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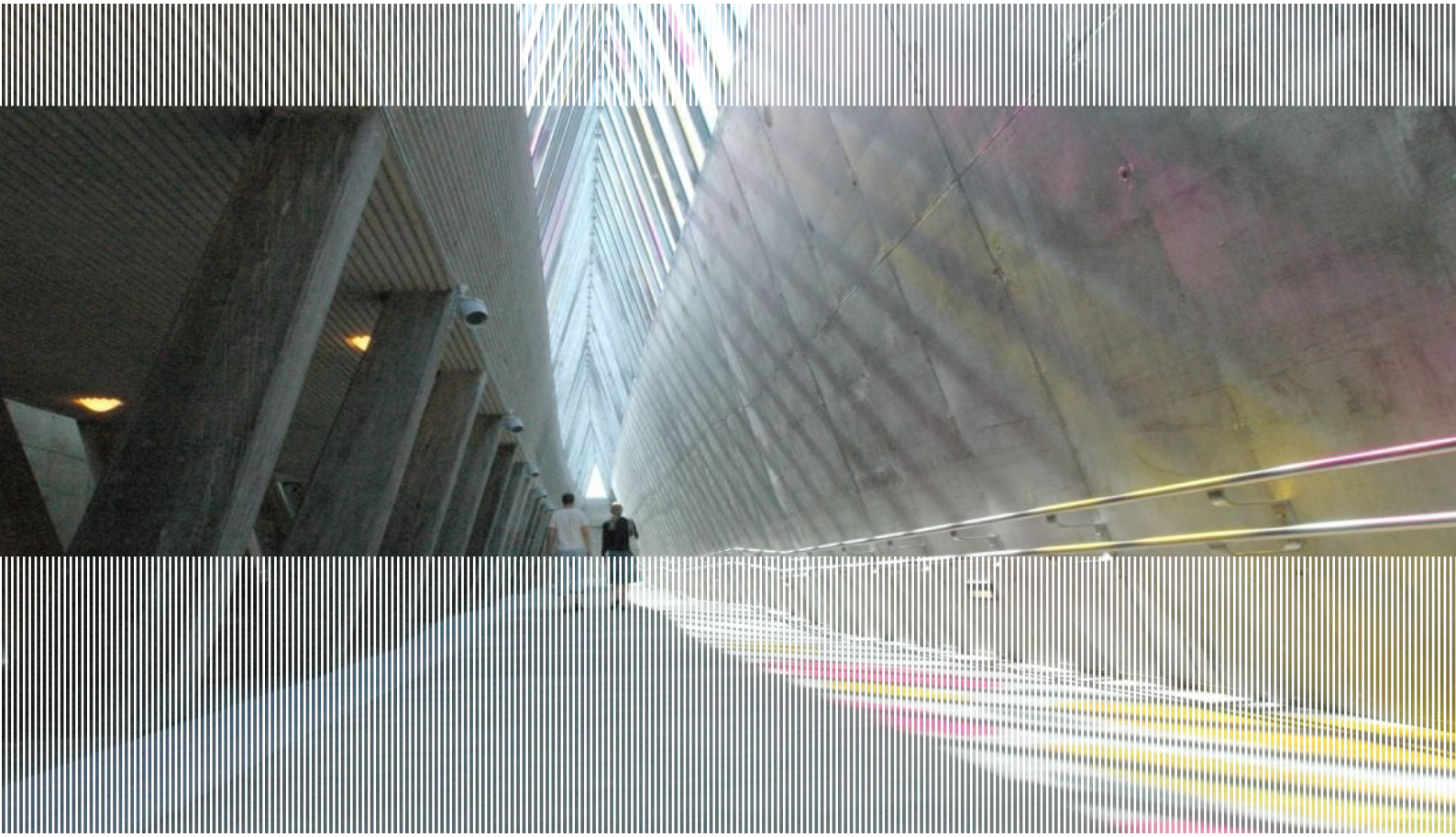
SINTEF Building and Infrastructure

COIN Annual report 2009



SINTEF

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COIN Annual report 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.

