

CONCRETE TECHNOLOGY *Today*

Pervious Concrete Pavement: A Win-Win System

by Dan Brown, P.E., Product Specialist, Holcim (US) Inc.



Fig. 1. Pervious concrete allows water to flow through it, allowing recharge of groundwater and reducing the need for storm water retention areas. (IMG13626)

CT032 — August 2003

Vol. 24, No. 2

Contents

Pervious Concrete Pavement: A Win-Win System

PCA Educational Courses

PCA Library—An Industry Resource

New Information Products

Concrete Technology Today is now available on the Internet at www.cement.org/cct

Use of pervious pavements helps owners and environment

Although pervious concrete has been in use for more than 50 years in a variety of applications, recent EPA regulations are causing many owners, specifiers and architects to reexamine applications of this unique material. Also referred to as "no-fines concrete" or "porous concrete," this material is comprised of narrowly graded coarse aggregate, cementitious materials, water, admixtures, and, in some cases, fibers. Little or no fine aggregate is included in the mixture. Carefully controlled amounts of water and cementitious materials are used to create a paste that forms a thick coating around aggregate particles without flowing off during mixing and placing. Using just enough paste to coat the particles maintains a system of interconnected voids on the order of 15% to 35% depending on materials and intended application. The result is a very high permeability concrete that drains quickly: Percolation rates of 100 to 750 liters per minute per square meter (2 to 18 gallons per minute per square foot) are common. Due to the high void content, pervious concrete is also lightweight, 1600 to 1900 kg/m³ (100 to 120 lb/ft³).

Construction Practices

After placement, pervious concrete resembles popcorn. Its low paste content and low fine aggregate content make the mixture harsh, with a very low slump. The compressive strength of pervious concrete is limited since the void content is so high. However, compressive strengths of 3.5 to 27.5 MPa (500 psi to 4000 psi) are typical and sufficient for many applications.

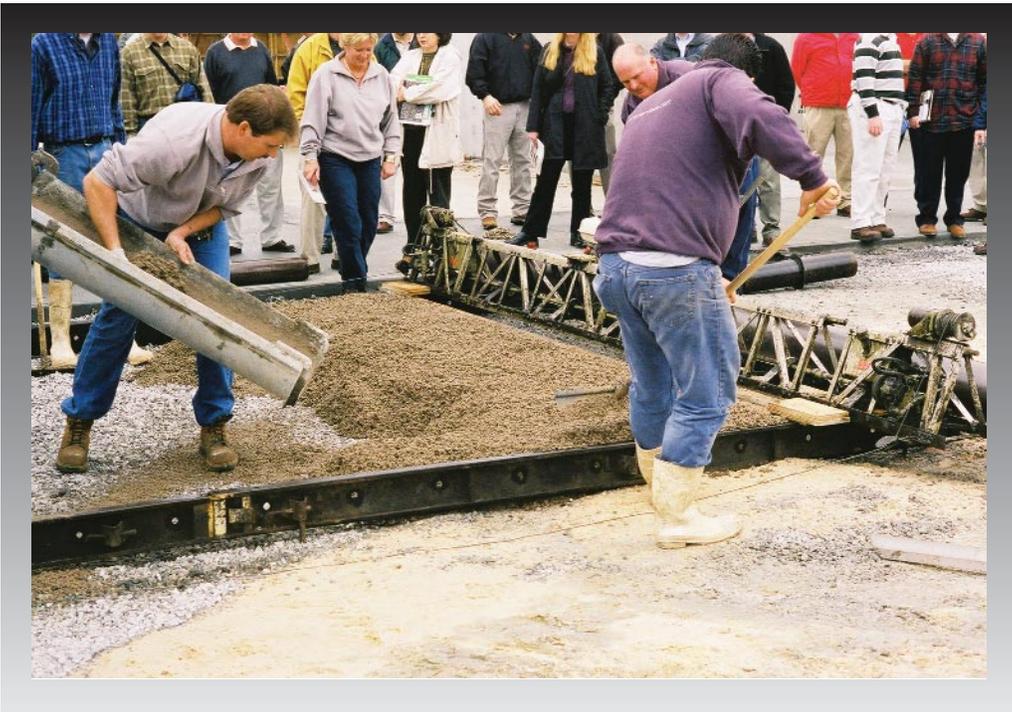


Fig. 2. Pervious concrete is usually placed by hand and then struck off with a vibratory screed, followed by compaction with a hand roller. Prompt curing with plastic sheeting is required. (IMG13627)

