Newsletter no. 1 – Steel Fibre Reinforced Concrete (SFRC) - Consortium

March 2011

Project introduction

The SFRC Consortium is an innovation consortium which was initiated in January 2010 and is set to run for 3½ years. The project is funded by the participating partners and the Danish Agency for Science, Technology and Innovation.

The partners are COWI, MT Højgaard, Unicon, Aalborg Portland, Bekaert, Convi, Hi-Con, CRH Concrete, The Danish Precast Concrete Association, DTU Byg and Danish Technological Institute.

The main purpose of the project is to enhance the sustainability of concrete structures by improving working environment, productivity and aesthetics through increased usage of steel fiber reinforced concrete.

This purpose is fulfilled by carrying out the necessary research activities needed to form the basis for the preparation of a pre-normative document containing guidelines for design, production and execution of steel fiber reinforced concrete structures. A more specific goal is to develop well documented and applicable solutions for 2-3 selected load bearing structural elements.

Work programme

The project is divided into 5 work packages:

WP1.	Simulation of form filling and mechanical properties of steel fibre reinforced self-compacting concrete (SFRSCC)
WP2.	Material development and testing
WP3.	Design guide
WP4.	Execution control and methods
WP5.	Demonstration and knowledge transfer

In the first year of the project there has been focus on

- selection of relevant structural elements to include in design guide and demonstration project
- simulation of flow properties of SCC with fibres in order to be able to predict fibre orientation and distribution
- preparation of formwork to be used for trial castings of SCC and CRC

These activities are described further in the following.

Selection of relevant structural elements

Bearing in mind the projects goal to prepare a pre-normative design guide, it was decided that the project should focus on a selection of 3-4 relevant structural elements with a great potential for using steel fibres in combination with traditional reinforcement.

Selection of the structural elements and the decision on whether or not to include them in the project is based on five different criteria. The selected elements will be included in the design guide and some of these are to be carried out as demo projects. These five selection criteria are:

A. Is the structural element within the scope of this project?
B. Does the structural element cover the partners' interests in the project?
C. Is the market potential large enough?
D. Are the environmental benefits sufficiently large?
E. Are the working environmental benefits sufficiently large?

After evaluation based on the listed criteria, the following structural elements are included in the project:

1. In situ foundations
2. In situ walls
3. Prefabricated pre-stressed beams

These applications will be included in the pre-normative guideline and also be demonstrated in full scale demonstration projects.

Simulations and flow modeling

Concrete is an inhomogeneously material which makes it difficult to describe and predict what happens in terms of fiber distribution and orientation when the concrete is being cast.

To establish a better understanding of these essential parameters a Ph.D project at DTU has been initiated in which, the formulated goal is to develop modeling tools to predict flow and mechanical properties of SFRSCC.

The preliminary results of the simulation work are quite promising. Simulation of suspensions, slump tests and L-box tests has been carried out, and right now we are working on simulating more complicated geometries.

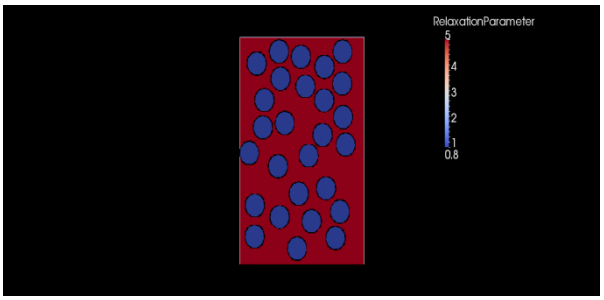

Figure 1: Graphic representation of a particle suspension

The simulation displayed in Fig 1. is modeling a high viscosity SCC with aggregates (suspended particles).

The simulation can be seen on http://www.youtube.com/watch?v=edablG3UH3U

The next step in the simulation has been to include fibres into the simulation. Fig. 2 shows a slump cone with concrete containing fibres, and the simulation can be seen on http://www.youtube.com/watch?v=ZoU6w89t2_8

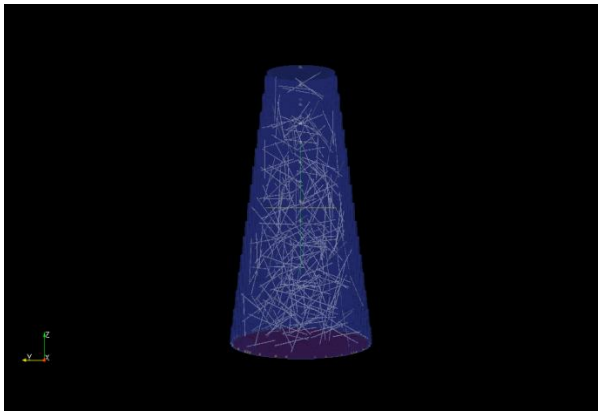

Figure 2: Simulation of a high viscosity SCC containing steel fibre

New formwork and trial castings with SCC and CRC

The very basic idea is, that flowing concrete will force the fibres to orientate in the flow direction, but how far should a certain SFRSCC flow for the fibres to orientate and what about the influence of viscosity? In an attempt to try an answer some of these questions, new formworks was produced over the summer 2010 at DTI.

This new formworks revolves around a container which is to be completely filled with concrete during casting to maintain pressure. On every

side of the container is a hatch and a detachable beam form made of see-through acrylic to be able to monitor flow. There are two separate chambers in each beam form.

Dimensions of the beams this formwork can produce are 150x150x2000mm.

Figure 3: New formworks to produce long 2m beams. See-through acrylic sides make it possible to monitor flow.

Trial castings at Hi-Con has been carried out where four beams were cast using JointCast, which is a high strength SFRC with very high viscosity. The first two beams (right hand side) were cast with JointCast containing 2 vol% fibres and the last two beams were cast with JointCast containing 3 vol% fibres.

The highly viscous JointCast was surprisingly able to completely fill the formworks, although a very low flow velocity was observed during the casting process due to the high viscosity.

Trial castings has also been carried out in the DTI laboratory where beams have been cast with different concrete mix designs containing different amount of fibres, and the rheological parameters have been mapped.

Figure 4: Casting of CRC beams at HiCon facilities. The flat slope of the casting front indicates a high viscous, slow flowing concrete.

The casting process was recorded for visual observation and to be able to model the flow later on if necessary, see http://www.youtube.com/watch?v=pHAN6DV-qZA

The cast beams have now been transported to Aalborg Portland facilities for further testing (destructive). The beams are to be subjected to 3-point bending tests according to EN 14651. The theory is that the more the fibres are orientated in the flow direction the higher the measured bending strength will be.

Coming up

Currently the project activities are focused on implementing CT scanning techniques for doing non-destructive determinations of fibre distribution and orientation. Furthermore, a new and very relevant foundation demo project is under way in Aalborg. This will be described in the next newsletter.

Contact

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