Newsletter No.4 from the SCC Consortium

June 2006

Introduction

A considerable part of the work of the SCC Consortium has been focused on “The Concrete Factory of the Future” and the development of new methods to improve the control of the mixing process. This newsletter describes the use of vision technology for online measuring of the particle size distribution, shape and moisture content of fine aggregates.

This is followed by a brief description of the coming SCC demo bridge that will be constructed in Give, Denmark in the autumn of 2006.

Vision technology

One of the goals of P2 project, “The Concrete Factory of the Future” within the SCC Consortium is online registration of the most important properties of the aggregate in the concrete manufacturing process using “vision technology”. The registration is envisioned to be part of a total control of the aggregate materials that are weighed out for each individual batch.

The most important properties are limited to particle size distribution, shape and moisture content for various types of sand.

A precise description of the moisture content, particle size distribution and shape in the specific batch improves the possibilities for adjusting the mixture in the mixer. This will be done, among other ways, through the use of an intelligent support system that contains models for the connection between the concrete composition and the flow properties.

The first step towards achieving this goal is to be able to determine these significant aggregate properties with sufficient accuracy using “vision technology”.

The following results were achieved through laboratory measurements of aggregate with varying particle size distribution, shape and moisture content.

Photography

First, photographs are taken of the concrete aggregate under standardized conditions. That is to say, photographs taken at various points in time will be comparable as the lighting etc. will be the same at all times. A VideometerLab (www.videometer.com) has been applied which captures multispectral high-resolution images with standardized diffuse lighting. Figure 1 shows a basic diagram of an instrument for capturing images.

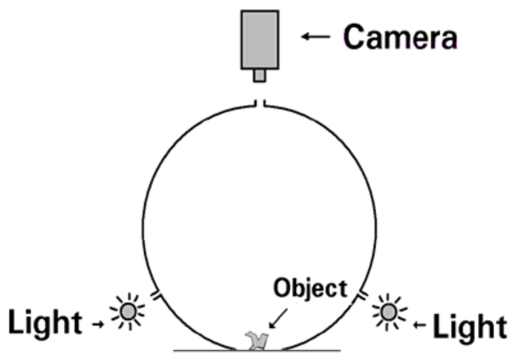

Figure 1: Basic diagram of instrument for capturing images.

Figure 2 shows the results of the captured image.

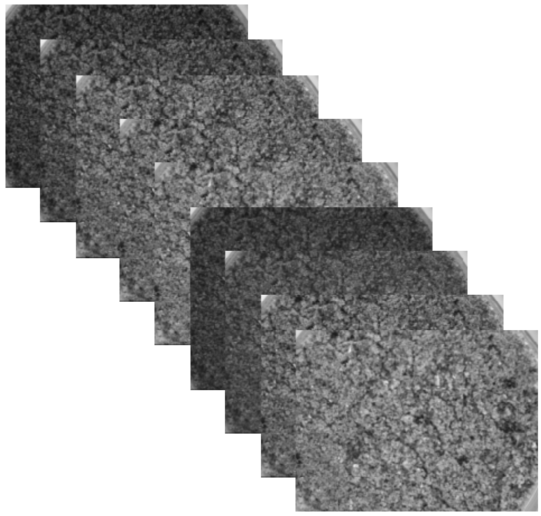

Figure 2: Example of the content of a multispectral image with 9 different bands from near-infrared to ultra blue.

Sand type determination

The initial analyses showed very clearly that the samples include information on the sand type, particle size distribution and moisture content. They also demonstrated that early information about the sand type will be useful for reducing the variance. Figure 3 shows the result of a complete cross-validation of "sand type".

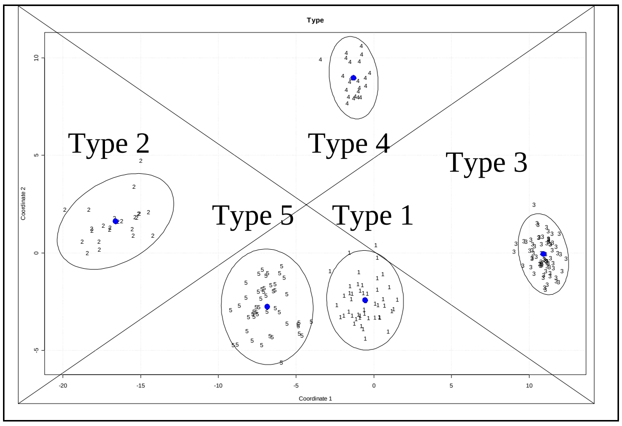

Figure 3: Discriminate analysis of different fine aggregate types.

