Portland Cement Association

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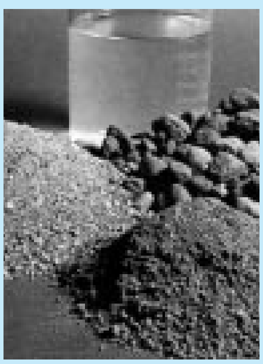

Tilt-Up Concrete – A Technique that Continues to Evolve

Tilt-up concrete tanks? Believed to be the first application of its kind for any type of tank construction, tilt-up concrete panels have been used in the $280-million expansion of the Metropolitan St. Louis Sewer District's Bissell Point Wastewater Treatment Plant. Scheduled for completion later this year, the expansion coincides with adoption of new guidelines from the Clean Water Act of 1987, and upgrades the 150-mgd facility to the secondary treatment level.

Trickling Filter Tanks

The cornerstone of the project has been the construction of six trickling filter tanks. Now in operation, the tanks house the world's largest installation of plastic sheet media filters—134 ft (41 m) in diameter and 32 ft (9.8 m) in depth—according to principals with Maryland Heights,

Tilt-up concrete is no longer confined to just industrial/commercial buildings, as evidenced in these new trickling filter tanks at Metropolitan St. Louis Sewer District's Bissell Point Wastewater Treatment Plant. Photos courtesy of Sverdrup Corporation.

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A 150-ton track-mounted crane with an eight-point lifting pick erects tilt-up concrete panel at Bissell Point WWTP.

Missouri-based Sverdrup Corp., primary engineer and joint venture manager.

Value engineering spawned the trickling tanks: Sverdrup's plan utilizes the trickling filter process before the more energy-intensive activated sludge system. This reduces the amount of power needed by the activated sludge system to treat the waste. Hazelwood, Missouri-based tank subcontractor, Clayco Construction Company, advanced value engineering further by advocating the use of tilt-up technology as a more economical solution to building the tanks than previous design concepts.

Panel Construction

Each tank is comprised of 24 tilt-up panels measuring approximately 17 ft (5.2 m) wide, 37 ft (11.3 m) high, and 9.5 in. (240 mm) thick. Cast-in-place concrete pilasters connect the panels, which rest on a 7-ft-high (2.1 m) reinforced concrete foundation wall.

The presence of concrete support members protruding from the tank floors and the sloped profile of the floors precluded their use as tilt-up panel casting surfaces. Clayco—anticipating that normal tilt-up concreting practices would not be possible—devised a panel construction scheme in which four casting beds were set up around each tank footprint. Panels were stack-cast six high, the finished inside surface of one panel becoming the casting bed for the next. Meramec gravel was used in the concrete so that the coarse aggregate near the exterior face of the panels (bottom surface as cast) could be exposed by sandblasting to serve for an attractive final finish.

Panel Erection

A 150-ton (136,000-kg) track-mounted crane and an eight-point lifting pick was used to erect, align, and plumb the 72,000-lb (32,700-kg) panels on top of the tank foundation walls. Temporary bracing of the panels was accomplished with a 3-point bracing method, which was required due to the sizable weight of the panels and the necessity of avoiding numerous column supports inside the tank.

Upon completion of panel erection, pilasters were cast using a custom-fabricated steel form. Coil inserts were utilized for installing rebar dowels in the sides of the panels; these would become embedded in the cast-in-place pilasters, tying all the panels together. Threaded inserts also were installed in the panel tops for anchoring the bridge forms used to cast a continuous concrete ring beam around the top of each tank. Upon completion of the pilaster and ring beam construction, all panels were sandblasted and treated with a siloxane penetrating sealer.

Summary

In summary, 144 tilt-up concrete panels weighing approximately 10.5 million lb (4.8 million kg) were used to build six concrete tanks to house trickling filters at one of the largest wastewater treatment plant modification projects in the country. This unique design gave the concrete contractor, Clayco Construction, the opportunity to construct solid concrete tanks using pieces held together with monolithic concrete pours—rather than totally monolithic. Clayco believes this is the first time tilt-up concrete has been used for any type of tank construction. They also believe that use of tilt-up technology not only provided a more economical solution than previous design concepts, but also shortened the field schedule considerably. Clayco notes: "We opened some eyes by utilizing tilt-up concrete for an application other than the typical scenario of large industrial building construction."