Pervious concrete is not difficult to place, but is a bit different from conventional concrete placement. It is a very low workability material, so considerable hand work may be necessary for placement. The use of a vibrating screed is important for optimum density and strength. After screeding, this material is usually compacted with a hand roller. There are no bull floats, trowels etc. used in placing pervious concrete. Conventional jointing methods and spacing are recommended. Curing with plastic sheeting must start immediately and continue for at least 7 days. Careful engineering is required to assure structural adequacy, hydraulic performance, and minimum clogging potential.

Paving the Way for Better Water Management

The principal uses for pervious concrete have been for parking lots, low traffic pavements, and pedestrian walkways. For these applications, the smallest sized aggregate feasible is used for aesthetic reasons. Coarse aggregate size 89 (9.5-mm or $\frac{3}{8}$ -inch top size) has been extensively used for parking lot and

pedestrian applications, dating back 20 years or more in Florida.

Pervious concrete's main advantage is its ability to pass large amounts of water quickly and this has dictated traditional applications: drainage media for hydraulic structures, porous base layers under heavy duty pavements, parking lots, tennis courts, and greenhouses. Its high porosity also gives it other useful characteristics: it is thermally insulating (in buildings) and has good acoustical properties (for sound barrier walls).

The interconnected void structure of this material allows water to pass through and percolate into the ground. This unique ability of pervious concrete captures rainwater and recharges ground water, reducing storm water runoff and helping owners comply with EPA regula-

tions. In the last few years, a high level of interest in pervious concrete has developed due to federal clean water legislation.

Control of "First Flush" Storm Water

Pervious concrete pavement systems provide a viable solution to the new requirements under the EPA Storm Water Phase II Final Rule (see Reference 1). Phase II regulations require programs and practices to help control the amount of hazardous contaminants in our waterways. Impervious pavements, particularly in parking lots, collect oil, anti-freeze and other automobile fluids, which may be washed into streams and lakes when it rains.

The EPA Storm Water regulations set limits on the levels of pollution in our streams and lakes. To meet these regulations, local officials have considered two basic approaches: reduce the overall runoff from an area and reduce the level of pollution contained in runoff. Efforts to reduce runoff include zoning ordinances and regulations that reduce the amount of impervious surfaces in new developments; green

space requirements; and implementation of "storm water utility districts" that levy an impact fee on a property owner, based on the amount of impervious area. Efforts to reduce the level of pollution from storm water include requirements for developers to provide systems that collect the "first flush" of rainfall (usually about 25 mm or 1 in.) and "treat" the pollution prior to release.

Pervious concrete pavement reduces runoff. It can also be used as part of a system to reduce the level of pollution contained in storm water that is captured, the so-called "first flush" that contains most of the pollution that comes from an impervious surface. By capturing the first flush of rainfall and allowing it to percolate into the ground, soil chemistry and biology are allowed to naturally "treat" the polluted water. Thus, storm water retention areas may be reduced, allowing increased land use.

Trees planted in parking lots capture some storm water and offer a cooling effect in the area, further reducing pollution. Pervious concrete pavement is ideal for protecting trees in a paved environment. For lack of water, trees planted in small "islands" in parking lots often have difficulty growing. Pervious concrete placed in parking spaces and pavements adjacent to tree islands greatly increases the amount of rain available to the trees without reducing usable area. Pervious concrete sidewalks allow urban trees to receive more water and still permit full pedestrian usage.

The use of pervious pavements has been growing in recent years as owners, architects, specifiers, and other concrete professionals become familiar with its benefits.