The main activities in 2009 were according to the plan established in 2008 based on the topics identified in the state-of-the-art-reports prepared in 2007 as need for further research. A number of research breakthroughs were reached, and one activity lead to a trial product which the Partner wants to develop to a final product outside COIN. The initial project structure, as established in 2007, was maintained. However, it was reorganised during 2009 to be put in to action at the start of 2010.

The 2009 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

More than 40 publications were produced in 2009, and one international workshop was accomplished. 13 master students had their degrees within COIN. The international cooperation was extended with participation in a Nordic project and two German projects.

The Consortium has a Board of Directors, three Technical Advisory Committees, TACs (replacing the previous Advisory Committee in connection with the reorganising of the project structure as previously mentioned), 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 TACs.

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 TACs. One partner announced to withdraw from 2010 and on.

Three new PhD students were engaged in 2009. One researcher was employed with SINTEF.

The accumulated cost in 2009 was NOK 33.6 mill.

"The partnership with COIN is valuable in our work to win new projects for harsh environments in Norway, Canada, Russia and other areas around the world, and to strengthen the Norwegian concrete cluster."

Jan-Diederik Advocaat
senior manager for marine concrete structures,
Aker Solutions

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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.

The museum Ivar Aasen-Tunet, Hovdebygda, Norway.
Architect: Sverre Fehn. Photo: Informasjonspartner

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, and is unchanged since 2007.

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 (replaced with 3 Technical Advisory Committees from 2010 and on, see below), 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.

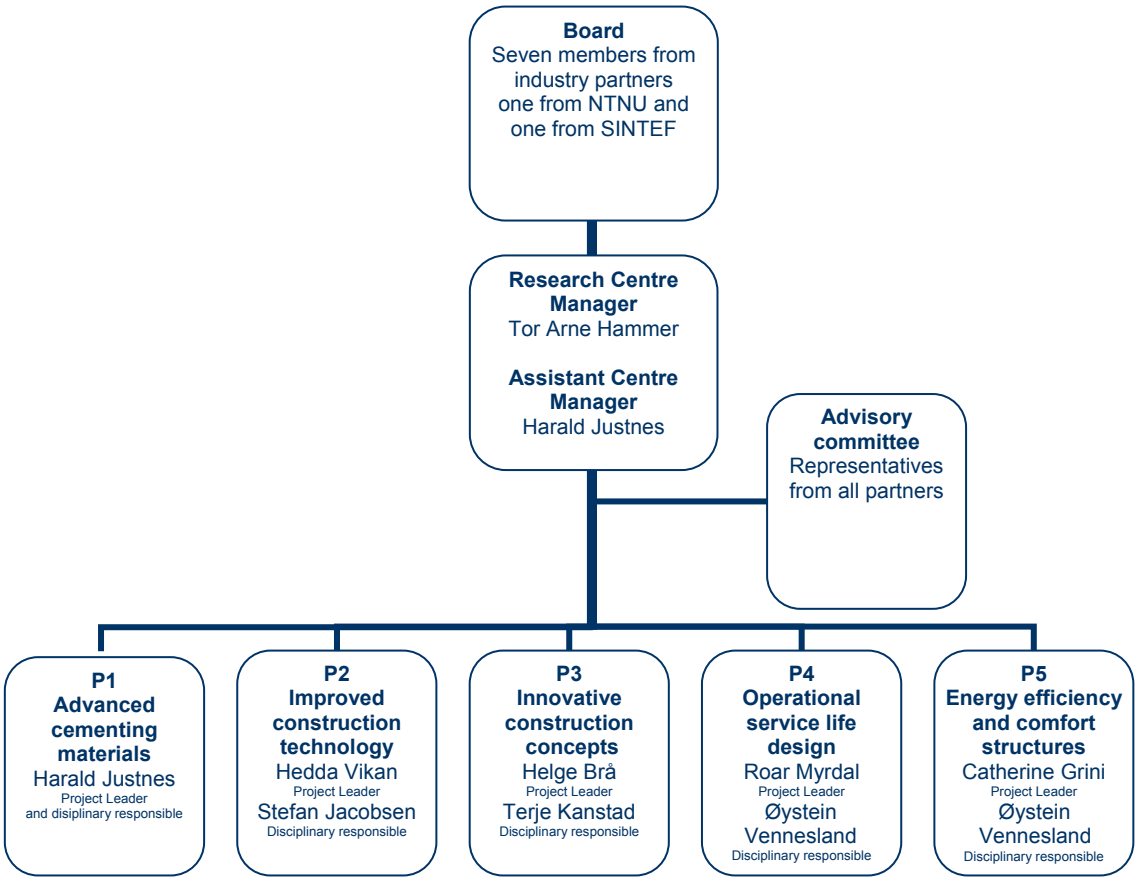
The initial project structure (from 2007) as well as the Advisory Committee, were reorganised during 2009. This was considered to be necessary, even if COIN had a good start in 2007 with high activity, a great engagement, good cooperation between the Partners and with the projects apparently well anchored in the innovation strategies of the Partners. And both the industry Partners, the Research Council as well as the researcher seemed satisfied with the work in the first two years. However, as time went by it turned out that the many wishes from the partners resulted in too many, and partly fragmented activities. Therefore, we realized that the work should be more concentrated in order to fulfil the objectives and success criteria of COIN. This was supported both the Research Council, the industry partners and SINTEF/NTNU, and the process of reorganisation started in November 2008 with the aim to have a reorganised project structure as well as clearer process for selection and objective of new project, for implementation at the start of 2010. Hence, the technical activities are now reorganized, and more concentrated, in 3 focus areas (FA), with belonging projects (presently 2-3 projects per FA), as shown below:

Focus area F1) Environmental friendly concrete structures
Focus area F2) Economically competitive construction
Focus area F3) Aesthetic & technical performance

Furthermore, each FA has a Technical Advisory Committee (TAC) with members from the Partners, and 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 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.

COIN organisation 2009



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

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.

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. Borregaard announced to withdraw from COIN from 2010 and on.

4 Technical activities, results

4.1 Concrete results from concrete innovation

by Aker Solutions

Aker Solutions is one of the partners in the COIN consortium, together with Norcem, Rescon Mapei, Skanska, Spenncon, Unicon, Maxit Group, Borregaard Industries, Veidekke, The Norwegian Public Roads Administration, NTNU and Sintef. We asked Jan-Diederik Advocaat, who is senior manager for marine concrete structures in Aker Solutions, to tell about their involvement and experiences with COIN.

Aker Solutions is world leading in the design, construction and installation of marine concrete structures. Our strategy is to focus on solutions for harsh environments and remote locations. As part of our innovation strategy, we are taking an active role in the Norwegian concrete cluster and the international R&D environment. One of our key partnerships is COIN – the Concrete Innovation Centre.

"COIN has strengthened the knowledge base in our company, improved our access to competent personnel and knowledge institutions and improved our networking with other partners," says Jan-Diederik Advocaat. He continues: "Results from COIN projects have been used in ongoing commercial projects within our company. We have also created new ideas for products and methods of execution in Aker Solutions based on this partnership."

In addition to financial support, Aker Solutions has been part of the COIN board and has actively taken part in research projects and participated in workshops. The company has made use of state of the art reports and other valuable reports that is made by the centre.

"One of the key results of this partnership for us is the valuable technology development from PhD candidates within ice abrasion and ice loading. This would not have been possible without the influence of the centre. We increasingly see that marine concrete structures are experiencing a renaissance in the oil and gas industry. The partnership with COIN is valuable in our work to win new projects for harsh environments in Norway, Canada, Russia and other areas around the world, and to strengthen the Norwegian concrete cluster", says Advocaat.

Sakhalin II, Sakhalin, Russia

The main activities in 2009 were according to the plan established in 2008 based on the topics identified in the state-of-the-art-reports prepared in 2007 as need for further research. A number of research breakthroughs were reached, and one activity lead to a trial product which the Partner wants to develop to a final product outside COIN. 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:

4.2 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

There is one PhD student working on cements with low CO_2 emissions (started in 2007), and a new PhD on admixtures to control hydration development. One master degree was written within the project.

Some research achievements in 2009:
Ongoing PhD-work has now proven chemical synergy between fly ash and limestone that gives higher strength than fly ash alone as cement replacement for more sustainable concrete.