Credits

Owner: Metropolitan St. Louis Sewer District

Engineers: Sverdrup Corp. and Havens & Emerson Joint Venture

General contractor: Goodwin Brothers Construction Co.

Tilt-up Concrete: Clayco Construction Co.

Consultant: Alper-Ladd, Inc.

Concrete supplier: Breckenridge Material Co.

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Promoting Quality in Laboratory Testing

Introduction

In the early part of this century, a number of organizations including the American Society for Testing and Materials, the National Bureau of Standards (now the National Institute of Standards and Technology), and the Portland Cement Association collaborated in activities to improve and standardize specifications and test methods for portland cement. This led to formation of the Cement Reference Laboratory as a Research Associate Program at the NBS in 1929 under sponsorship of ASTM Committee C-1 on Cement. Much later, in 1980, ASTM Committee C-9 on Concrete and Concrete Aggregates also became a sponsor, and the name of the laboratory was changed to the Cement and Concrete Reference Laboratory, or CCRL. The two sponsoring ASTM committees formed a Joint Subcommittee on CCRL to provide guidance in its operation. Today, CCRL operates under a Memorandum of Agreement between ASTM and NIST.

CCRL operates voluntary programs which promote the quality of laboratory testing of cements, concrete, aggregates, reinforcing steel, and pozzolans. A companion organization, the AASHTO Materials Reference Laboratory (AMRL), also operates voluntary programs similar to CCRL's, but covering highway construction materials such as soils, aggregates, asphalt cement, and bituminous concrete (see box).

Fig. 1. CCRL inspector uses elastic calibration device (called a proving ring) to verify loading accuracy of a laboratory testing machine.

CCRL Programs

The work of CCRL is having a significant impact, not only in the United States, but also at the international level. While most are in the United States and Canada, over 1,000 laboratories in 15 countries around the world participate in CCRL's laboratory inspection and proficiency sample programs.

In the United States, CCRL programs are used by the following organizations as part of their laboratory quality assurance programs:

- 305 commercial testing laboratories.
- 50 state transportation laboratories.
- Federal government agencies.
- County and local government agencies.
- Construction materials trade associations.
- Private construction materials industries.
- Cement producers.
- Research and development laboratories.
- Universities.

CCRL programs operate under the following policies:

- Programs are limited to laboratories using standard methods of test.
- Utilization of CCRL programs is voluntary.
- Work is strictly advisory in nature.
- Laboratories are not rated, certified, or accredited.

The four major functions of CCRL are to:

- Inspect testing laboratories.
- Distribute proficiency test samples.
- Participate in the work of technical committees.
- Study issues related to testing of construction materials.

Inspecting Laboratories

CCRL uses a "hands-on" approach in evaluating a laboratory. In addition to review of test equipment and procedures, the concrete inspection includes a review of the laboratory's quality system based on the requirements of ASTM C1077, *Standard Practice for Laboratories Testing Concrete and Concrete Aggregates and Criteria for Laboratory Evaluation.*

When evaluated, a laboratory is entitled to more than a simple check of its paperwork; CCRL personnel carry proving rings (Fig. 1), balances, testing weights, thermometers, psychrometers, spherometers, micrometers, and other specialized tools. Using detailed worksheets, laboratory equipment is evaluated to make certain it complies with ASTM standard tolerances. A laboratory can rely on CCRL measurements; the calibration or verification of CCRL equipment is traceable to standards at the National Institute of Standards and Technology.

CCRL also uses a "hands-on" approach in evaluating a laboratory's test procedures. Using ASTM test methods, CCRL has developed detailed worksheets to describe various test procedures. These worksheets are used to evaluate techni-

Construction Materials Reference Laboratory at NIST

Both the federal government and the private sector are placing increasing emphasis these days on improving the quality of construction in the United States. Ensuring the quality of testing of construction materials is an important step towards achieving this objective.

Programs of the Construction Materials Reference Laboratory (CMRL) located at the National Institute of Standards and Technology (NIST)—formerly the National Bureau of Standards—promote the quality of testing. CMRL is located in the Building Materials Division of the NIST Center for Building Technology in Gaithersburg, Maryland. CMRL consists of the Cement and Concrete Reference Laboratory (CCRL) and the AASHTO Materials Reference Laboratory (AMRL).

