

Cluster 3 – Aggregate and Concrete Production

Background

The ECO-SERVE Network is financed from the European Commission under the 5th Framework Program. Reference is made to www.eco-serve.net.

Cluster 3 "Aggregate and Concrete Production" is one out of 4 clusters within the network, the others dealing with wastes as secondary fuels and raw materials for cement production, production and application of blended cements, and pavements respectively (Figure 1).

When establishing the network, it was decided to join concrete and aggregate industry across Europe into one cluster in an effort to contribute to a reduction in the environmental impact of their activities and to aim at a sustainable development in this combined business sector. Such development should be coupled with industrial demands on improved productivity and societal needs for the development of harmonized technology for durable structures of high quality.

The linking of Cluster 3 activities to the rest of the ECO-SERVE network and to the production line of building materials is illustrated in Figure 1.

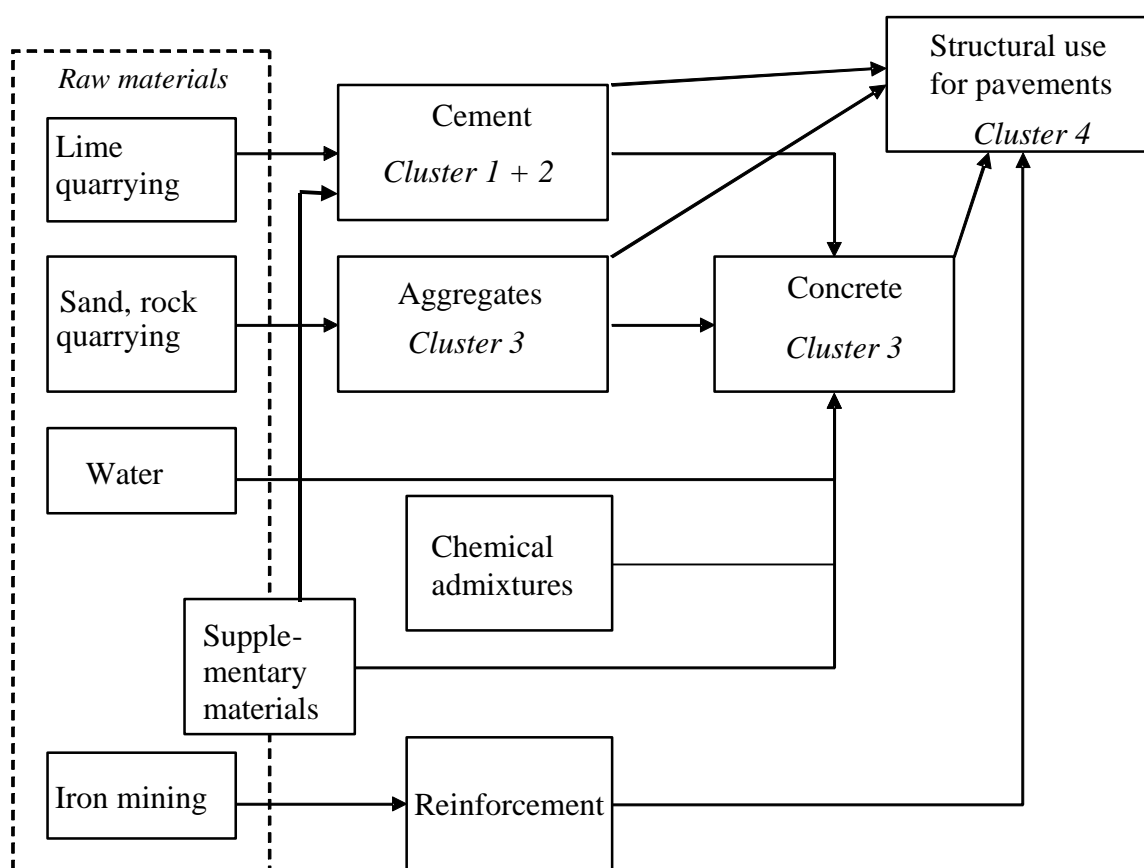


Figure 1 Constituents of concrete and its relationship with the ECO-SERVE Network clusters. Pozzolanas may be natural volcanic material or waste products from power plants.

