CONSIDER THE CURE – PART ONE: FACTORS AFFECTING PROPER CONCRETE CURING PRACTICES

BY TERRY SWOR, PG, AND GERARD MOULZOLF, PG – AET SAINT PAUL

Thanks to this past brutal winter, many of you are noticing scaling or mortar flaking in new exterior concrete flatwork such as sidewalks, driveways, parking lots, and curbs and gutters. This superficial deterioration can be the result of many factors, including inadequate concrete curing.

Proper concrete curing involves providing and/or maintaining adequate moisture and temperature to permit the portland cement in the concrete mix to properly hydrate and gain strength with time. The freeze-thaw durability of concrete is dependent upon three factors: 1) the incorporation of fine air voids (air entrainment) in the concrete, 2) proper finishing, and 3) curing for the development of durability strength. These factors result in beneficial properties that maximize water-tightness, freeze-thaw durability and volume stability.

It’s important, however, to note; Curing is the final step in the nearly 70-step, highly complex process of concrete production and placement. As in any process, missing or poorly performing any step can negatively impact the outcome (i.e., finished concrete) in terms of appearance and sustainability.

Proper curing is not only necessary; it’s critical. Still, proper curing practices are often overlooked due to a number of factors such as scheduling, environmental constraints and aesthetics. Granted, these factors present some very hard choices on the part of the construction team/owner.

Environmental conditions

The Upper Midwest’s typical early-winter weather and its potential for numerous freeze-thaw cycles can wreak havoc on early-age concrete, especially that which isn’t properly finished and cured. Design concrete strength, which at 4500 psi is the minimum strength specified to resist repetitive freeze-thaw cycles, can be attained under proper ambient conditions at 28 days; the longer the curing process, the greater likelihood of reaching the design strength. However, the practicalities of modern construction scheduling do not permit a 28-day curing interval. Not incorporating plans for providing the best finishing and curing at the time of your work may prove costly if winter weather comes early.

Early-age concrete that reaches its design strength may still be relatively porous. As a result, design strength doesn’t necessarily equal durability strength. Concrete requires additional time for the complete hydration of the cement to fill pore spaces and capillaries, which, if unfilled, can represent avenues for significant moisture infiltration.
Plan for Emissions Test | continued from page 1

agencies are diligent about making sure each plant adheres to strict operational requirements. Depending on the nature and location of a plant, agencies may require testing of plant emissions every two to five years.

During an air emissions stack test (also called a performance stack test), highly trained test professionals collect or continuously analyze samples of the stack’s gas stream. Through a combination of detailed test methodologies and specialized equipment, these professionals are able to assess a facility’s compliance with permit requirements. The results of an air emissions stack test can impact a plant’s future operating conditions—and the entire operation’s bottom line. But plant owners need not worry: a little planning can go a long way toward a successful stack test. Here’s how:

1. Develop a solid understanding of permit requirements—before construction begins

Plant owners who know their permit requirements through and through are able to recognize two very important details: 1) which of the plant’s processes need to be tested, and 2) how often the tests need to occur.

Having this information during the plant’s design phase helps owners accommodate the proper placement of sampling locations and sample ports. Installed directly in the plant’s ductwork, sample ports provide a way for testing equipment to access the stack’s gas stream. The design and location of these ports are based on the pollutant to be tested, the duct configuration, and the requisites of the specific test methodology. Access to these sample ports is usually achieved via permanently installed ladders and platforms, temporary scaffolding or lift equipment.

Plant owners who aren’t fully aware of permit requirements are often placing themselves at risk for making expensive, last-minute modifications to plant infrastructure once regulatory deadlines draw near. The location of sampling ports could have been addressed during the design phase.

2. Record process data correctly

Understanding permit requirements also gives plant owners an understanding of how process data should be recorded. The types of process data required by state agencies ranges from production numbers to amperage of motors to frequency of maintenance. Most permits require documentation of nearly every plant process—and a level of detail that goes beyond numbers. The bottom line: Plant owners should be certain the data they’re collecting is sufficient for meeting permit requirements.

3. Talk to your testing firm

When it comes to understanding permit requirements and process data, plant owners should be sure to have a conversation with their testing firm. For instance, we at AET often perform pre-test site visits for our clients to make sure permit requirements are met. If things aren’t as they should be, we’re able to proactively work with the plant owner to make corrections ahead of regulatory deadlines.

4. Establish site-specific test protocol

Regulatory agencies require a site-specific test protocol (typically prepared by the testing firm and submitted for regulatory agency approval) that documents the following: the source to be tested; conditions under which the source and control device, if any, will be operated; and operational parameters for both the source and control device. The protocol also details pollutants to be tested, sampling locations and test methods. Any test modifications must be pre-approved by the agency as part of the test protocol.

Most agencies require that test protocols be submitted 30 days prior to the test date, but this requirement varies from state to state. For certain federally mandated performance tests, the submittal may be as far out as 60 days.

While these tips are a good place to start, plant owners should always consult with their testing firm about their specific situation. Planning ahead for air emissions stack tests is not only good for plant operations but also for helping emissions stay within accepted limits. And that’s good for generations to come.

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Consider the Cure | continued from page 1

intrusion leading to saturation. The critical saturation of this paste can overwhelm even properly air entrained early-age concrete. In addition, research and experience suggest that concrete given time before winter to significantly dry after proper curing will perform better in real-life durability testing.