CMRL promotes the quality of testing through assessment of the performance of testing laboratories, support to national standards committees in the preparation of test methods, and use of CMRL programs by quality control and quality assurance systems. CMRL programs are currently based on over 150 standard methods of test for construction materials prepared by ASTM and the American Association of State Highway and Transportation Officials (AASHTO). Benefits arising from CMRL programs include: (1) production of data, which is used to quantify standard measurement techniques, (2) improvement in the reliability of test measurements, and (3) availability of a communications link between construction materials testing laboratories and standards writing committees.

Sponsored by AASHTO, the AMRL was established as a Research Associate Program in 1965. AMRL operates under a Memorandum of Agreement between AASHTO and NIST. AMRL's primary responsibility is to provide services that promote the uniformity of testing in construction materials testing laboratories and assist the transportation industry in obtaining reliable measurements of highway material properties. The Subcommittee on Materials of the AASHTO Standing Committee on Highways has established an AMRL Monitoring Council to provide oversight of AMRL's operations.

Fig. 2. CCRL inspector evaluates laboratory technician's procedure during routine compressive strength test of cylindrical concrete specimen.

cians performing the procedures (Fig. 2). Any deviation from the prescribed procedure is noted, and if necessary, the correct technique is demonstrated.

At the completion of a visit, a comprehensive oral report and a preliminary written report are presented to the laboratory supervisor. A final written report is subsequently provided; it is treated as strictly confidential, but may be distributed to parties designated by the inspected laboratory.

When it comes to inspecting construction materials testing laboratories, no one has more experience than CCRL—they've been doing it since 1929. A cycle of laboratories requesting inspections is completed in 2 to 2-1/2 years. During the last inspection cycle, CCRL performed 1090 inspections at 578 laboratories in all 50 states, Canada, Puerto Rico, and Mexico.

Proficiency Test Samples

Proficiency sample programs provide comparisons of results of standard tests within or among various laboratories for the purpose of aiding in the recognition and correction of deficiencies. Uniform samples are prepared from lots of a given material and sent to participating laboratories with instructions for performing the tests. Each laboratory returns the results to CCRL for review and analysis. A final report with statistical information is provided to all participating laboratories. Materials included in the CCRL proficiency sample program are: portland cement, blended cement, masonry cement, portland cement concrete, and fly ash. Samples of blended cement, masonry cement, and fly ash are distributed once a year; samples of portland cement and portland cement concrete, twice a year.

Other Activities

CCRL staff also provide technical support to the standards committees of ASTM. Data from the laboratory and proficiency sample programs are used by standards committees in assessing the adequacy of current test methods, in determining the impact of revisions to standards, and in developing precision statements. Support to standards committees has proven to be of significant benefit to the construction industry since it provides direct liaison between the authors and the users of ASTM standards covered by CCRL programs.

Technical studies are conducted to aid in the improvement of standard methods of test for concrete construction materials, and to support the development of new programs. Studies may be conducted individually by CCRL staff, cooperatively with other NIST units, or with organizations outside NIST. A study may be initiated by a request from a technical committee or other interested organization, or a problem requiring study may be identified while conducting laboratory inspection and proficiency sample programs.

The AASHTO Accreditation Program (AAP) uses the results from CCRL inspection and proficiency sample programs in its evaluation criteria. AAP is the largest accreditation program for concrete testing laboratories in the United States. Established in 1988, the AAP currently has over 70 accredited laboratories in the concrete testing field.

Summary

The Cement and Concrete Reference Laboratory is a joint operation of Committees C-1 and C-9 of ASTM and the National Institute of Standards and Technology. CCRL's success is evidenced by the large number of laboratories that participate in its inspection and proficiency sample programs. CCRL is a unique example of cooperation between federal, state, and local governments, standards developers, and industry. The 63-year record of CCRL illustrates the value of these programs in improving the quality of testing concrete construction materials.

Laboratory participation in the programs of CCRL is voluntary, and is initiated by requests from interested organizations; those who participate pay fees established by the sponsoring organizations. The CCRL fee structure is based on reimbursement of costs. For more information about CCRL, contact Ray Kolos or Robin Haupt, Cement and Concrete Reference Laboratory, National Institute of Standards and Technology, Building 226, Room A365, Gaithersburg, Maryland 20899; phone 301/975-6704 or fax 301/975-2128.

For More Information

1. Pielert, James H., " Construction Materials Reference Laboratories at NIST," *ASTM Standardization News*, American Society for Testing and Materials, Philadelphia, December 1989, pages 40-44.

