. SINTEF Building and Infrastructure participates in WP 2 (Materials) and WP 4 (Assessing functional performance) with links to parallel research activities in COIN.
The coordinator of REFCEM is Dr Wolfgang Dienemann, Heidelberg Cement, Germany.
The application will be sent in 2009.

5.2.3 Reducing resource intensive industries' footprint to protect our one and only Earth (1EARTH)

Late October 2008 Harald Justnes participated in the initiation meeting 1EARTH. Towards optimization of resources management and zero waste disposal objectives, the project will develop and demonstrate the potential to improve processes and products management in Resource Intensive Industries (RIIs): resource optimization needs using non avoidable and non reusable waste instead of fossils fuels and virgin raw materials, improvement of their competitiveness and environmental footprint, development of waste-to-resources technologies: upstream by waste qualification, pre-processing technologies turning waste to alternatives resources, inherent health & safety; downstream by improved industrial processes and new products development able to use low grade waste generated resources for end-of-life product management. Those "co-processing" activities turning wastes into resources will readdress completely the waste management hierarchy targeting zero disposals (incineration and land filling) and total recycling to products. For this project, a cross-sector consortium (keys RII's, academics, environmental experts) has been formed to establish new suitable alliances and to achieve optimal synergy.

The preliminary proposal (1st round) was sent February 2009, and if it passes this round a full proposal has to be written during the spring and sent in July 2009. SINTEF Building and Infrastructure will lead WP2; *Economical Resources:* Establish the overview of existing and relevant material flows in resource intensive industries (RIIs)**.** Enable the creation of possible "couples" linked to WP3;*(Holcim) Co-processing:* the recovery of energy and materials from waste in RIIs. It can help alleviate the environmental footprint of RIIs.

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). In addition to the three proposals mentioned above, SINTEF Building and Infrastructure applied for one EU-funded project on thermal mass (project 5), and another on aggregates (project 2). (The latter was refused per February 2009.)

Other kinds of international cooperation:

- One student from the Technological Educational Institution of Athens worked for 6 months in Project 2
- One post doc from Malaysia (project 1)

6 Recruiting

Six PhD fellowships were announced and 49 persons applied. Norwegian/ Nordic candidates have shown little interest, but the financial crises might change this. Lack of funds is limiting the opportunity to get all PhDs wanted, and only one PhD student will start in 2009. It was decided not to push the industrial partners for increased funds in these financial times. Alternative funding might be sought, and the PhD situation will be evaluated spring 2009.

SINTEF Building and Infrastructure employed one more researcher who will work in COIN projects.

7 Accounts

The accumulated cost in 2008 was NOK 33.6 mill, of which NOK 23.6 mill was spent by the host (SINTEF) and its research partner (NTNU), and NOK 10 mill by the industry partners. The financing was NOK 14.9 in cash, of which NOK 10.1 mill. were from the Research Council of Norway, and NOK 5 mill were in-kind from the partners. All partners, except one, increased their in-kind contribution beyond the amount given in the agreement.

8 Publications

COIN has produced more than 60 publications in 2008, all listed in appendix A3. The majority are proceedings in scientific conferences, and Nordic Concrete Federation's XXth Symposium in Bålstad, Sweden were coloured by COIN and its 14 presentations.

Eleven reports have been published, including two PhD thesis, six state of the art reports and one report containing presentations from the workshop on Critical chloride content in reinforced concrete.

In addition there have been a number of oral presentations of COIN.