Figure 3 shows that, on the basis of each specific image, it is possible to determine the sand type exactly. The model was produced through an optimal linear transformation that was discovered through what is called a canonical discriminant analysis. On the other hand, it can be concluded that if the sand type is known, the error variance can be reduced considerably.

Determination of particle size distribution

The goal of this analysis is to determine the respective particle size distribution for each sand sample based on image information. In other words: Is it possible to predict the particle size distribution based on image information – i.e. the amount of aggregate passing different sieve sizes?

A representative sample was taken from three types of sand to determine their particle size distribution according to the Danish standard DS 405.9.

The phenomena we would like to determine "exist" on different scales, which means that fine details disappear when they are high-stop filtered. Figure 4 shows examples of sand types with "fine" (top row) and "rough" (bottom row) particle size distribution illustrated according to different scales s ∈ {1.0, 5.0, 20.0, 30.0}.

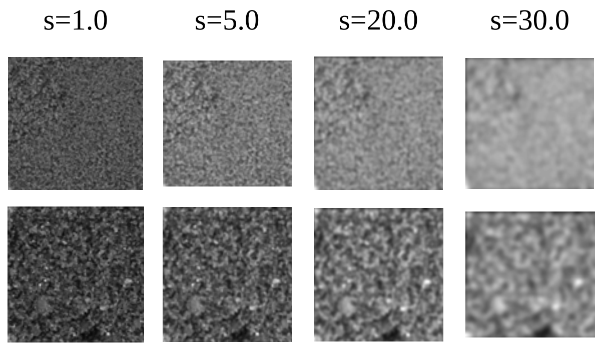

Figure 4: Illustration of images according to different scales. Top: "fine" particle size distribution and bottom: "rough" particle size distribution.

As shown in Figure 4, the increasingly rougher structures will disappear when the scale progresses upwards as these only "exist" up to a certain level. Thus the variation in the intensity of the images of the samples with the finer particle size distribution will decrease faster than the corresponding rough particle size distribution. This difference will form the basis of the further analyses. Figure 5 shows an example of the result of an analysis where the particle size distribution for a specific sand type is predicted for a "fine", "normal" and "rough" particle size distribution.

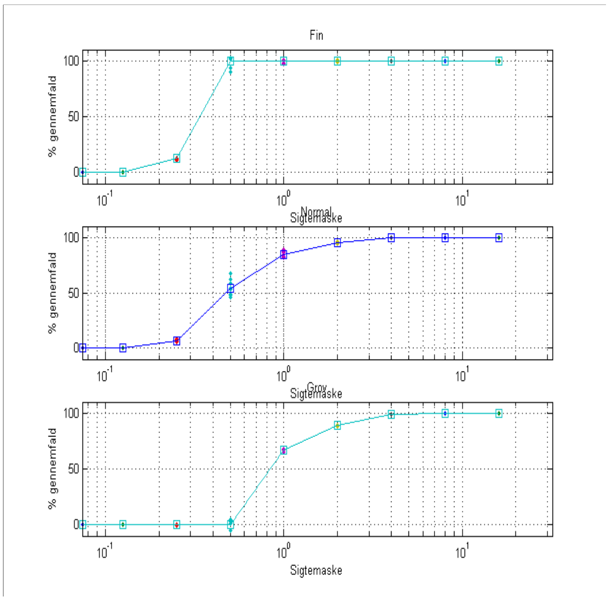

Figure 5: The predicted particle size distribution (averaging of triplicates) for a fine, normal and rough particle size distribution of a specific sand type.

Thus it is possible to predict the particle size distribution with good precision based on the existing image information. The variation lies in the range of 2% passing on average for all sieve sizes.

Based on the new features, all parameters are estimated in what is called a generalized linear model.

Moisture determination

The first step is to expand the number of “spectral bands” with new bands consisting of combinations of the original. This makes it possible to highlight “non-linear” contexts in a future linear model, which is not possible based on the original bands. The principle is illustrated in Figure 6.