For more information please contact:

Dan R. Brown, P.E.
Product Specialist
Holcim (US) Inc.
1-800-292-4355 (office)
Chairman of ACI Committee 522, Pervious Concrete
Email: danr.brown@holcim.com

Reference 1: *Storm Water Phase II Final Rule: An Overview, EPA 833-F-00-001, Fact Sheet 1.0, US Environmental Protection Agency, Office of Water, January 2000, 4 pages.*
Available at: <http://www.epa.gov/npdes/pubs/fact1-0.pdf>.

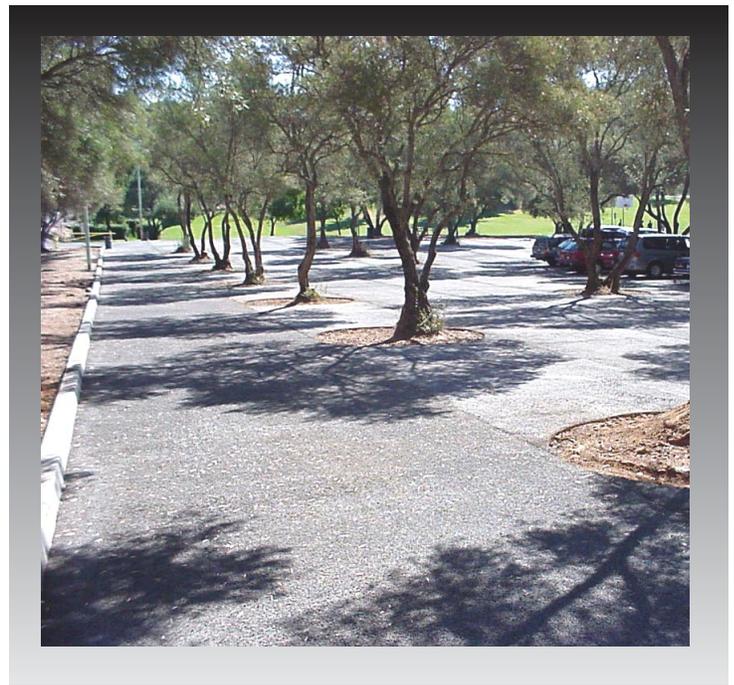


Fig. 3. Trees in this parking lot in California are adequately watered by percolation through the pervious concrete pavement. (IMG13628)

New Documents Available from ACI

The American Concrete Institute has recently issued the following committee reports and specifications:

- *Guide for the Design and Construction of Concrete Reinforced with FRP Bars*, ACI 440.1R-03
- *Slag Cement in Concrete and Mortar*, ACI 233R-03
- *Design and Construction Practices to Mitigate Corrosion of Reinforcement in Concrete Structures*, ACI 222.3R-03
- *Specification for Unreinforced Concrete Parking Lots*, ACI 330.1-03

These publications are available from ACI International, P.O. Box 9094, Farmington Hills, Michigan, 48333. You may order by telephone at 248.848.3800, or on-line at <http://www.concrete.org/BOOKSTORE/BKSTR.HTM>.

PCA Educational Courses

Knowledge has quickly become the single greatest competitive advantage that a company can gain in today's business environment. And the best way to gain that competitive advantage is to attend programs that not only inform, but immediately impact your bottom line. This year, the Portland Cement Association is once again offering three of the most popular courses in the concrete industry. This solid line-up of educational programs addresses each area of concrete technology. Concrete: Principles and Practices is an intensive immersion into every aspect of concrete technology. Focusing primarily on ready-mixed concrete, this program is the industry standard for new hires and personnel transitioning into technical services. It's also a great program for people that know enough to know that they really don't

know enough. Aggregates and Admixtures in Concrete Mix Design is an advanced and in-depth look at two of the most misused and misunderstood ingredients in the concrete mixture. Optimizing aggregate and admixture use can have a significant impact on a producer's profitability. This program is geared towards cement company, ready mixed concrete producer, testing lab, engineering, government, and contractor personnel trying to get the most out of their materials. Troubleshooting is a must for personnel that need to know what went wrong and why. The emphasis here is on the practical. What do you need to do and when. Whether its hours, days, or even months after the fact this program is the single best tool you can have when you get that dreaded call-back.