Appendices

Annual report COIN - COncrete INnovation Centre

Key Researchers

Name	Institution	Main research area
Andresen, Inger	SINTEF	Project 5: Energy efficiency comfort
Brå, Helge	SINTEF	Project 3: Innovative construction concepts
Engelsen, Christian	SINTEF	Project 1: Advanced materials and admixtures
Grini, Catherine	SINTEF	Project 5: Energy efficiency comfort
Hammer, Tor Arne	SINTEF	
Haugan. Lars	SINTEF	Project 2: Improved construction technology
Hveem, Sigurd	SINTEF	Project 5: Energy efficiency comfort
Jacobsen, Stefan	NTNU	Project 2: Improved construction technology
Jensen, Tore Myrland	SINTEF	Project 3: Innovative construction concepts
Justnes, Harald	SINTEF	Project 1: Advanced materials and admixtures
Kanstad, Terje	NTNU	Project 3: Innovative construction concepts
Klausen, Anja B. E.	SINTEF	Project 3: Innovative construction concepts
Markeset, Gro	SINTEF	Project 4: Operational service life design
Myrdal, Roar	SINTEF	Project 1: Advanced materials and admixtures
Stemland, Hans	SINTEF	Project 4: Operational service life design
Vennesland, Øystein	NTNU	Project 4: Operational service life design
Vikan, Hedda	SINTEF	Project 2: Improved construction technology
Østnor, Tone Anita	SINTEF	Project 1: Advanced materials and admixtures

Visiting Researchers

Name	Affiliation	Nationality	Sex M/F	Period	Topic
Wang, Xiao Hui	3.1	Chinese	F	2007-2008	Interfaces (Nano-indenter)

Postdoctoral researchers

Name	Nationality	Period	Sex M/F	Topic
Lee, Siaw Foon	Malaysian	2007-2010	F	Rheology, microfibers

PhD students with financial support from the Centre budget

Name	Nationality	Period	Sex M/F	Topic
de Weerdt, Klaartje	Belgian	2007-2011	F	Cements with low CO_2 outlet
Lindgård, Jan	Norwegian	2007-2011	M	AAR: Lab. testing vs field performance
Møen, Egil	Norwegian	2007-2011	M	Ice abrasion
Sandbakk, Sindre	Norwegian	2007-2011	M	Fibre reinforced concrete

PhD students with partial financial support from the Centre budget

Name	Funding	Nationality	Period	Sex M/F	Topic
Hagelia, Per	NPRA	Norwegian	2008-2009	M	Deterioration Mechanisms and Durability of Concrete with Emphasis on Sprayed Concrete in Aggressive Ground and the Expansion Mechanism of Alkali-Silica Reaction
Sæther, Irina	Norut	Norwegian	2008-2009	F	Numerical life cycle simulation of corrosion damaged and retrofitted concrete structures

PhD students working on projects in the centre with financial support from other sources

Name	Funding	Nationality	Period	Sex M/F	Topic
Angst, Ueli	NTNU	Swiss	2007-2011	M	Modelling critical chloride cont. and corr. proc.
Døssland, Åse Lyslo	NTNU	Norwegian	2007-2008	F	Fibres
Grepstad, Linn	NTNU	Norwegian	2007-2011	F	Hybrid structures
Ji, Goumin	NTNU	Chinese	2007-2008	M	Volume stability and crack tendency
Landgraff, Martin	NTNU	Norwegian	2007-2011	M	Hybrid structures
Lindgård, Jan	SINTEF	Norwegian	2007-2011	M	AAR: Lab. testing vs field performance
Nedreli, Håvard	NTNU	Norwegian	2007-2011	M	LWAC – testing and modelling

Master degrees

Name	Sex M/F	Topic
Andersen, Harald I.	M	Connection between bubble decks - experiments and nonlinear analysis
Ask, Morten	M	Fibre
Berg, Stein Are	M	Selfcompacting fibre reinforced concrete
Bolduc, Sam	M	Prouction process
Braten, Christian	M	Connection between bubble decks - experiments and nonlinear analysis
Dyrhaug, Geir	M	Synthetic fibre reinforced concrete Casting techniques, fibre orientation and distribution
Gjone, Arne	M	Fibre - litterature study
Kalogiannidis, Evangelos	M	Workability
Løvstad, Lars	M	Fibre

