



ecra

european cement research academy



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Next ecra events to come:

- Blended Cements
October 13, 2004
- Experiences with Precalciner Kilns
November 3 - 4, 2004
- First International Conference on Innovation and Future Developments
in Cement Production and Concrete Construction
in Amsterdam
November 12, 2004

Blended cements - there is still a lot to learn about

Cements with reduced clinker content - a contribution to sustainable cement production

Various cements with a reduced clinker content – in the following designated as blended cements - can be regarded as traditional and well-tried for some European regions. Nevertheless there is still a need for the exchange of knowledge on these cements and tremendous possibilities with regard to the development of new blended cements. Besides their contribution to the reduction of CO₂ emissions in cement and concrete production, these cements offer a lot of advantages in terms of tailor-made solutions for different kinds of application.

A lot of technical benefits can be drawn from the use of blended cements. Cements containing blast furnace slag can be used as low alkali cements, sulfate resisting cements and cements with low heat of hydration. A moderate addition of limestone fines can decrease the water demand of the cement and could improve the workability of the concrete. At the same time the general performance of such cements is comparable to Portland cement. In principle the role of the main constituents in cement is well understood. Nevertheless, some aspects are still not fully known such as the reactivity of slag and its contribution to cement performance.

Reactivity of blast furnace slags

The vital functional links between the material properties of ground blastfurnace slags (gbfs) and the physical properties of mortar and concrete made of slag containing cements have not been identified yet. Therefore the Research Institute of the Cement Industry assessed the chemical reactions of some blastfurnace slags in an aqueous medium by conducting fundamental chemical investigations.

Reaction of blastfurnace slag with water

Scanning electron microscope photographs of five in water suspended and dried blastfurnace slags show coatings of different thickness around the blastfurnace slag particles. These rims are for example water containing silica gels. Depending on their thickness and compressibility they can as a cement constituent contribute differently to standard compression strength. Furthermore, a varying

proportion of dissolved alkalis is found in the eluate of the suspended blastfurnace slags. The quantity of easily soluble alkalis is a rough measure of the thickness of the blastfurnace slag glass layer that has been corroded during water suspension.

Aluminium protection against glass corrosion

Aluminium oxide acts as a glass corrosion inhibitor which is assumed to be formed of hydrous aluminate and aluminosilicate surface layers. Hence the corrosion resistance of gbfs depends on the aluminium which is available for that surface building process. Since the latter can not be determined directly during hydration an indirect procedure has been adopted: in the presence of dissolved sulphate, aluminium forms ettringite if calcium is available. As a consequence, an

increase in ettringite formation or in gypsum depletion, respectively, is an indirect indicator for the active aluminium portion in gbfs. The remaining aluminium shows low activity and contributes to the formation of structure-destabilising gel rims around the blastfurnace slag particles. Consequently reduced gypsum depletion in a mortar or paste is assumed to correlate with the slag hydration and at the end with the standard compressive strength of slag containing cements (fig. 1). Further investigations are underway to verify this.

Durability: the mix is the trick

Durability is one of the major requirements in terms of sustainable concrete structures. Besides the fundamental understanding of the behaviour of different main constituents and their influence on strength

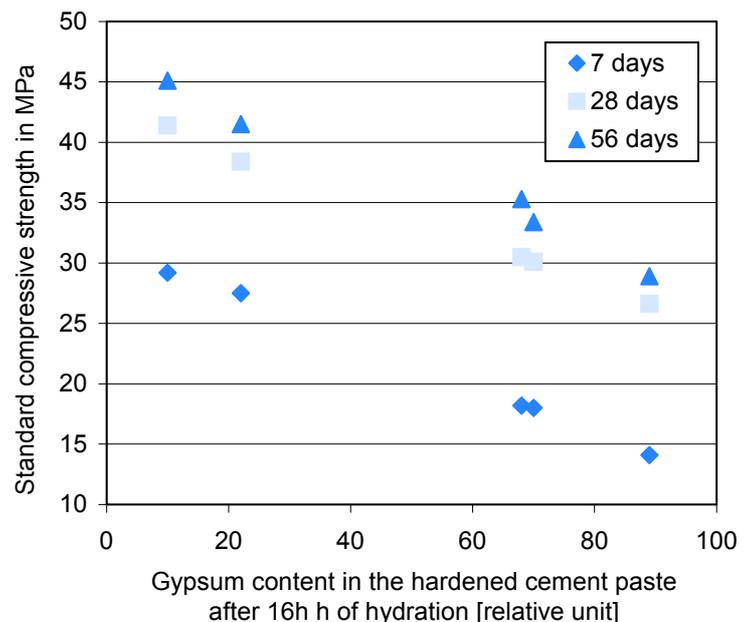


Fig. 1: Correlation between the gypsum content of the hardened cement pastes made of blastfurnace cements with five different gbfs after 16 hours of hydration (X-ray diffractometry; signal of selected gypsum peak in % of the peak after 1h hydration) and the standard compressive strength of cement as defined in DIN EN 196 Part 1

development and workability, the verification of concrete durability using blended cements is of outstanding importance. It is in their nature, that no main constituent has advantages in view of all technological and ecological aspects. Therefore a clever blend of different main constituents is an encouraging alternative.