2003 – 2004 courses:

| | 2003 | 2004 |
|--|------------------------------|----------------|
| 1. Cement Manufacturing for Process Engineers | October 6-9 | |
| 2. Mill Grinding | October 20-22 | January 12-14 |
| 3. Concrete: Principles & Practices | October 27-30; December 8-11 | March 8-11 |
| 4. Logistics for the Cement Industry | | January 21-23 |
| 5. Kiln Process | November 3-6 | February 9-12 |
| 6. Cement and Clinker Microscopy | November 10-14 | February 16-20 |
| 7. Concrete Troubleshooting | November 17-19 | February 2-4 |
| 8. Aggregates & Admixtures in Concrete Mix Designs | December 1-3 | February 23-25 |
| 9. Cement & Concrete Overview | | January 19-20 |

NEW! One Day Regional Programs

Coal Mills...Challenges, considerations, and common sense operation

September 25 – St. Louis, MO; November 12 – Colton, CA

Clinker Coolers...Balancing cooler conditions with clinker quality and combustion requirements

September 26 – St. Louis, MO; November 13 – Colton, CA

For more information: Contact Julie Clausen, Education Coordinator -- jclausen@cement.org
 Phone: 847.972.9032; Fax: 847.966.9781
<http://www.portcement.org/et>

Clarification: Deterioration Mechanisms in Sulfate Exposures

The editors of *Concrete Technology Today* received a couple comments regarding our article entitled "A New Mechanism for Sulfate Attack"¹. The readers took exception to the title referring to sulfate attack when the article described what might more properly be termed physical salt attack. In fact the article is based on *Performance of Concrete in Sulfate Environments*² a recent research report from the Portland Cement Association in which monitoring and analysis of long-term performance of concretes in the field and in the laboratory occurred under very severe sulfate exposure conditions. The report concluded that physical salt attack was an important mechanism in these exposures. Only limited sulfate attack was found. Although formation of other salts may damage concrete, in the present case the salts were forms of sodium sulfate. The term "sulfate attack" was used in the title of the article to inform the reader that a deterioration mechanism other than classic sulfate attack had been observed. The intent was not to define physical salt attack or sulfate attack. Perhaps a more accurate title would have been: "A New Deterioration Mechanism for Sulfate Exposures." It should be noted that terminology on this topic is still being developed by the industry.

Classical sulfate attack is a reaction between external sources of sulfate that infiltrate the pore structure of concrete and react with cement hydration products in damaging expansive reactions. The mechanism of physical salt attack is due to sulfate salts (or other salts) that form after the evaporation of solutions that infiltrate the concrete. Upon subsequent wetting and drying (and possibly heating and cooling) cycles, salt crystals form and expand, damaging the concrete. Note that the PCA test plot studied only sodium sulfate exposures and not other salts.

Using low water-cementitious materials ratios minimizes damage by both mechanisms by reducing the ability of solutions to penetrate the concrete.



Fig. 1. Concrete beam (top) after 16 years outdoor exposure to a severe sulfate environment, with its upper surface deteriorated. Companion concrete prism (bottom) continuously immersed in a similar solution in a laboratory shows no deterioration. (68854)

Use of sulfate resistant cements, such as Type II and Type V cements, may help reduce damage to concrete exposed to sulfates for concretes with a moderate water-cementitious materials ratio. Sulfate resistant cements provide little to no benefit at high water-cementitious materials ratios.

Reference 1: "A New Mechanism for Sulfate Attack," Concrete Technology Today, CT031, Portland Cement Association, Skokie, Illinois, Volume 24, No. 1, 2003. Available from http://www.portcement.org/pdf_files/CT031.pdf

Reference 2: Stark, D. C., Performance of Concrete in Sulfate Environments, RD129, Portland Cement Association, Skokie, Illinois, 2002, 28 pages. To obtain a copy, call 800.868.6733 or visit the PCA Web site at www.cement.org, select "Bookstore," and enter "RD129" in the search field.