The aggregate and concrete industry is presently facing a growing, public awareness relating to the environmental profile of their activities. With concrete being the by far most important

construction material and annual aggregate production being of the order of 10 tonnes per capita throughout Europe, a major part of the environmental impact of the total building sector is related to these materials. The following figures illustrate the current situation of the building sector as to its importance for sustainable development* :

- 40 % of the total energy consumption arrives from this sector
- The sector uses globally 40 % of all produced materials.
- Approximately 40 % of the CO₂ emission can be related to buildings and constructions.
- Approximately 40 % of the global amount of waste comes from production and demolition of buildings and structures.
- The sector uses approximately 40,000-50,000 different products where part of them contains substances harmful to health and safety.

Thus, our materials sector will also have to bear a great part of responsibility in fulfilling the OECD described necessity of reducing energy consumption and emission by a factor 4 within the next 10 years.

In a recent paper from the EU (COM, 2001ⁱ) the following statement was made: “The global implementation of sustainable development requires more particularly: the design, development and dissemination of technologies making it possible to *ensure more rational use of natural resources, less waste production and a reduction in the impact of economic activity on the environment.*”

In an OECD-report on sustainable development (OECD, 2001ⁱⁱ) it is stated in a chapter on managing natural resources: “where appropriate, *encourage life-cycle, recycling, and materials-flow approaches to managing natural resources.* Before implementing mandatory recycling, however, ensure that neither total materials and energy flows, nor conditions in the anticipated markets for recycled products, would result in the costs of these programmes exceeding projected benefits.”

The quotes given above show that sustainable development will be of major importance in government policies in the coming years and several EU member states have formulated policies aimed at securing environmentally sustainable industries. The ECO-SERVE Network will help to convert these theoretical policies into practical applications, and the role of Cluster 3 in applying this for the volume important materials aggregates and concrete is crucial.

Objectives

According to the Eco-Serve network work plan for Cluster 3, dated February 2002, the overall objective of Cluster 3 is to contribute to a reduction of the environmental impact of concrete and aggregate production: to make them more cost-effective while improving or at least maintaining the technical performance.

It is further, an objective to perform mapping activities in the field, i.e. establish an overview/inventory of stakeholders, record their views, obstacles towards environmentally friendly production technologies and to co-ordinate national and European research activities in the field.

* Figures taken from <http://www.nordicinnovation.net/article.cfm?id=1-834-251> obtained in a Nordic project on environmental indicators in the building sector.

Scope of work (milestones and criteria)

M1 Establishment of network members

Include as many national networks and research groups as possible and make links to these.

M2 Workshop

The workshop including collection of information from the network participants.

M3 Baseline-report

The baseline-report including state-of-the-art covering on-going European and national research, as well as the economic, environmental, political and societal issues for optimum management of aggregate resources and production of concrete with reduced environmental impact. The report will include input from all cluster 3 members on the current research in their national R&D-projects in this field. It will be the basis and a consensus fundament for identifying future research needs.

Focused research teams

Focused research teams may be established among the members on the grounds of the results from the baseline- report. They will decide on the need for possible limited research to be carried out among the network members or identify needs for future research.

M4 BAT-report

The BAT-report will present the optimization of aggregate production according to specified end-use requirements as well as production of concrete with reduced environmental impact. It will include decisions on what research still needs to be done after the Eco-Serve network activities.

M5 Guidelines for aggregate

- guidelines for the extraction and production of material to ensure mass balance in the production
- use of aggregates within acceptable environmental and economical production
- the optimal use of manufactured fine aggregates
- various local aggregate resources within the production of concrete
- quality assessment systems in aggregate production.

M6 Guidelines for concrete

For concrete it will contain the following aspects of constructing with green concrete (concrete with reduced environmental impact):

- reduced clinker content, e.g. from packing investigations of aggregates
- use of cement with reduced environmental impact, e.g. blended cements
- use of residual products/fillers/pozzolanas to substitute clinker (fly ash from coal combustion, fly ash from co-combustion, sewage sludge incineration ash, fly ash from bio fuels, limestone filler etc.)
- use of residual products from the construction industry (concrete slurry from washing mixers, fillers from aggregate production etc.)
- green structural solutions (minimal structures, composite structures, etc.).

Important papers, concrete

1) Danish Centre for Resource Saving Concrete Structures

Web site: www.greenconcrete.dk

Summary:

A 4-year project running from 1998 to 2002 involving all Danish concrete stakeholders from cement manufacturer to ready-mix producer, consultant and contractor. The Danish Ministry of Science, Technology and Innovation provided the funding of the 7 M EURO project together with the participants. The Danish Technological Institute acted as project manager.

The background, scope and purpose of the project are found on the Green Concrete web site together with a list of participants and a comprehensive list of downloadable reports and articles.