Sørhøy, Christoffer A.	M	Synthetic fibre reinforced concrete Casting techniques, fibre orientation and distribution
Zyck, Theresa	F	Fibre
Aasprong, Øystein	M	Fibre

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(All figures in 1000 NOK)

Funding

	Amount	Amount
The Research Council		10 077
The Host Institution SINTEF		2 252
Research Partner NTNU		6 433
Aker Solutions	462	
Borregaard Industries Ltd	1 224	
maxit Group	1 648	
Norcem	3 086	
Rescon Mapei	1 092	
Skanska	1 241	
Spenncom	737	
Norwegian Public Roads Administration	1 432	
Unicon	1 654	
Veidekke	2 100	
Transferred from 2007	914	
Transferred to 2009	-766	14 824
Public partners*		
		33 585

Costs

SINTEF Building and Infrastructure		14 590
NTNU		8 993
Aker Solutions	212	
Borregaard Industries Ltd	925	
maxit Group	1 268	
Norcem	1 636	
Rescon Mapei	942	
Skanska	577	
Spenncom	257	
Norwegian Public Roads Administration	932	
Unicon	1 154	
Veidekke	2 100	10 002
Public partners		
Equipment		
		33 585

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Journal Papers	Author	Journal
COIN - Concrete Innovation Center	Tor Arne Hammer	Concrete International
Diffusion potentials as source of error in electrochemical measurements in concrete	Ueli Angst, Øystein Vennesland, Roar Myrdal	Materials and Structures, electronic version
Aggregate packing and -void saturation in mortar and concrete proportioning	Stefan Jacobsen	Materials and Structures
Ice abrasion data on concrete structures - overview	Egil Møen, Stefan Jacobsen et. al	Nordic Concrete Research
Probabilistic service life modelling of ice abrasion on concrete structures	Esko Sistonen, Stefan Jacobsen	Nordic Concrete Research

Published Conference Papers	Author	Conference
Aging Factor Concept – Chloride intrusion	Steinar Helland	Nordic Concrete Federation Workshop - Hirtshals, Denmark
Aging Factor Concept – Chloride intrusion	Steinar Helland	8th International Symposium on Utilization of High-Strength and High-Performance Concrete - Tokyo, Japan
An Investigation of Bond Strength between Fibre and Concrete	Sindre Sandbakk	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Critical chloride content for corrosion in reinforced concrete.	U. Angst, Ø. Vennesland, C. K. Larsen, B. Elsener	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
COIN – and durability of concrete structures	Øystein Vennesland, Tor Arne Hammer, Ueli Angst	Workshop on: Nordic Exposure Sites - Input to revision of EN 206-1 - Hirtshals, Denmark
COIN - Concrete Innovation Center	Tor Arne Hammer	Borregaard Symposium - Lofoten, Norway
COIN - Concrete Innovation Center	Tor Arne Hammer	Norsk Betongdag - Oslo, Norway
Comparing Intergrinding and Separate Grinding of Blended Cements	Klaartje De Werdt, Harald Justnes	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Concrete Innovation centre (COIN) - Advanced cement materials and the use of bio-admixtures	Christian John Engelsen	4th International Symposium on the Marine Biotechnology and Advanced Materials, Korea
Concrete Surface Quality - An Overview	Hedda Vikan	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Concrete with Reduced Cracking	Harald Justnes, Sindre Sandbakk	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Concrete Workability and Fibre Content - An Overview	Hedda Vikan	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Connection between bubble decks - experiments and nonlinear analysis	Christian Bråten, Harald I. Andersen	The 5th International DIANA Users Meeting - Trondheim, Norway
Cracking risk analysis of the Bjøvika submerged tunnel at hardening phase	Guomin Ji, Terje Kanstad	The 5th International DIANA Users Meeting - Trondheim, Norway
Critical chloride content in reinforced concrete - state of the art	Ueli Angst, Øystein Vennesland	2nd Int. Conf. on Concrete Repair, Rehabilitation and Retrofitting - Cape Town, South Africa
Detecting critical chloride content in concrete using embedded ion selective electrodes – effect of liquid junction and membrane potentials	Ueli Angst, Øystein Vennesland	Workshop on: Critical chloride content in concrete, Trondheim, Norway

