

E-Concrete? Believe It!

by

**Dale P. Bentz, Edward J. Garboczi and Geoffrey J. Frohnsdorff
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899 USA**

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<http://ciks.cbt.nist.gov>

CONCRETE TECHNOLOGY GOES ONLINE WITH A VIRTUAL TESTING LAB FROM THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

In recent years, the complexity of concrete mixture proportioning has increased dramatically. New chemical admixtures, such as high-performance superplasticizers and shrinkage-reducing admixtures, have been introduced into the marketplace. The use of supplementary cementitious materials such as fly ashes, slags, and calcined clays has become commonplace. At the same time, the composition and fineness of portland cements have been adjusted to produce the high early-age strengths demanded by "fast-track" construction practices. Assuring the quality of concretes containing these materials, and optimizing the performance of these new concretes in both the short term and long term, is a daunting task facing the construction industry. Researchers in the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST), in collaboration with industrial partners, are developing a comprehensive set of Web-based "e-concrete" tools to assist the industry with this undertaking.

Virtual Cement and Concrete Testing Laboratory. The Virtual Cement and Concrete Testing Laboratory (VCCTL) consortium was formed in January 2001. Its overall goals are to develop a user-friendly, computer-based virtual testing system to reduce the needed amount of physical testing of concrete and to expedite the research and development process. This will result in substantial time and cost savings to the concrete construction industry as a whole, while facilitating innovation. The VCCTL consortium currently consists of three NIST laboratories: BFRL, the Information Technology Laboratory (ITL), and the Materials Science and Engineering Laboratory (MSEL), as well as seven industry members: the Portland Cement Association (PCA), Holcim Inc., Master Builders Technologies (MBT), W.R. Grace & Co.-Conn., Cemex, Dyckerhoff Zement GmbH, and the German Cement Association (VDZ).

Version 1.0 is currently online. These models predict the chemical, physical, and microstructural changes taking place in the hardening of cement paste. The models can be used to examine the influence of water/cement (w/c) ratio, cement

particle size distribution, mineral admixtures, and/or gypsum form and content on the developing properties of concrete and other cement-based materials. Properties predicted include chemical shrinkage, heat release and temperature rise, setting, diffusivity, and strength development.

Current research in the consortium is focused on three topic areas: 1) enhancements to the cement chemistry and microstructure development model to take into account the effects of additional materials such as slags and limestone and to predict the composition of the fluid in the pores; 2) computation of the mechanical properties (elastic moduli, creep, shrinkage) of three-dimensional cement-based microstructures; and 3) experimental measurement and computer modeling of the flow properties (viscosity, yield stress, workability) of cement paste and concrete.

Electronic monograph for modeling and measuring. Many of the papers and research reports published by the Building Materials Division of BFRL within the past 12 years have been gathered and organized into an "electronic monograph"—a 2,300-page, Web-based "book." The monograph, which grows as new information becomes available, is organized into sections on various aspects of the science of cement-based and cement-related materials. Individual chapters deal with microstructure characterization and development, mechanical properties, and degradation mechanisms. A search engine serves as an index. Many models can be easily downloaded from the monograph's main page.

Computer integrated knowledge system. The website provides access to a computer-integrated knowledge system (CIKS) for predicting the service life of reinforced concrete exposed to chlorides. The system includes mixture proportioning according to American Concrete Institute (ACI) specifications for normal and high performance concrete, accompanied by predictions of concrete diffusivity, service life, and rate of chloride ingress.

Concrete optimization software tool. In a joint project with the Federal Highway Administration and the Statistical Engineering Division of ITL, BFRL has developed a concrete optimization soft-

ware tool (COST) that can guide the optimization of concrete performance based on the available raw materials and user-defined performance attributes. The user selects the factors to be optimized (e.g., cost, strength, rapid chloride permeability test results) and the mixture parameters to be varied (e.g., w/c ratio, aggregate contents, admixture additions). The Web-based software recommends a set of mixture proportions to be prepared and tested to achieve the most efficient identification of the optimum. The user then inputs the test results and the software performs graphical and statistical analyses to determine the mixture proportions for optimum performance.

Visible cement data server. In a joint ITL/BFRL project funded by the NIST Advanced Technology Program, a website containing actual 3-D microstructures of hardening cement paste, hardening plaster of Paris, and building bricks has been created. The website includes the original 3-D data files, a description of the material imaged for each data set, and a collection of C language computer programs that will be of use in processing and analyzing the 3-D microstructural images.

The authors believe that the contributions to e-concrete technology described here may be viewed as early steps in a coming revolution in concrete technology, in which computer-based tools—founded on sound experimental and computational materials science—will provide greatly accelerated innovation leading to enhanced and optimized performance of concrete in all its myriad applications.

—By Dale P. Bentz, chemical engineer, VCCTL manager; Edward Garboczi, leader, Inorganic Building Materials Group, NIST; Geoffrey J. Frohnsdorff, chief, Building Materials Division.

FOR MORE INFORMATION

Contact Dale Bentz at the National Institute of Standards and Technology.



Call: (301) 975-5865



Online: dale.bentz@nist.gov
www.bfrl.nist.gov

To visit the websites of any of the tools described above, please go to: <http://ciks.cbt.nist.gov>