Ordinary clay can be used as a cement replacement when calcined at medium temperature. This can solve the resource problem when the demand for supplementary cementing materials will increase as the trend of making blended cements are put into global practice. Calcined "blue" clay will soon be a product for one of the partners and can save some of their factories from shutting down; See interview with Geir Norden at Saint Gobain Weber, see chapter 4.7.

Furthermore, another type of clay, marl, which is considered as a low quality clay and thus unexploited, has shown promising results to be another supplementary cementing material.

Initial work with a two component admixture to control hydration (one accelerating and one retarding), shows promising results. The work also contributes considerably to the understanding of interaction between admixtures and cements.

A bio-admixture to reduce concrete permeability (and thus contribute to increased life time) has been tested. The initial tests confirm that the permeability can be considerable reduced.

4.3 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

Five master degrees were written within the project in 2009.

Some research achievements in 2009:
The work on fibre reinforcement is continuing, and the focus in 2009 was to finalise the work to establish reliable test methods. Also, the framework and expert group for preparing a guideline to design fibre reinforced concrete was established.

There is to date no suitable and available tool to describe wanted appearance of a concrete surface. COIN has been working on developing a classification system for concrete surfaces that defines different quality classes in terms of measurable parameters pore size distribution, number of pores and grey tone variations. The work has shown that registration of pores could be done manually from photos. A quantitative classification system for pores has been developed. Grey tone and grey tone variations were measured both with electronic and manually measurement methods. The correlation between measured degree of blackness in NCS-code and visual impression was, however, not satisfactorily, and more work is needed.

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. Due to the cross-sectored character of this research area, it has been of importance to compose a multidiscipline research team, comprising experts from aggregate processing, processing equipment, engineering geology and concrete technology. It is a major achievement so far in the project to have such a team operational, and within the team to have a strong industrial involvement that can secure a direct into-the-operation innovative value of the research performed. The latter is of specific importance, since no one situation is equal between individual suppliers, producers and end-users.

4.4 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

Four PhD-students are engaged in the project, of whom one started in 2009. Seven master degrees were performed within the project.

Some research achievements in 2009:
There has been made further extensive progress in developing a new high strength light weight aggregate for concrete, based on pure blue clay: An initial study on fibre reinforcing the lightweight aggregate in the production showed very promising results in terms of considerably increased strength (without any significant density change).

4.5 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

There is one new PhD student in the project, and two PhD students who started before 2009.

Some research achievements in 2009:
Based on the analysis of several decades of field data from North Sea structures significantly more reliable input parameters for modelling of chloride ingress into concrete have been developed; particularly relating to the time dependency of chloride diffusion coefficients in concretes at different ages and exposures.

New knowledge has been established on disturbing diffusion potentials during electrochemical measurement in concrete. It has been demonstrated that these potentials can lead to misinterpretation of data from electrochemical measurement techniques, e.g. when chloride levels in concrete are measured by chloride sensitive electrodes embedded in the concrete.

4.6 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.

The concept of utilising thermal mass in building has been implemented in more office buildings (considered as pilot projects), and followed up by energy consumption measurements and interviews about indoor climate. We see a growing interest for the concept among architects and owners.

An international workshop was planned (accomplished in January 2010), with the aim to find future research tasks regarding utilisation of concrete in low energy consumption buildings.

4.7 Interview with Geir Norden, Saint Gobain Weber (maxit)

What has COIN meant to Saint Gobain Weber (SGW)?
Above all we find it useful to be in a centre that holds the competence that we not necessarily have ourselves. SGW has another philosophy regarding industrial collaborations like COIN than the Norwegian maxit, which originally joined as partner. Yet, the results gained within the centre are being noticed by the corporation.

Testing of calcined clay as alternative pozzolan has been a sub project within COIN where SGW participated. Why do you withdraw the activity on calcined clay from COIN?
As the activities become more product specific, we find it more correct to do develop the product internally. We will still use Trondheim as a source of competence in the continuation of the project, although alternative European organizations exist. We have hired a German PhD candidate who will be working with the concrete department at SINTEF and materials technology department at NTNU. The PhD will continue to investigate the mechanisms that are making the clay work in order to secure the quality of the product.

What does SGW expect of this if it is developed into a new product?
Calcined clay can replace huge amounts of cement and thereby contribute to considerably lower CO_2 emissions. In addition we see changes in the rheology of different product applications, which is very positive in many connections. The product will be an important base material for internal use, and will secure jobs and value creation.