2. *Need a Thorough Evaluation of Your Testing Laboratory? Why not Consider CCRL,* Cement and Concrete Reference Laboratory, National Institute of Standards and Technology, Gaithersburg, Maryland, March 1993.

3. Gray, Robert J., "Variability of Compressive Strength Test Results," *Concrete Technology Today*, Vol. 11, No. 2, PL902.01B, Portland Cement Association, June 1990, pages 1-4.

Pouring it on in Public Works

Public works is front and center in the 1993 edition of *Concrete Today,* the annual supplement to *Engineering News-Record* written and produced by PCA on behalf of the cement and concrete industries.

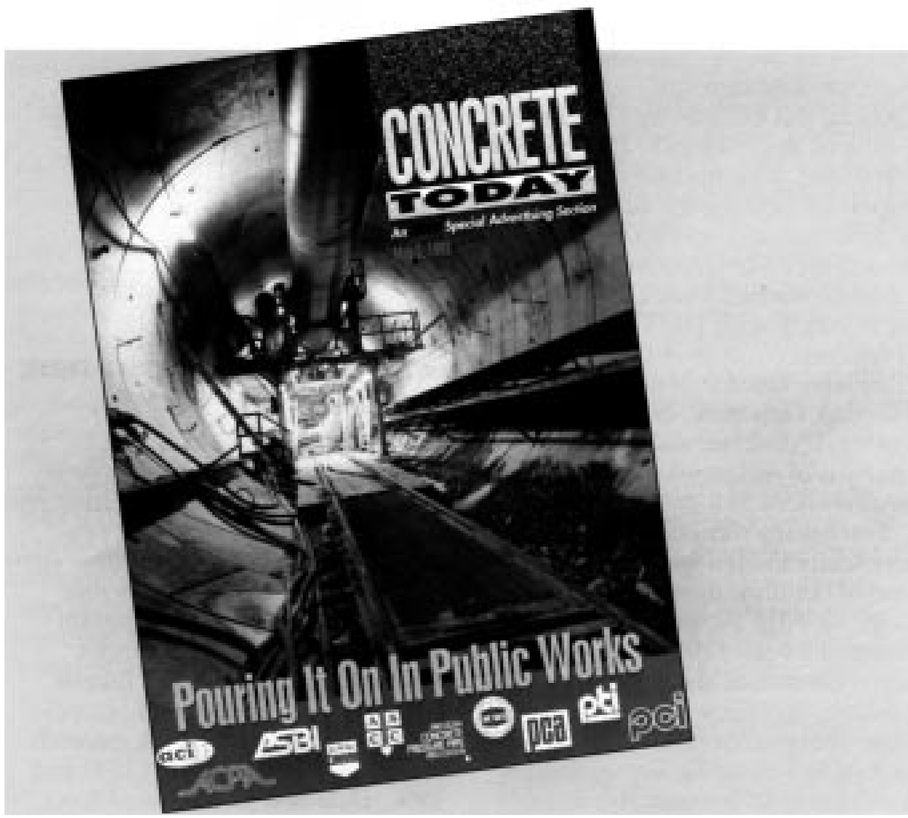
As previous editions scoped high-rise buildings and other trendy milestones, this year's *Concrete Today* plays to the strengths of transportation and environmental infrastructure and public buildings ... bright spots in an otherwise lackluster construction economy. The current edition profiles projects large and small—from bridges and outfall tunnels to libraries and advanced water purification plants—that have fueled the 1990s' public works agenda and now leave long-lasting concrete signatures for future generations.

The introduction to *Concrete Today* offers some additional perspective: "What's good for public works is naturally good for the concrete industry....concrete interests are rapidly deploying new material and equipment technologies in the interests of longer service-life transportation pavements and structures, esthetically engaging public facilities, improved water pollution control systems, and higher quality drinking water."

Joining PCA and the American Concrete Pavement Association as cosponsors of this year's *Concrete Today* were: American Concrete Institute, American Concrete Pressure Pipe Association, American Segmental Bridge Institute, American Society for Concrete Construction, Concrete Reinforcing Steel Institute, International Concrete Repair Institute, Post-Tensioning Institute, and Precast/Prestressed Concrete Institute.