Published Conference Papers	Author	Conference
Durability of surface protection systems in harsh marine climates	Claus K. Larsen	11th International Conference on Durability of Building Materials and Components- Istanbul, Turkey
Environmental Characterisation of Concrete Products in View of the Ongoing European Standardisation Work	Christian John Engelsen, Roar Myrdal	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Experience with different fibre types and fibre volumes in laboratory testing of structural concrete	Terje Kanstad, Åse Døssland, Sindre Sandbakk, Helge Brå	7th international congress. Concrete: Construction's sustainable option - Dundee, Scotland
Experimental testing and constitutive modelling of concrete	Håvard Nedrelid	The 5th International DIANA Users Meeting - Trondheim, Norway
Fiberarmering i bærende konstruksjoner:Status og aktuelle forskningsresultater	Terje Kanstad	Dansk Betongdag - Haderslev, Denmark
Fibre Reinforcement in Load Carrying Concrete Structures	Åse L. Døssland, Terje Kanstad	The 5th International DIANA Users Meeting - Trondheim, Norway
Fresh Fibre Reinforced Concrete – A State of the art report	Hedda Vikan	International Workshop & Nordic Miniseminar Fibre Reinforced Concrete - Trondheim, Norway
From Set Retarders to Hardening Retarders: A New Concrete R&D Challenge	Roar Myrdal	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Frost dilation measurements on concrete cores from a dam with ASR	Stefan Jacobsen, Jan Lindgård	13th ICAAR - Trondheim, Norway
Frost dilation measurements on concrete cores from a dam with ASR	Stefan Jacobsen, Jan Lindgård	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Future HPC - driven by industrial need for innovation as well as environmental and social needs?	Tor Arne Hammer	8th International Symposium on Utilazation of High-Strength and High-Performance Concrete - Tokyo, Japan
Hardening Retarders for Massive Concrete (Awarded best paper at the conference)	Justnes, H,, Wuyts, F. and Van Gemert, D	5th ACI/CANMET International Conference on High-Performance Concrete Structures and Materials - Manaus, Brasil
Ice abrasion on concrete; data and testing	Egil Møen, Stefan Jacobsen	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Ice abrasion on concrete; data and testing	Egil Møen, Stefan Jacobsen	Nordic Concrete Research Workshop: Ice abrasion on concrete structures - Helsinki, Finland
Improvement of the Ice Zone on Concrete Structures for Sub Arctic Areas	Kjell Tore Fosså	Nordic Concrete Research Workshop: Ice abrasion on concrete structures - Helsinki, Finland
In-field performance of north sea hsc/hpc offshore platforms with regard to chloride resistance	Steinar Helland, Ragnar Aarstein, Magne Maage	Nordic Concrete Federation Workshop - Hirtshals, Denmark
Lightweight Aggregate Concrete under Triaxial Compression	Håvard Nedreli, Svein Ivar Sørensen, Helge Brå	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Microstructure of binder from the pozzolanic reaction between lime and siliceous fly ash, and the effect of limestone addition	Klaartje De Weerdt, Harald Justnes	1st Int. Conf. Microstructure Related Durability of Cementitious Composites - Nanjing, China
Non-chloride Accelerating Admixtures for Concrete: An Overview and Current Norwegian Research	Roar Myrdal	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Published Conference Papers	**Author**	**Conference**