How does this new product meet SGW's success criteria for R&D?
Calcined clay fulfils all our five selection criteria. This has enabled financing the work and the PhD fellow on the subject. SGW has exceedingly focused our positioning as a supplier of environmentally friendly products with a corresponding production. Four of the five criteria are considering environmental aspects, the fifth considers new development.

You have contributed with considerably more in-kind work and cash funding than the agreement. What is the reason for this?
Especially the project on calcined clay has become extensive and work intensive. We tried to simplify the process, but have had to simulate the full scale production when producing the samples. We have also mapped our own clay deposits and tested mortar in our laboratories.

How will you continue your partnership in COIN?
We will continue the other activities as planned. In addition we have a new idea, which might have great influence for light weight concrete and building materials. We think this activity fits perfectly with COIN's vision, and expect it to be accepted as a new project.

5 International cooperation

5.1 Interview with PhD Klaartje de Weerdt, SINTEF Building and Infrastructure

Could you describe shortly the work in your PhD study?
The aim of my PhD study is to develop the basis for new all-round Portland composite cement for the Norwegian market. During cement production large quantities of CO_2 are emitted, on average about 0.9 ton per ton of ordinary Portland cement. Apart from the emissions linked to the energy used for burning and grinding the clinker, there is a chemical release caused by the de-carbonation of the limestone powder to give clinker, consisting of calcium silicates and aluminates. The de-carbonation of the limestone powder is responsible for about half of the total amount of CO_2 emitted.

The Norwegian cement producer Norcem has reduced their net CO_2 emissions by using alternative fuels, optimizing the heat transfers during the process etc. Another option to reduce the CO_2 emissions is to replace part of the clinker with supplementary cementing materials such as slag, fly ash and metakaoline, with other words producing composite cement.

The commercial all-round composite cement currently produced in Norway contains up to about 20% fly ash. The goal of the project is to develop all-round composite cement (CEM II/B-M) in which at least 30% of the clinker is replaced by supplementary cementing materials. As limestone and fly ash are already available at the cement plant, it was opted to first optimise a combination of these two. That is when we discovered a synergic effect between the two components: fly ash and limestone powder.

You have stayed 6 months at Empa in Switzerland. What is the reason for this, and what have you done?
June 2008 I read an article by Dr. Barbara Lothenbach et al. on the influence of limestone powder on the hydration of Portland cements. In this study different methods were used to examine the system and a thermodynamic model was applied. After finding the synergic effect between the fly ash and the limestone powder, the use of these techniques and the model would be perfect to further examine and illustrate the effect.

Dr. Hedda Vikan, project leader in COIN, encouraged me to contact Dr. Barbara Lothenbach, as she had spend several months during her PhD at Empa, the institute at which Lothenbach works. September 2008 I travelled together with one of my supervisors, Knut Kjellsen, to Empa in Dübendorf, Switzerland, for a meeting to discuss a possible collaboration. We concluded there and then that I would return for a period of six months in 2009.

I got to work together with several experts such as Lothenbach, who is an expert in thermodynamic modelling, and Gwenn Lesaout and Mohsen Ben Haha, who are experts in respectively XRD-Rietveld and SEM-image analysis.

How will you follow up when you are back in Norway?
The plan for 2010 is to process all data and write 4 to 5 journal articles based on the results. The articles comprising data acquired at Empa will be written in collaboration with the researchers from Empa.

In what way are the industrial partners involved in your work?

My main supervisor, Adjunct Proffessor Knut Kjellsen is chief engineer at the research department of Norcem AS. He provides a direct link with the industrial partner, as Norcem is the main stakeholder within COIN concerning my PhD project. Kjellsen backed up the idea to collaborate with Empa and even invited a researcher from HeidelbergCement Technology Centre (HTC), Dr. Maciej Zajac, into the cooperation with Empa. Dr. Maciej Zajac was a valuable discussion partner during the project. He invited Dr. Lothenbach and me to present my PhD-project and give an introduction to the COIN centre at the headquarters of HTC in Leimen, Germany in October 2009.