A main outcome of the Green Concrete project is a set of guidelines on how to produce and apply green concrete. The definition of green concrete is associated with the full life cycle of a structure where concrete is the governing material and where measures have been taken to minimise the environmental impacts. These environmental impacts may be in terms of energy consumption, emissions of CO₂, material consumption and waste production, etc.

The following green measures are documented through the course of the project:

- More energy efficient cement production.
- Minimise consumption of cement clinker for concrete design.
- Use various ash materials (waste) as substitute for cement.
- Reuse cement slurry in the production of new concrete (minimise waste).
- Reuse stone dust (from aggregate crushing in Sweden) as substitute for natural sand.

The level of documentation includes production, workability, fresh and hardened properties and implications for structural design.

It is the hope of the Danish Centre for Resource Saving Concrete Structures that the experiences gathered during this project will be transferred into the guidelines of best practice to be produced under the ECO-Serve network.

2) Concrete for the environment – a Nordic network

Web site: www.nordicinnovation.net

Direct link: <http://prosjektweb.nordicinnovation.net/news/default.asp?proID=95>

A Nordic network has been formed with participants from all five Nordic countries. The background for the network is the need for a common understanding on how to define environmentally sustainable concrete structures and the need for creating a Nordic critical mass to match similar networks in Europe and elsewhere. The network was initiated January 2001 and is running until December 2003.

3) “Innovation by the Concrete Impulse Package (ICIP)”

Web site: <http://www.ecsn.net/icip>

The European project entitled “Innovation by the Concrete Impulse Package (ICIP)” is based on four methodologies which encompass successful and proven national methods of concrete use and innovation. These aim to support two aspects of the building industry with reference to innovation in the concrete sector;

- Access to and collaboration with other networks
- Improving awareness, knowledge and influence behaviour of SME's

Elaborating these four methodologies and making direct contacts with SME's, the project has contributed to improving knowledge flow and subsequent implementation of ideas with respect to concrete, the most important building material in today's society. Within the ICIP project 12 Concrete Societies worked together under the banner of the European Concrete Society Network (ECSN) to approach and influence SME's in their own national concrete sector.

These methodologies are:

- Determination and publication of 'best practices on concrete design and construction'
- Multidisciplinary connections, workshops & model programme for SME's
- Linking demonstration projects within Europe
- Help-desk/advisory services for SME's

These methodologies enhance the knowledge, position and behaviour towards technical innovations in the concrete sector. The four main problems associated with innovation and SME's, are:

- Difficult access to finances for SME's
- Insufficient co-operation between SME's and the scientific R&D sector
- Lack of structured communication between SME's and public authorities, universities and research institutes
- Quality of management and workforce (skills)

It is important to state that the projects considered within ICIP all follow a market driven approach. Only then is a successful implementation possible as earlier experiences have often shown a failure of a top-down approach to innovation. That is why the work within ICIP started with a general study and questionnaire on needs of SME's in the concrete sector in three different EC countries.

Important papers, aggregate

Tailored production of aggregates for concrete

The most novel technique in tailoring production for use in concrete is the development of manufactured sand, in the US sometimes called stone sand. In Norway a great deal of research has been carried out during the last decade^{iii,iv,v&vi}.

Research regarding improvement of aggregates properties through crushing technology has been carried out supported by crusher manufactures, both by the Finnish Nordberg^{vii,viii} (now Metso) and by the Swedish Svedala (now part of Metso and Sandvik)^{ix,x,xi,xii,xiii&xiv}.

Overview of aggregate consumption in Europe

An overview of the production of aggregates (Sand & Gravel and Crushed Rocks) in Europe is provided in the report; Minerals Planning Policy and Supply Practices in Europe^{xv}. All figures in the report were extracted from the European Minerals yearbook Final Draft 1995.

Some of the National Geological Surveys in Europe present annually an account of the national use of aggregates (i.e. Norwegian Geological Survey, NGU^{xvi, xvii}).

Some links

1) European Ready Mixed Concrete Organisation (ERMCO)

Web site: www.ERMCO.org

The web site contains valuable information and several downloadable reports and statistics from the European ready mix concrete industry.

2) International Bureau for Precast Concrete (BIBM)

Web site: www.BIBM.org

BIBM includes all types of precast concrete products. An environmental manifesto is available to download from the web site.

3) fib-Symposium “Concrete and the environment”, October 2001

Web site: <http://fib.epfl.ch/>

The following quotation is taken from the Presidents message in the proceedings of the 2001 fib-Symposium “Concrete and Environment”.