Chloride induced corrosion

The exclusive use of limestone fines besides clinker in a range up to 35 % may lead to resistance against chloride penetration comparable to Portland cement based concretes. On the other hand the benefits of blast furnace slag in terms of chloride penetration are well known and become apparent in **fig. 2**. The combination of limestone fines and blastfurnace slag therefore offers the possibility to benefit from the advantages of both main constituents. The example shows, that cement with 25 % limestone and 10 % blast furnace slag shows a significant decrease of the chloride migration coefficient compared to the Portland cement of comparable strength.

Sulfate resisting cements

At European level, an intensive discussion takes place about how sulfate resisting cements can be standardized. It was decided to develop a research programme to get more fundamental understanding of the

correlation between sulfate attack and sulfate resistance. Against this background the forthcoming ecraseminar on blended cements will cover this topic in detail as well.

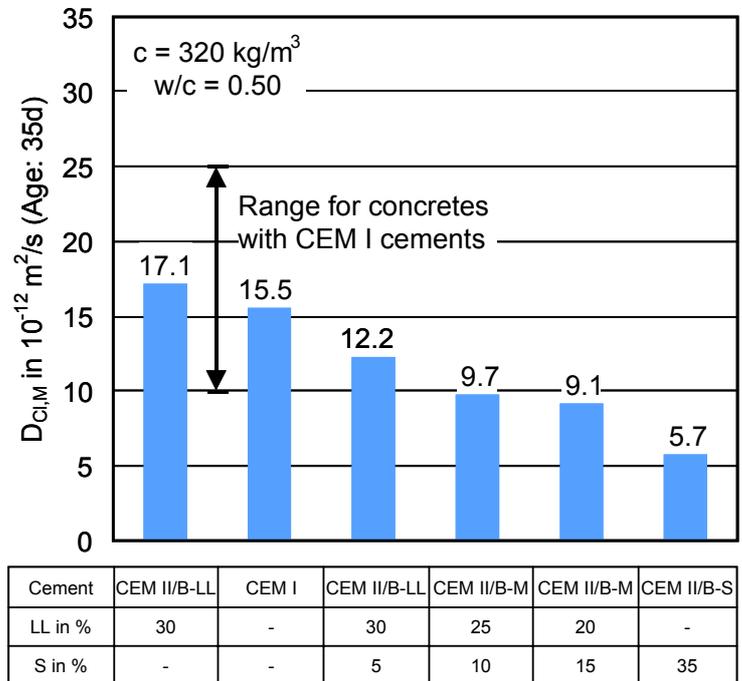


Fig. 2: Chloride migration coefficient $D_{Cl,M}$ for concrete with Portland cements and Portland composite cements with limestone (LL) and blastfurnace slag (S)

Waste incineration is subject to tight emission monitoring

EU-Directive requires sampling even for components emitted in very low concentrations

The requirements on the measurement and monitoring of cement kilns' emissions have currently reached a very high level. This is mainly due to the European waste incineration directive 76/2000/EC which sets very strict emissions limits.

According to the EU Directive on the incineration of waste the emissions of total dust, SO_2 , NO_x , TOC, CO, HCl and HF have to be measured continuously in the exhaust gas of co-incineration plants, i. e. a cement kiln which uses secondary fuels. However, the Directive provides for certain exemptions and as a consequence the requirements can differ from one European country to another.