The industrial applicability of this project is shown by a pilot project launched by Norcem in 2009. In the construction of the new meteorological centre in Oslo they used "low-carbon" cement with exactly the same composition as the optimum fly ash limestone combination found in my study.

The staff at EMPA, Laboratory for Concrete and Construction Chemistry in Appenzell, Switzerland, summer 2009. Klaartje de Weerdt, SINTEF, first row to the left.

5.2 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.

New cooperation activities in 2009:

Institution / project	Activity 2009
Aberdeen University	Mutual visits to discuss sustainability and durability issues
Minbas. Swedish project (Cementa/CBI).	Mutual exchange of knowledge on aggregate research, through meetings/seminars
Metso Minerals, Finland	Subcontractor to Norcem (Norstone) on aggregate research
EMPA Dübendorf	PhD exchange to EMPA (Klaartje de Weerdt)
ETH, Zürich	Agreement of PhD-supervision (Ueli Angst)
Helsinki University of Technology (TKK) and VTT, Finland	Joint project, "Duraint" (Ice abrasion)
IBMB Braunschweig	Visit to IBMB to discuss common activities. Planned exchange student Maria Pauluhn to perform work at SINTEF/NTNU in 2010 on early age cracking
ICI Iceland	Agreement about collaboration on 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 (P1)
New Brunswick University	Agreement of PhD supervision (Jan Lindgård)
Freiburg University	Exchange student Lisa Wieghardt on super-LWA
EPFL, Lausanne	Tor Arne Hammer is Guest Academic
Universidade Federal de Goiás, Brasil	Prof. Enio P Figueiredo guest researcher at NTNU, on stainless steel reinforcement

5.3 EU-funded projects

In regards of materials technology, EU's Seventh Framework Programme (7FP) has not announced any calls meeting the needs of our business sector, except for nano technology. Initiatives have therefore been on calls within energy performance, and in 2009 COIN was a part of two applications: Reducing the Environmental Footprint of Cement-based Materials (REFCEM) and Reducing resource intensive industries' footprint to protect our one and only Earth (1EARTH). Both applications were refused.

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

2009 was a good year for PhD recruiting: Four new PhD-students were engaged, of which two are females. All positions in the plan are now filled. One is Norwegian, one is Vietnamese, and two are German. Two of them started early 2010. We searched especially in Norway, but got one, only. Good cooperation with German institutions made it possible to find highly qualified candidates. One of them was engaged as a part of a common project with the University of Dresden, in which NPRA is a partner. The candidate from Vietnam is also a strategic choice by that very fact that one of the COIN Partners wishes to come closer to the market of Southeast Asia.

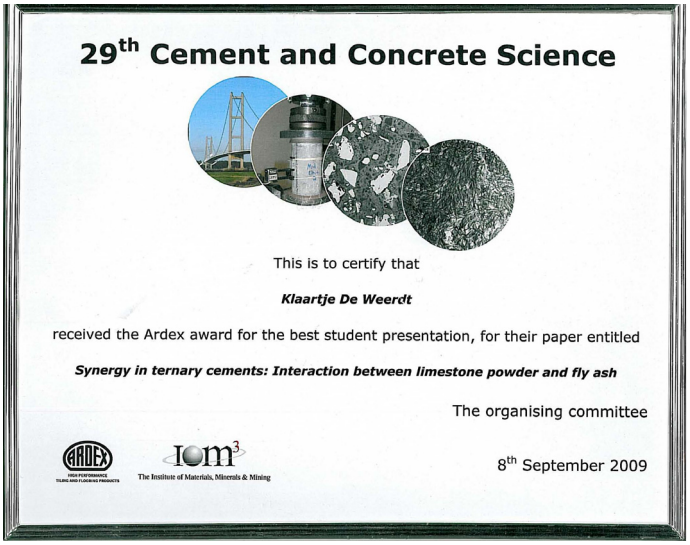
SINTEF Building and Infrastructure employed one more researcher who will work in COIN projects.

7 Communication

COIN has produced more than 40 publications in 2009, all listed in appendix A3. Ten reports have been published, including one state of the art report. In addition there have been a number of oral presentations of COIN, and 7 articles in journals with referees.