Aesthetic requirements

Concrete can be cured through the use of water and various chemicals called curing compounds/sealers (we’ll discuss the properties of each in part two of this article). Certain curing practices can affect the appearance and wear resistance of the finished concrete. For example, the use of polyethylene, burlap, or a combined product called “burlene” can result in color variations, termed “tiger striping,” to the finished concrete when differential drying has occurred. Likewise, some departments of transportation may specify the use of a curing compound for their roads and bridges, which is very effective for curing, but its potential for non-uniform color and wear is not aesthetically acceptable for most other commercial and residential applications.

Timing

Curing should take place immediately after concrete is placed and finished; not hours later, and certainly not on the following day. It is critical for early-age concrete to be subjected to moisture and temperatures above 50 degrees Fahrenheit for appropriate strength gain. Low humidity and even a slight wind can quickly compromise surface paste and result in a network of fine, random surface cracks, known as “crazing cracks,” which generally occur within 24 hours after placement. Furthermore, if the concrete dries

Carbonation (unstained paste) proceeds up to 3 mm deep in 1 day to pH indicator. Note sub-horizontal microcracking (incipient intrusion leading to saturation. The critical saturation of this paste can overwhelm even properly air entrained early-age concrete. In addition, research and experience suggest that concrete given time before winter to significantly dry after proper curing will perform better in real-life durability testing.

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When fully completed next year, the Wayzata Bay Center Redevelopment project, which includes the Regatta Condominiums, will be a stunning addition to the downtown Wayzata, Minnesota, waterfront.

The $225 million project, which broke ground in 2012, has involved the redevelopment of an outdated shopping mall to a 14.5-acre mixed-use development with condo, senior housing, office, retail, and structured parking spaces.

This task alone is no small effort; however, the project’s real challenge lies beneath its eye-catching structures: The site was once a wetland.

As a project team member, American Engineering Testing (geotechnical, environmental, and construction testing services) has had the privilege of tackling this challenge with engineers Ericksen Roed & Associates (structural) and LHB (civil); general contractor Adolfson & Peterson Construction; L.H. Bolduc Co. (piling); InSite Architects; BohLand Development; Weis Builders; Cuningham Group (architect); BKBM Engineers (structural for Regatta Condominiums); and Senior Housing Partners.

The poor, compressible soils have inspired the team to devise complex engineering solutions—the most notable of which may be the site’s vast network of foundation piling. To prevent the new construction from shifting and settling (a major issue with the site’s previous development infrastructure), the entire development—including roadways and sidewalks—was built on top of piles. More than 2,800 piles have been driven to date, essentially creating a giant land bridge. AET’s on-site technicians must observe the installation of each pile—a role AET has filled for the past two years.

With its diverse expertise and plenty of collaboration, the project team was also able to address another significant challenge: how to allow the site’s pile-supported buildings and infrastructure to “mesh” with the non-pile-supported infrastructure of adjacent sites. To control movement at critical transition areas, the team adopted an innovative system of flexible utility connections and hinged roadway and sidewalk slabs.

Emphasizing “green” initiatives, the project’s Stormwater Management Plan was developed to capture stormwater rather than send it off-site. Stormwater is being captured below the street in designated sand bed basins throughout the site. This allows the water to infiltrate back into and help recharge the groundwater table.

This portion of the project is on track to be completed by spring of 2015.

Tom Venema is a principal engineer and vice president in AET’s Construction Services Division. He can be reached at tvenema@amengtest.com.

AET performed soil probes ahead of pile driving to account for soil variations in November 2012.

A freshly sawcut and lapped cross section of concrete exposed (scaling) within the carbonated paste. Carbonated paste (low pH) is not freeze-thaw resistant.
AET UPDATES

New Employees Mar. - Jun. 2013

Tyler Boley
Nicholas Chouanard
Gene Erzar, PE
Walt Feeger, PE
Jessica Foster
Alex Grenell
Doug Trangsrud, PE, has re-joined AET as our St. Paul Construction Services Mgr.
During this time we also hired 49 temporary and seasonal staff members—welcome!

Promotions and Certifications

Dave Fitterer – NDT Division Manager
Taryn Kuusisto – Professional Engineer

On the Move

Tom Venema, PE - Principal Client Mgr.
Mike McCarthy, PE - Principal Client Mgr.
Brian Arman - Senior Project Mgr.
Jim Miller - Supervisor of AET’s Albertville regional office

AET in the News

Gregory Reuter, PE, PG, D.GE, principal engineer in AET’s Geotechnical Division, co-authored a paper with Dr. Gianni Togliani, a geotechnical consultant from Massagno, Switzerland, that was published in the proceedings for the 3rd International Symposium on Cone Penetration Testing held in Las Vegas, Nevada, on May 13-14. The title of the paper is “CPT/CPTu Pile Capacity Prediction Methods – Question Time.”

See Us at These Upcoming Events

“Learn what to do about moisture in concrete slabs” with John Amundson, PE
Jul. 18, Chippewa Falls, WI
EDAM Wayzata Bay Center Project Event
Jul. 24, 3:00 PM – Wayzata, MN
MNCREW Golf Event – Aug. 5
MnSPE Golf Event – Aug. 7
FHWA Midwest Regional Geotech. Conf.
Oct. 1-3 – Bloomington, MN

Employee Spotlight – Andrew Walters, PE

Andy Walters, a geotechnical engineer in AET’s Wausau office, recently completed ACEC WI’s Future Leaders Institute program, which involved a six-session leadership and career development series for upwardly mobile leaders of the engineering industry. Andy says he feels privileged to have had the opportunity to attend the program, and is looking forward to putting his new skills to work in his role at AET.

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