The PCA Library – An Industry Resource

"If knowledge is power... then you want to go where the information is!"

Most libraries these days—whether academic libraries, public libraries, or specialized technical libraries—are much more than simply "collections of books." The electronic world has radically changed all that, and the PCA Library is no exception. The Library, located in Skokie, Illinois, with a printed collection of nearly 100,000 materials, is one of the largest collections of cement and concrete information in the world. Recently, it has expanded its scope to include PCA's extensive image collection (over 100,000 images). The Library also offers a wide range of services outside the realm of its collection that can benefit anyone searching for information related to cement or concrete:

- electronic literature searches using hundreds of databases
- access to web documents
- referrals to subject specialists within PCA
- bibliographies on various topics such as self-consolidating concrete, stucco, recycled concrete, and wash water
- electronic copies of older PCA publications.

Nationwide Service

"But I live in Delaware...how can you help me?"

The Library's customers come from cement companies, ready-mix plants, precast manufacturers, architectural and engineering firms, universities, and other organizations all over the country and outside the U.S. Most of them are remote customers who can't visit in person. When an inquiry comes in, via phone or email, a library staff member discusses the type of information needed, performs a search using its automated catalog and other electronic sources, and provides the results by fax or email. If the request involves copying of articles, they can be mailed or faxed. If the request is for images for a presentation, electronic files are emailed or burned to a CD. Bear in mind that small fees are charged to cover a portion of the costs of these services.



The staff at PCA's library are always ready to assist those in need of construction information. (l. to r.) John Shaw, Bill Burns, and Connie Field. (IMG13625)

Sound familiar?

"I read an article a couple of years ago about the effects of fly ash on ASR..."

"I'm giving a PowerPoint presentation next week and need several images to illustrate..."

"My customer would like some advice on deicers for driveways. I know what to tell him, but I'd rather have some documentation..."

"Where can I get a list of cement and concrete-related web sites?"

"I'd like to start a basic collection of books on concrete materials – what would you recommend?"

"What does the technical literature say about optimizing manufactured sand as an aggregate?"

"What's the best way to clean oil stains on concrete?"

We specialize in answering questions like these. If you have a concrete-related question, give us a call. If you plan to be in the Chicago area, you are welcome to visit the library in-person. More information is available in the Library Update newsletter at www.cement.org/pdf_files/LU113.pdf.

Contacts:

Connie Field, Manager, (847) 972-9174

Bill Burns, Information Coordinator, (847) 972-9176

John Shaw, Library Associate (847) 972-9178

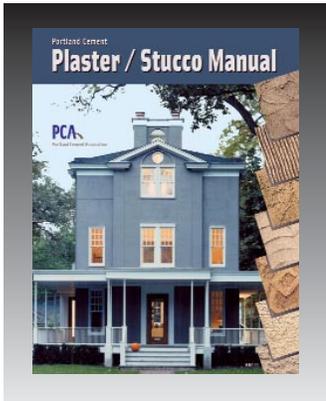
Email: library@cement.org

Hours: Monday – Friday 8:00 a.m. – 4:00 p.m.

New Information Products

The following information products are now available. To purchase them in the United States, contact the Portland Cement Association, Customer Service, P.O. Box 726, Skokie, IL 60077-0726, telephone 800.868.6733, fax 847.966.9666, or Web site www.cement.org (fax and Web available 24 hours/7 days a week). In Canada, please direct requests to the nearest regional office of the Cement Association of Canada (Halifax, Montreal, Toronto, and Vancouver—www.cement.ca).