In addition to these emissions some exhaust gas parameters have to be recorded continuously as well, such as the concentration of oxygen, the pressure, temperature and water vapour. These parameters are necessary to standardize the

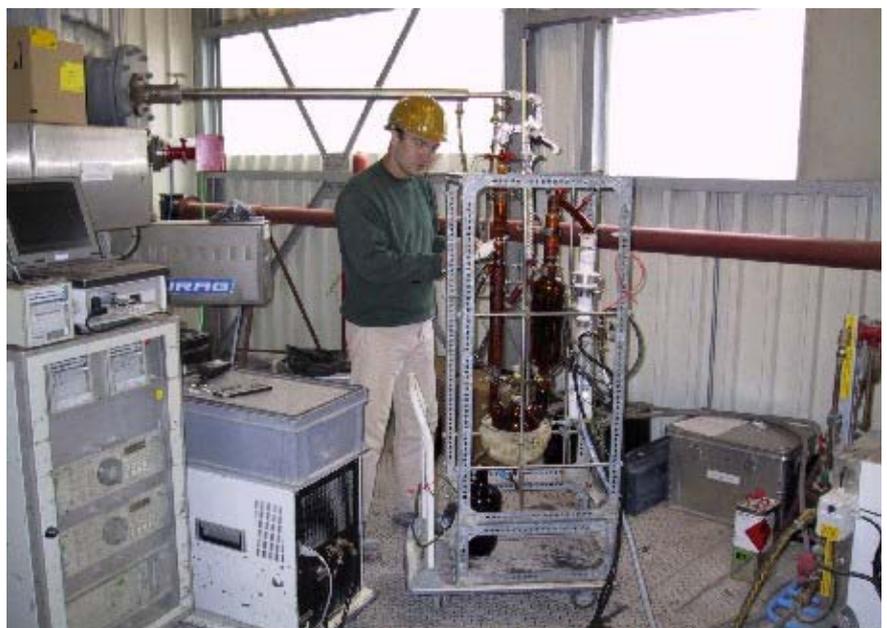


Fig. 1: Set-up for dioxin measurement

measured concentrations at a temperature of 273 K, a pressure of 101,3 kPa, 10 % oxygen, dry gas.

Besides these continuous measurements periodic measurements of trace elements, dioxins and furans, and - in some cases - polycyclic hydrocarbons or other pollutants have to be carried out.

Continuous measuring techniques

Relevant continuous measuring principles are IR- and UV-photometry as well as FTIR-spectrometry and flame ionisation detection.

According to the EU Directive the installation and functioning of the automated monitoring equipment has to be controlled by an annual surveillance test. Calibration has to be done by means of parallel measurements with reference methods at least

Daniel Gauthier takes over ecra chairmanship from Håkan Fernvik

July 1, 2004 Daniel Gauthier has taken over the chairmanship of the European Cement Research Academy from Håkan Fernvik who is one of the founders of ecra.

We want to express our gratitude towards Håkan Fernvik whose dedication to the objectives of the Academy was a fundamental support during the founding days



Håkan Fernvik

every three years.

With the results of the parallel measurements the analytical function of the complete monitoring equipment has to be calculated by regression analysis.

Finally this mathematical correlation is fed into the emission data acquisition unit.

Periodic sampling techniques

Trace metals have to be measured periodically. The same applies to dioxins and furans although it has been shown many times, that their emissions are on a very low level at cement kilns and, even as important, independent of the type of fuel used in the kiln. HF and HCl are subject to periodic measurement only, because it has been proven that emission concentrations are very low due to the alkaline atmosphere in the kiln and the pre-heaters.

The periodic measurements ha-

and beyond. We wish him for his retirement all the best.

Daniel Gauthier has already been a member of ecra's Technical Advisory Board since its foundation. We thank Daniel Gauthier for taking over this new responsibility and we are looking forward to the continuation of the successful work of ecra under his chairmanship.



Daniel Gauthier

ve to be carried out according to CEN-standards. If CEN standards are not available, ISO standards, national or international standards should ensure the provision of data of an equivalent scientific quality.

During each periodical measurement it is necessary to determine the relevant exhaust gas parameters. Besides the gas volume flow the current temperature and water vapour of the gas flow as well as the surrounding pressure and the gas density have to be measured. These parameters are important to determine the total mass flows but also to standardise the measuring results to 273 K, 1013 mbar, dry gas.

Requirements of the measuring site

It is necessary for emission measurements to have suitable measurement sections and measurement sites available. Emission measurements in flowing gases require defined flow conditions in the measurement cross section, which means an ordered and stable flow profile without vortexing and back-flow.

To determine any possible concentration differences in the measurement cross section, the measurements of the flow velocity and concentration or mass flow density are generally carried out in form of a grid measurement.

In grid measurements, the measurement points are distributed in the measurement cross section so that each measurement point represents an element of a similar area of the measurement cross section.

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European Cement Research Academy
Tannenstr. 2 · 40476 Düsseldorf
P. O. Box 30 03 32 · 40403 Düsseldorf
Germany
Phone: +49 (0)211 2 39 83 8-0
Fax: +49 (0)211 2 39 83 8-500
info@ecra-online.org
<http://www.ecra-online.org>