Klaartje de Weerdt received the Ardex award for best student presentation at the 29th Cement and Concrete Science conference in Leeds, UK. Harald Justnes, Christian Engelsen and Kåre Helge Karstensen were accredited High Merit for their paper at 11th NCB International Seminar on Cement and Building Materials in New Dehli, India.

COIN uses "Byggeindustrien", the trade magazine for the Norwegian building industry, to communicate results and other relevant information to the Norwegian market. We had 4 articles in Byggeindustrien in 2009.



Appendices

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Lars Bjerkeli, Skanska Norge AS
Ingrid Dahl Hovland, Spenncon
Stein Tosterud, Unicon

Accounts COIN 2009

(All figures in 1000 NOK)

Funding

	Amount
The Research Council	9.176
The Host Institution SINTEF	2.181
Research Partner NTNU	8.160
Aker Solutions	416
Borregaard Industries Ltd	1.178
maxit Group	2.615
Norcem	3.124
Rescon Mapei	1.092
Skanska	754
Spenncom	631
Norwegian Public Roads Administration	1.221
Unicon	1.027
Veidekke	1.953
External funding	63
	33.591

Costs

SINTEF Building and Infrastructure	13.155
NTNU	11.049
Aker Solutions	166
Borregaard Industries Ltd	878
maxit Group	1.985
Norcem	1.674
Rescon Mapei	943
Skanska	390
Spenncom	150
Norwegian Public Roads Administration	721
Unicon	527
Veidekke	1.953
	33.591

COIN Publications 2009

Journal papers

Xiao H Wang, Stefan Jacobsen, Jian Y He, Zhi L Zhang, Siaw F Lee and Hilde L Lein, *"Application of nanoindentation testing to study of the interfacial transition zone in steel fiber reinforced mortar",* Cement and Concrete Research, pp 701-715, Vol. 39, 0008-8846

Gro Markeset, *"Critical chloride content and its influence on service life",* Materials and Corrosion, pp 593-596, Vol. 60, 0947-5117

Ueli Angst, Øystein Vennesland and Roar Myrdal, *"Diffusion potentials as source of error in electrochemical measurements in concrete",* Materials and Structures, pp 365-375, Vol. 42, 1359-5997

Xiao Hui Wang, Stefan Jacobsen, Siaw Foon Lee, Jian Ying He and Zhi Liang Zhang, *"Effect of silica fume, steel fiber and ITZ on the strength and fracture behavior of mortar",* Materials and Structures, online version, 1871-6873

Stefan Jacobsen, Lars Haugan, Tor Arne Hammer and Evangelos Kalogiannidis, *"Flow conditions of fresh mortar and concrete in different pipes",* Cement and Concrete Research, pp 997-1006, Vol. 39, 0008-8846

Siaw Foon Lee, Arild Monsøy, Hilde Lea Lein and Stefan Jacobsen, *"Sample preparation of steel fiber reinforced mortar for ITZ-porosity and microstructure study using BSE-IA",* Cement and Concrete Research, 0008-8846

Jan Lindgård, Philip J. Nixon, Ingmar Borchers, Björn Schouenborg, Børge Johannes Wigum, Marit Haugen and Urban Åkesson, *"The EU "PARTNER" project- European standard tests to prevent alkali reactions in aggregates. Final results and recommendations",* Cement and Concrete Research, 0008-8846

Published conference papers

Tone Anita Østnor: *"Forskning på alternative bindemidler innen COIN",* CBI-Informationsdag 2009, Stockholm, Sweden, 12 March 2009

Siaw Foon Lee, Jianying He, Xiao Hui Wang, Zhiliang Zhang and Stefan Jacobsen: *"Study of P-h curves on nanomechanical properties of steel fiber reinforced mortar",* 3rd International Symposium on Nanotechnology in Construction, Prague, Czech Republic, 1 June 2009

Siaw Foon Lee, Xiao Hui Wang and Stefan Jacobsen: *"Effect of steel fiber on the rheological and mechanical behaviour of self-compacting mortar",* 2nd European Asian Civil Engineering Forum, Langkawi, Malaysia, 4 August 2009

Siaw Foon Lee, Xiao Hui Wang and Stefan Jacobsen: *"Effect of steel fiber on the rheological and mechanical behaviour of self-compacting mortar",* 7th Asia Pacific Structural Engineering and Construction Conference, Langkawi, Malaysia, 6 August 2009