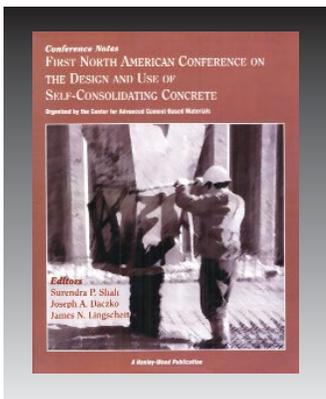
Plaster/Stucco Manual, EB049



This updated how-to guide and technical manual contains everything you need to know about plastering and stucco. Illustrated with numerous color photos, the manual contains essential information on materials, bases, mixes, hand and machine applications, and curing. A glossary of plastering terms, a tool list, a troubleshooting guide, and a

guide specification are included. Featuring the latest ASTM and CSA standards, this is an excellent resource for architects, engineers, specifiers, inspectors, contractors, plasterers, and apprentices.

Conference Notes: First North American Conference on the Design and Use of Self-Consolidating Concrete, LT272

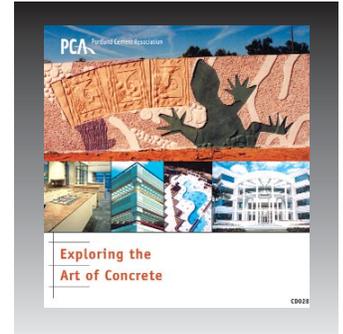


This soft-bound volume contains the 80 papers presented at the November 2002 conference sponsored by the Center for Advanced Cement Based-Materials, and presents the most current, in-depth information available on all aspects of self-consolidating concrete. Written for both producers and contractors, it includes detailed test results

and case studies, research data, and practical guidance. It underscores the many benefits of self-consolidating (also known as self-compacting) concrete including noise reduction, labor cost savings, and superior performance. Published by Hanley-Wood Publications, 2003.

Exploring the Art of Concrete, CD028

This CD on architectural and decorative concrete describes what it is, how to produce it, where to use it, and its advantages. It includes an extensive technical manual on white cement concrete in three languages (English, Spanish, and French) a guide specification, brief fact sheets, case studies, images, historical documents, and newsletters. These technical and promotional resources are essential references for architects, designers, producers, builders, and other users.



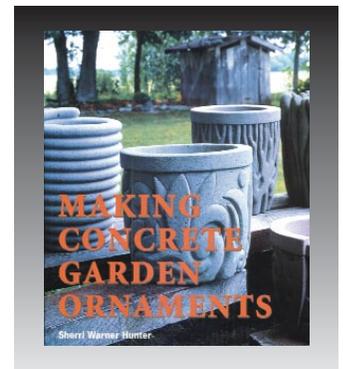
Self-Compacting Concrete: A Bibliography of Resources, LB06

The PCA library has recently updated this 18-page bibliography with references to more than 250 technical reports, journal articles, conference presentations, and links to web documents on SCC.



Concrete Garden Ornaments, LT273

This colorful book is a feast for the eyes—a pictorial gallery of imaginative, whimsical, artistic concrete objects for the garden. It is also a "how-to" book, with clearly-presented instructions for making each object, as well as a discussion on the fundamentals of concrete. Some projects are intended for the novice, some are considerably more challenging. Projects include planting containers, obelisks, sculpture, mosaic stepping stones, chairs, and more. Published by Lark Books, 2001.

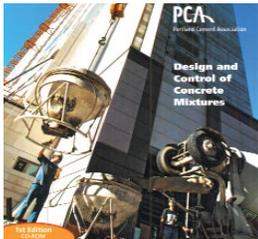




Portland Cement Association
5420 Old Orchard Road
Skokie, Illinois 60077-1083

ADDRESS SERVICE REQUESTED

Design and Control of Concrete Mixtures Now Available on CD-ROM!



Interactive CD contains the entire book and much more!