The 11th edition of *Concrete Today* appeared in the May 3, 1993, issue of *Engineering News-Record* magazine. Not to be confused with *Concrete Technology Today, Concrete Today* is the editorial/advertising supplement that appears annually in a May issue of McGraw-Hill's weekly, *ENR.*

Free copies of the 88-page *Concrete Today* reprint are available. Contact Don Marsh, Corporate Communications, PCA, 5420 Old Orchard Road, Skokie, IL 60077-1083; phone 708/966-6200 ext. 338.



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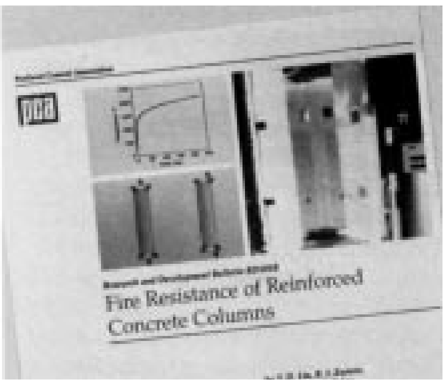
New Research Results Announced

The following new research and development bulletins are now available. To purchase any of these bulletins in the United States, contact Portland Cement Association, Order Processing, P. O. Box 726, Skokie, IL 60076-0726; telephone 708/966-6288, or fax 708/966-9666 (*24 hours a day, 7 days a week*). In Canada please direct requests to the nearest regional office of the Canadian Portland Cement Association (Halifax, Montreal, Toronto, and Vancouver).



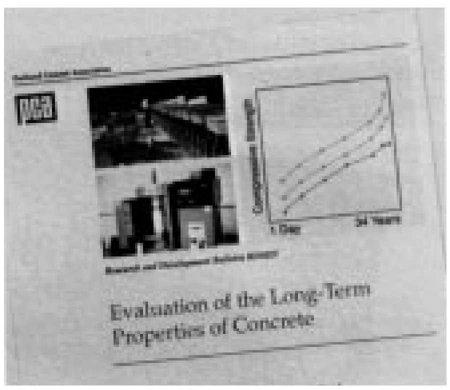
Fire Resistance of Reinforced Concrete Columns, RD101B

Funded jointly by PCA and the National Research Council of Canada, this bulletin by T. D. Lin, R. I. Zwiers, R. G. Burg, T. T. Lie, and R. J. McGrath is comprised of two papers addressing the fire resistance of concentrically and eccentrically loaded concrete columns. The columns studied were 12 ft 6 in. (3.8 m) in length with 1-1/2 in. (38 mm) of concrete cover over the tie bars. They were fabricated of either siliceous, carbonate, or lightweight aggregate concrete and included columns of rectangular and circular cross sections in a variety of sizes.

Test results showed that both concentrically loaded and eccentrically loaded columns designed according to the *ACI 318 Building Code* have a nominal 3-hour fire endurance rating. Test results also indicated that concrete aggregate type and column cross-sectional geometry are significant factors affecting fire resistance. A relationship between fire resistance and load/strength ratios was obtained, and temperature distributions measured in selected cross-sections are included in the report. Measured fire resistance ratings for eccentrically loaded columns were compared with companion columns tested with concentric loads.

This 34-page bulletin contains answers to many long-standing questions related to the fire resistance of reinforced concrete columns. For example:

- Does concrete strength and amount of reinforcement affect fire endurance?
- Is fire endurance affected by fixed end conditions or by type of restraint?
- What is the effect of concrete's relative humidity on fire endurance?
- What is the fire endurance of columns of different cross sections?
- What is the effect of eccentric loading on fire resistance of columns?
- How does type of concrete aggregate affect fire endurance?



Evaluation of the Long-Term Properties of Concrete, RD102T

Unique in scope, this R&D bulletin retires one of PCA's longest running and most exhaustive testing programs while laying to rest some age-old questions over how concrete changes with time. In a program sponsored by Portland Cement Association, University of Illinois Professor Sharon L. Wood compiled data from four major PCA research projects initiated between 1940 and 1956. Data was summarized from more than 6500 concrete samples representing nearly 300 combinations of cement types, mix proportions, and curing conditions.

The study focused on the critical mechanical properties of compressive strength, flexural strength, and modulus of elasticity (stiffness)—key indicators of concrete's strength and durability. Concrete specimens made from the five ASTM C150 types of portland cement, as well as portland blast-furnace slag cement, portland-pozzolan cement, and air-entraining cement were tested at ages between 1 day and 34 years while exposed to moist, dry, and outdoor environments. Reported relationships compare compressive strength, flexural strength, modulus of elasticity, water-cement ratio, curing condition, specimen type, and normalized strength, as well as mortar and concrete compressive strength. Water-cement ratios ranged from 0.35 to 0.83. Compressive strength levels ranged from normal to high strengths of over 13,000 psi (90 MPa).