Numerical simulations of service life cycle of reinforced concrete structures	I. Sæther	The 5th International DIANA Users Meeting - Trondheim, Norway
Operation Service Life Design - A Focus Area in COIN	Gro Markeset	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Packing of fibres and aggregate reviewed and calculated with Westmans equation	Stein Are Berg, Stefan Jacobsen	International Workshop & Nordic Miniseminar Fibre Reinforced Concrete - Trondheim, Norway
Pozzolanic activity of sintered clay and interaction with limestone powder	Klaartje De Werdt, Tone Østnor, Harald Justnes	Cement and Concrete Science - Manchester, UK
Probabilistic Service Life Modeling of Ice Abrasion on Concrete Structures	Esko Sistonen, Stefan Jacobsen	Nordic Concrete Research Workshop: Ice abrasion on concrete structures - Helsinki, Finland
Pullout testing of different fibre types	Sindre Sandbakk, Åse Døssland, Terje Kanstad	International Workshop & Nordic Miniseminar Fibre Reinforced Concrete - Trondheim, Norway
Pumpability of mortar and concrete as related to rheology	Stefan Jacobsen	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
Rapid repair of airfield runway in cold weather using CAC mortar	Harald Justnes	Centenary Conference 2008; Calcium Aluminate Cements - Avignon, France
Recent advances in modelling of the constituent release from recycled concrete aggregates with different degree of carbonation	Christian John Engelsen	International Conference Sustainable Concrete Construction - Ratnagiri, India
Recent experience with load carrying concrete structures containing large amounts of synthetic and steel fibres.	Terje Kanstad, Yngvil H. Øvrelid, Sindre Sandbakk, Stefan Jacobsen	International Workshop & Nordic Miniseminar Fibre Reinforced Concrete - Trondheim, Norway
Shore Approach - 26 years experience with high quality concrete in XS3 exposure	Magne Maage	Nordic Concrete Federation Workshop - Hirtshals, Denmark
Stainless steel as reinforcement in concrete	Øystein Vennesland, J. I. Kvamme, H. H. Bjørnsen and Marte Næss	Eurocorr - Edinburgh, UK
Sustainable cement and concrete industry – an overview of the international conference in Lillehammer, Norway 2007	Stefan Jacobsen	2008 International Expert Workshops on Cement & Concrete Technology for Sustainable Development -Beijing, Shenyang and Jinan, China
The Norwegian Concrete Research Progamme COIN	Tor Arne Hammer	XX Symposium on Nordic Concrete Research - Bålsta, Sweden
The reactivity of Fly Ash and Limestone in Cementitious Systems	Klaartje De Werdt, Harald Justnes	Cement and Concrete Science - Manchester, UK
The reactivity of Portland cement containing limestone and fly ash	Klaartje De Werdt, Harald Justnes	Cement and Concrete Science - Manchester, UK

Books

	Author
Fibre reinforcement in load carrying concrete structures. Laboratory investigations compared with theory and finite element analysis	Åse Lyslo Døssland
Cracking risk of concrete structures in the hardening phase. Experiments, material modelling and finite element analysis	Guomin Ji

Reports	Author
Low water permeability through hydrophobicity	Harald Justnes
Quality improvers in cement making – State of the art	Christian J. Engelsen
Means of improving concrete construction productivity – State of the art	Hedda Vikan
Pumping of concrete and mortar – State of the art	Stefan Jacobsen, Jon Håvard Mork, Siaw Foon Lee, Lars Haugan
Diffusion tight concrete – Preliminary study	Tore Myrland Jensen
Critical chloride content in reinforced concrete. COIN workshop, 5-6 June 2008, Trondheim, Norway	Gro Markeset, Øystein Vennesland (Editors)
Effect of surface treatment on chloride ingress and carbonation in concrete structures – State of the art	Thale Sofie Wester Plesser
Modelling of reinforcement corrosion in concrete structures – State of the art	Gro Markeset, Roar Myrdal
Stainless steel reinforcement in concrete structures – State of the art	Gro Markeset
Experience and results in connection with AAR -4.1 Testing 60°C	Sigrun Kjær Bremseth

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.