Igor Sartori: *"Night flushing and ceiling acoustic solutions: the effect on summer thermal comfort and energy demand",* CISBAT, Lausanne, Switzerland, 2 September 2009

Siaw Foon Lee and Stefan Jacobsen: *"Backscattered electron imaging analysis on interfacial transition zone between steel fiber and cement paste in steel fiber reinforced mortar",* European Congress and Exhibition on Advanced Materials and Process, Glasgow, UK, 8 September 2009

Catherine Grini: *"Bruk av betongens termiske egenskaper - norske forhold",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

Tor Arne Hammer: *"COIN - erfaringer og utfordringer",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

Terje Rønning and Jan Lindgård: *"Internasjonal samarbeid - hvordan ivaretar vi norske intresser?",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

Tone Anita Østnor: *"Kalsinerte leire - fremtidens pozzolan?",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

Mari Bøhnsdalen Eide: *"Klassifiseringssystem for forskalte betongoverflater",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

Ueli Angst: *"Kritisk kloridinnhold i betong – finnes det?",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

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Sindre Sandbakk: *"Økt bruk av fiberbetong",* SINTEF-NTNU Betonginformasjonsdag 2009, Trondheim, 14 October 2009

Klaartje De Weerdt and Harald Justnes: *"Synergic Reactions in Triple Blended Cements",* 11th NCB International Seminar on Cement and Building Materials, New Dehli, India, 18 November 2009

Roar Myrdal: *"Development of Chemical Admixtures for Early Hardening of Blended Cements",* 11th NCB International Seminar on Cement and Building Materials, New Dehli, India, 19 November 2009

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Hedda Vikan: *"Influence of temperature, cement and plasticizer type on the rheology of paste",* pp 371-380 in Design, Performance and Use of Self-Consolidating Concrete, SCC'2009 (Proceedings PRO065), Rilem Publications, 978-2-35158-073-8

Hedda Vikan, Lars Haugan and Stefan Jacobsen: *"Rheology and pumpability of mortar",* pp 88-96 in Rheology of Cement Suspensions such as Fresh Concrete: Proceedings of the 3rd International RILEM Symposium (RILEM Proceedings PRO 68), Rilem Publications s.a.r.l., 978-2-351580912

S.F. Lee, J.Y. He, X.H. Wang, Z.L. Zhang and S. Jacobsen: *"Study of P-h curves on nanomechanical properties of steel fiber reinforced mortar",* pp 281-286 in Nanotechnology in Construction 3, Springer Berlin Heidelberg, 978-3-642-00980-8

Sellevold, Erik Johan; Maage, Magne; Smeplass, Sverre; Kjellsen, Knut O.; Lindgård, Jan; Myrdal, Roar; Bjøntegaard, Øyvind; Jacobsen, Stefan: Betongteknologi 1 (4215) kompendium. Trondheim: Institutt for konstruksjonsteknikk

COIN Projects reports
Harald Justnes: Acceleration by retardation

Harald Justnes: Combined setting and hardening accelerator for concrete

Terje Kanstad: Fibre Reinforced Superlight Concrete: Testing of materials and ful scale beams

Sigrun Kjær Bremseth: Fly ash in concrete. A literature study of the advantages and disadvantages

Harald Justnes: Gypsum free and low porosity cement

Ola Skjølsvold: Kloriddiffusjon i betong. Vurdering av aldringseffekten ved felteksponering

Harald Justnes: Low porosity through optimized particle packing of concrete matrix

Harald Justnes: Pozzolana from minerals

Børge Johannes Wigum, Svein Willy Danielsen, Odd Hotvedt and Bård Pedersen: Production and utilisation of manufactured sand - State of the art

Magne Maage and Steinar Helland: Shore approach high quality concrete. Results of inspection over 26 years

Presentations
Catherine Grini: "Tung og deilig", Mur-dagen, 12 March 2009

Einar Aassved Hansen: "Attraktive betongbygg", Byggedagene, 26 March 2009

Tor Arne Hammer, Fabrikkbetongkonferansen, 26-29 March 2009

Tor Arne Hammer, NB's informasjonsdag, 12 October 2009

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.