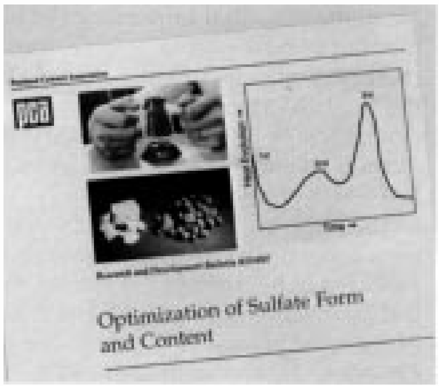
This 99-page bulletin concisely evaluates concrete properties from PCA's long-time studies. It answers a variety of common questions often posed by concrete technologists, such as:

- Does concrete continue to gain strength after 1 year?
- What are typical variations with test age for strength?
- What is the relationship between cube and cylinder strength?
- How do curing conditions affect strength gain?
- What is the relationship between flexural and compressive strength?

The answers to these and many more questions can be found in this valuable reference.

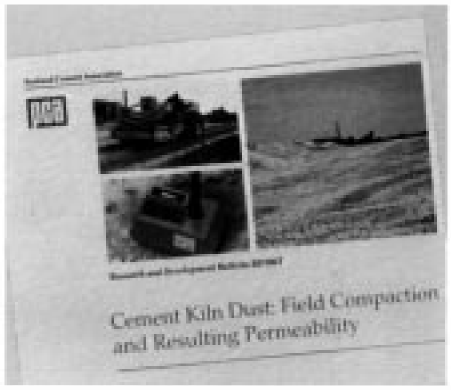
Optimization of Sulfate Form and Content, RD105T

The increased use of high-sulfur fuels in the cement industry during the last 15 years has resulted in a significant increase in sulfate in clinker (the product of a kiln, which is ground to make portland cement). Elevated clinker sulfate can cause a



drastic reduction in the amount of gypsum required to control C_3A hydration. Because the time of set of cement is largely dependent on this reaction, and high sulfur fuels are widely used, PCA was prompted to fund a research project that would optimize cement performance based on sulfate form and content.

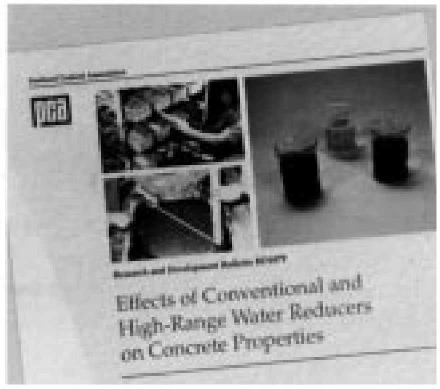
The study suggests that early aluminate hydration reactions can have a profound effect on cement paste flow and strength development. Chemical and physical forms of sulfates in cement can have a strong influence on these early reactions. According to researcher Fulvio J. Tang, author of the study, interground gypsum is more effective than interblended gypsum. The often-noted strength properties of high-alkali cements and their tolerance for higher sulfate additions were observed. Better control of the aluminate hydration up to 24 hours generally resulted in higher 28-day strengths. Low C_3A clinker responded positively to a wide range of sulfate sources (including anhydrite) as set-control agents. The resulting cements produced were found less sensitive to the effects of the soluble alkalies. The data also suggest that there is no single optimum sulfate level for strength development at all ages since sulfate level that showed highest one-day strengths did not necessarily provide best strengths at 28 days. Analytical techniques developed during this study helped to optimize gypsum addition—and increase strength—to yield cements of consistent performance, even for some problem cements.



Cement Kiln Dust: Field Compaction and Resulting Permeability, RD106T

Using a combination of laboratory and field trials, this PCA-funded research was performed to determine whether cement kiln dust (CKD) is compactible and if so, the permeabilities resulting from various degrees of compaction. Researcher H. Alan Todres found that densities of up to 105% of standard Proctor maximum could be achieved in the field. The best compaction results were obtained for lifts not exceeding a thickness of 6 in. (150 mm).