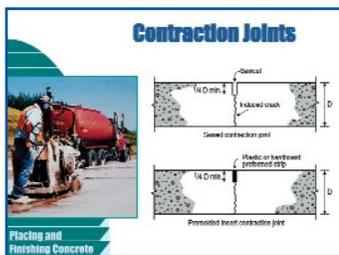
The concrete industry's premier publication is now available on one fully searchable CD. In addition to having access to the book's entire text, photos, and graphics, users can click on selected references and be immediately linked to informative Web sites, as well as 170 PCA research reports. Each chapter also contains short instructional videos that offer viewers an in-depth look at selected concrete materials, properties, and practices.

Gajda, John, *Development of a Cement to Inhibit Alkali-Silica Reactivity*, Research and Development Bulletin RD115, Portland Cement Association, 1996, 58 pages.

Gaynor, Richard D., "Calculating Chloride Percentages," *Concrete Technology Today*, PL983, Portland Cement Association, http://www.portcement.org/pdf_files/PL983.pdf, 1998, pages 4 to 5.

Gebler, S. H., *The Effects of High-Range Water Reducers on the Properties of Freshly Mixed and Hardened Flowing Concrete*, Research and Development Bulletin RD081, Portland Cement Association, http://www.portcement.org/pdf_files/RD081.pdf, 1982.

Numerous links provide instant access to selected references.



The CD contains PowerPoint® presentations for each chapter.

By activating the keyword search feature, users can go directly to each point within the book that contains the selected word or phrase. A comprehensive glossary provides definitions for 146 industry terms.

Each of the book's 18 chapters has also been converted to PowerPoint®, providing users with the perfect graphics and notes to make authoritative presentations. The instructional videos are also included in the PowerPoint® format, bringing each of the presentations to life.

To order a copy of *Design and Control of Concrete Mixtures* (CD100), call 800.868.6733 or visit the PCA Web site at www.cement.org, select "Bookstore," and enter "CD100" in the search field.

CONCRETE TECHNOLOGY Today

Portland Cement Association ("PCA") is a not-for-profit organization and provides this publication solely for the continuing education of qualified professionals. THIS PUBLICATION SHOULD ONLY BE USED BY QUALIFIED PROFESSIONALS who possess all required license(s), who are competent to evaluate the significance and limitations of the information provided herein, and who accept total responsibility for the application of this information. OTHER READERS SHOULD OBTAIN ASSISTANCE FROM A QUALIFIED PROFESSIONAL BEFORE PROCEEDING.

PCA and its members make no express or implied warranty in connection with this publication or any information contained herein. In particular, no warranty is made of merchantability or fitness for a particular purpose. PCA and its members disclaim any product liability (including without limitation any strict liability in tort) in connection with this publication or any information contained herein.

PUBLISHER'S NOTE:

Intended for decisionmakers associated with the design, construction, and maintenance of concrete structures, *Concrete Technology Today* is published triannually by the Construction Information Services and Product Standards and Technology departments of the Portland Cement Association.

Our purpose is to highlight practical uses of concrete technology. If there are topics readers would like discussed in future issues, please let us know. Items from this newsletter may be reprinted in other publications subject to prior permission from the Association. For the benefit of our readers, we occasionally publish articles on products. This does not imply PCA endorsement.

Martin McGovern, Editor,
Construction Information

Paul Tennis, Associate Editor,
Product Standards and Technology

E-mail: mmcgovern@cement.org



Portland Cement Association

5420 Old Orchard Road

Skokie, Illinois 60077-1083

847.966.6200 Fax 847.966.9781

www.cement.org

PCA Newsletters Go Electronic

**Sign up now
to continue
your FREE
subscription.**

**Don't miss a
single issue.
Register
online or
return the
card today!**

Beginning in 2004, PCA will publish the *Concrete Technology Today* Newsletter in electronic format only. Printed copies will no longer be mailed out to subscribers. If you want to continue receiving this publication, you will need to make sure we have your email address.

Register online at www.cement.org/signup and complete your personal interest profile. Select the electronic newsletters you would like to receive and your interest areas. Or return the enclosed card and we'll enter your subscription information for you.



FREE

Register online and download *Concrete Information, Portland, Blended, and Other Hydraulic Cements, IS004, a \$21 value.**

* Free download is available only to those who register online.