Based on the new features, all parameters are estimated in a model where the moisture content depends on a number of the calculated features.

Our models are currently capable of predicting the moisture in the aggregate with an accuracy of approximately 0.25-0.30 moisture percent. “Modern regression methods” are currently being developed to further reduce the deviation.

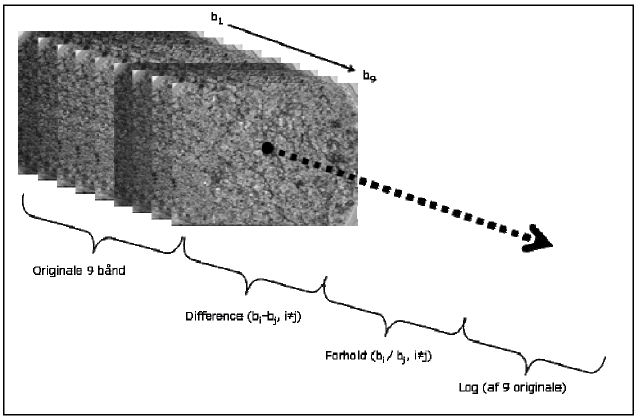

Figure 6: Generation of new image features based on the existing bands.

Aggregate shape

As the last part of the project, the aggregate shape is determined through image analysis.

Preliminary results for various types of concrete aggregate indicate that it is possible to group them relatively according to their angularity.

SCC Bridge

The Danish Road Directorate has tested innovative technologies in bridges for many years. In co-operation with the SCC Consortium, a demonstration bridge will be constructed using SCC where the latest technology and knowledge of construction methods will be applied and demonstrated on a full scale. The bridge will be constructed over the future motorway between the Danish cities Herning and Vejle and will be located on the stretch between Brande and Riis. The bridge is an elevated crossing over the Lille Donnerupvej road that primarily serves agricultural machinery traffic. The bridge is projected with two spans approximately 25 metres long with a column in the motorway central strip. The width of the bridge deck between the inner sides of the edge beams will be approximately 5 metres and the bridge deck itself will have a cross fall and a downward gradient of 25 ‰ and 10 ‰, respectively.

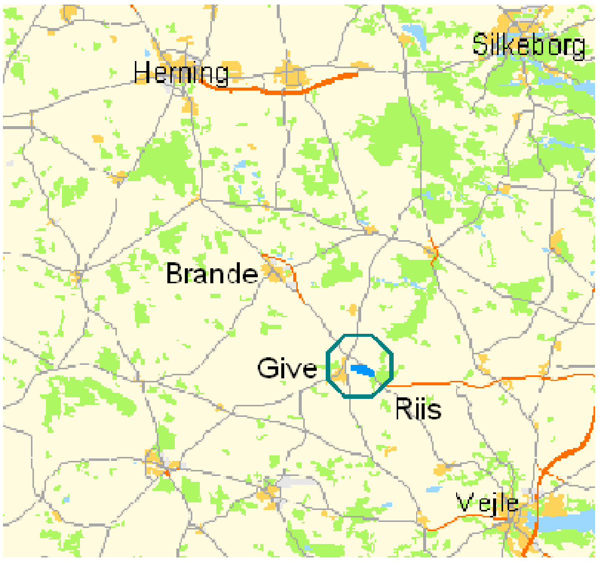

Figure 7: Location of the SCC bridge over the future motorway.

A reference bridge of traditional concrete will be chosen in the same manner. Productivity measurements on the two bridges can be used to demonstrate the advantages of SCC over conventional concrete.

SCC Portal

The first Danish SCC-portal with Information on **SCC** is now open at

www.VoSCC.dk

The purpose of the portal is to provide information on SCC regarding production, composition, construction, etc. It will be continuously updated with results from the SCC consortium. See for example the most recent conclusions about working environment.

Further information

See: www.scc-konsortiet.dk

or contact:

Lars Gredsted – MT Højgaard

Steering Committee Chairman

Tel.: +45 22 70 98 16

E-mail: lag@mthojgaard.dk

Mette Glavind – The Danish Technological Institute, Concrete Centre

Project Manager

Tel.: +45 72 20 22 20

E-mail: mette.glavind@teknologisk.dk