Field compacted specimens displayed an inverse relationship between density and permeability. The standard Proctor test was satisfactory for compaction control and for establishing a laboratory maximum dry density and optimum moisture content. A nuclear density gage accurately measured field density but not moisture content. Knowledge of moisture content is essential for proper determination of dry density. Microwave drying was found to provide reliable results in less than 10 minutes, so it is accepted and recommended as an alternative to conventional oven drying. Both chemical and physical analyses of the CKD are provided along with a photographic review of the project. This follow-up to *Cement Kiln Dust Management: Permeability,* RD103T, announced last year, is a timely report as environmental regulations continue to emphasize the safe disposal or management of CKD.



Effects of Conventional and High-Range Water Reducers on Concrete Properties, RD107T

High-range water reducers (HRWR) or superplasticizers are most useful in producing highly workable concretes, but less effective when specified solely to reduce a mix's cement and water contents, this recent PCA research report contends.

Researchers David Whiting and Willy Dziedzic used conventional and second generation high-range water reducers to reduce water contents by 8% to 9% and by 15% to 16%, respectively. Testing included slump loss, air loss with time, setting time, and bleeding.

Similar tests were carried out on flowing concretes, where cement and water contents were maintained constant and HRWR admixtures were added to increase slump levels to 175 mm to 225 mm (7 in. to 9 in.). In this series, testing was carried out at temperatures of both 23°C (73°F) and 32°C (90°F). Hardened concrete specimens were tested for freeze-thaw resistance, resistance to deicer scaling, permeability to chloride ion, drying shrinkage, and compressive strength development. Air-void systems were analyzed by linear traverse.

Use of chemical admixtures to reduce both water and cement contents resulted in accelerated rates of slump loss and shorter working times compared to control mixes. When used to produce flowing concretes, working times were equivalent to those for mixes without the admixtures. In general, setting times were increased from 1 to 2 hours at 23°C (73°F) and by lesser amounts at

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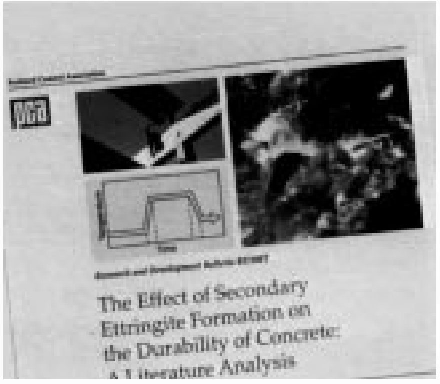
32°C (90°F) . Bleeding of flowing concretes was greater than that of control mixtures. Rate of air loss was significantly greater in cement-reduced mixtures containing HRWR chemicals compared with controls; however, air loss rates in flowing concretes were roughly equivalent for all mixtures tested. Drying shrinkage was moderately increased in these concretes.

The Effect of Secondary Ettringite Formation on the Durability of Concrete: A Literature Analysis, RD108T



In this study funded by PCA, The University of Calgary's Professor of Civil Engineering, Robert L. Day, reviews and analyzes the available literature pertaining to the causes, effects, and prevention of secondary (delayed) ettringite in concrete. Case studies of probable damage to concrete due to secondary ettringite formation were examined first. Fundamental research on secondary ettringite formation, its chemistry, and deposition mechanisms were then reviewed. Key investigations on the topic are analyzed in detail. Next, the potential importance of (a) method of heat-curing, and (b) the chemistry of cement are outlined. In the final chapter, a rapid test for evaluation of potential secondary ettringite susceptibility—the Duggan test—is evaluated.

The analysis indicates a potential for a secondary ettringite formation problem in heat-treated concrete, but it may involve only a small fraction of the total precast concrete in North America. However, it is unlikely secondary ettringite formation is, or will be, the sole mechanism responsible for premature deterioration. The critical factors that determine extent of damage are (a) duration of delay period before heating the concrete, (b) severity of the heating and/or cooling regime, and (c) the SO_3–Al_2O_3 ratio of the cement. There is no evidence that non-heat-treated concrete is susceptible to this phenomenon.

PUBLISHER'S NOTE:
Intended for decisionmakers associated with design, management, and construction of building projects, *Concrete Technology Today* is published triannually by the Construction Information Services Department of the Portland Cement Association.

Our purpose is to show various ways to use concrete technology to advantage and how to avoid potential problems. If there are problems or ideas 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.

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