““Concrete and the environment” is on its way to become one of the major topics in practical design and construction. During the last decade research on concrete and concrete structures has mainly focused on aspects like performance safety and serviceability. The consciousness of the significance of durability and sustainability is still relatively young. However, it is now already a common feeling that those aspects must play a crucial role in the near future. This new way of thinking will have important consequences for the direction in which design strategies will develop. The same holds true for the process of execution and the developments of contractual regulations, code requirements and research.“

The Symposium took place in October 2001 in Berlin, and the main subjects were:

- impact of concrete structures on man and environment,
- influence of environment on the service life of concrete structures,
- ability of concrete structures to protect man and environment against hazards.

The symposium covered various areas of importance, gave a good idea of state of the art and showed perspectives to new ideas and developments.

4) Vision 2030: A Vision for the U.S. Concrete Industry.

The U.S. Concrete Industry has developed a unified vision for the future concrete industry, and has thereby committed themselves to work towards common goals. The Vision is published in the ACI monthly magazine Concrete International, Vol. 23, March 2001, pp. 25-34.

5) Concrete Vision 2025 (Danish Concrete Industry)

Web site: www.danskbetonraad.dk

The Danish Concrete Industry has followed the example from the U.S. Concrete Industry by formulating the Danish Concrete Vision 2025. The Danish Concrete Board carried out the work during 2002. A 10-page booklet summarising the visions can be downloaded from the web site given above.

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- ⁱ COM (2001) 94 final, 21.1.2001: "Proposal for a council decision concerning the multiannual framework programme 2002-2006 of the European community for research, technological development and demonstration activities aimed at contributing towards the creation of the European research area"
- ⁱⁱ OECD (2001): Report on sustainable development: "Policies to enhance sustainable development" (Draft policy report presented to the meeting of the ad hoc group of national officials on sustainable development in Paris 19-20 Feb. 2001)
- ⁱⁱⁱ Lindgård, J., & Johansen, K., 1995_a: Maskinsandforedling og ny anvendelsesteknologi i betong. Delrapport I: Praktisk anvendelse av maskinsand. SINTEF Konstruksjoner og betong, rapport nr. STF70 A95085, 15 pp. (In Norwegian).
- ^{iv} Lindgård, J., & Johansen, K., 1995_b: Maskinsandforedling og ny anvendelsesteknologi i betong. Delrapport II: Dokumentasjon av materialeegenskaper. SINTEF Konstruksjoner og betong, rapport nr. STF70 A95086, 45 pp. . (In Norwegian).
- ^v Danielsen, S.W.D. & Ørbog, A., 2000: Sustainable Use of Aggregate Resources through Manufactured Sand Technology. Quarry Management, July 2000, 27(7), 19-28.
- ^{vi} Franzefoss Pukk AS 2001: Production and use of manufactured sand in Norway, Final report April 2001, Franzefoss Pukk AS.
- ^{vii} Heikkilä, P., 1991: Improving the Quality of Crushed Rock Aggregate. PhD. Helsinki University of Technology.
- ^{viii} Nordberg, 1999: SAND. Applications, Manufacturing, Classification, Requirements. Norberg Way of Sand making. Norberg-Lokomo 28.09.1999.
- ^{ix} Hudson, B. 1996_a: The Effect of manufactured Aggregate and Sand on Concrete Production and Placement. Svedala P437-1-8/96. 10 pp.
- ^x Hudson, B., 1996_b: Flour Power. The influence of minus 75 micron material on concrete, as well as the importance of particle shape with manufactured sand. xx pp.
- ^{xi} Hudson, B., 1998_a: Impact of manufactured sand in concrete. Quarry, Desember 1998, pp 1-4.
- ^{xii} Hudson, B., 1998_b: Aggregate Shape Affects Concrete Cost. Quarry, November 1998, pp 1-4.
- ^{xiii} Hudson, B., 1999_a: Concrete Workability With High Fines Content Sands. Quarry, February 1999, pp 1-4.
- ^{xiv} Hudson, B., 1999_b: Crushers affect product quality. Quarry April 1999. pp 1-5.
- ^{xv} Department of the Environment, HMSO, 1995: Minerals Planning Policy and Supply Practices in Europe, Main Report 96 pp, with Technical Appendices.
- ^{xvi} Norwegian Geological Survey, 2003: Mineralressurser i Norge. Bergindustrien i 2002. NGU rapport 2003.040, 23 pp. (In Norwegian).
- ^{xvii} Norwegian Geological Survey, 2003: Norway's coastal aggregates. Production in 2002 and potential. NGU rapport 2003.042, 30 pp.