

TENNESSEE

Winter 2014/15  
VOL. 28, NO. 3

# CONCRETE

MAGAZINE



## CONCRETE COMMUNITY SERVICE:

Helping Raptors and the Upper Cumberland Area

—See page 8

## A CHEAPER ESTIMATE OF

Concrete Heat Evolution Due to Hydration

—See page 10

*Helping Design Dreams  
...Become Reality*

**STALITE**   
ROTARY KILN EXPANDED LIGHTWEIGHT AGGREGATE

**Is  
Strongly Superior**

800-898-3772  
[www.stalite.com](http://www.stalite.com)

Tennessee Concrete is published for the Tennessee Concrete Association—

705 Fort Negley Court  
Nashville, TN 37203  
Phone: 615-360-7393  
Fax: 615-360-6670  
Website: [www.tnconcrete.org](http://www.tnconcrete.org)

**Publisher:**

The KaHoy Group, LLC

**Editor:**

Alan Sparkman

**Advertising Director:**

Morris Woods

**Art Direction:**

Ventura Group, LLC

For advertising rates and information, contact Morris at 800.315.9950 x602.

Subscriptions in US, free upon request. Outside US, \$12 per year. To subscribe, contact TCA at the above address.

Articles appearing in Tennessee Concrete are frequently contributed by outside, independent sources. Conclusions drawn from these articles may be at variance with the opinions of our readers.

Tennessee Concrete welcomes response and rebuttal and will make every effort to print these responses. Send comments to: Editor, Tennessee Concrete, 705 Fort Negley Court, Nashville, TN 37203.

Tennessee Concrete and its publishers assume no liability for errors or omissions in articles or advertisements appearing in Tennessee Concrete.

**© 2015 The KaHoy Group, LLC**

All rights reserved. The contents of this publication may not be reproduced by any means, in whole or in part, without the prior written consent of the publisher.

# contents

Winter 2014/15 VOL. 28, NO. 3



## 4

### **PRESIDENT'S COLUMN**

CONTINUING TO WORK HARD

by Derris Johns



## 6

### **DIRECTOR'S COLUMN**

MARKED IMPROVEMENT, NOW WHAT LIES AHEAD

by Alan Sparkman



## 8

### **CONCRETE COMMUNITY SERVICE**

HELPING RAPTORS AND THE UPPER CUMBERLAND

by L. K. Crouch, Jason E. Miller, Aaron Crowley, and Alan Sparkman



## 10

### **A CHEAPER ESTIMATE OF CONCRETE HEAT DUE TO HYDRATION**

by L. K. Crouch, Aaron Crowley, Daniel Badoe, Tony Greenway, Robert Craven and Heather P. Hall



## 18

### **CIM UPDATE**

CIM WELCOMES JASON CRABTREE, THE NEWEST ADDITION TO OUR STAFF

Dr. Heather J. Brown



**Derris Johns**  
2014 TCA President

I have seen firsthand the value of being an active member of the Tennessee Concrete Association ...I gained big benefits for my business. I strongly urge every member to step up and become an active member...you have nothing to lose and everything to gain!

# CONTINUING TO **WORK HARD** TO INSURE OUR SURVIVAL

It has been a privilege and reward to serve as a TCA board member since 2009 and to serve as the 2014-15 TCA President. Before serving in this capacity, I would have never volunteered my time or energy to help my industry but I have seen firsthand the value of being an active member of the Tennessee Concrete Association and not just a dues payer. What I discovered was that in the process of helping my industry, I gained big benefits for my business. I strongly urge every member to step up and become an active part of our association. You have nothing to lose and everything to gain!

Just as each of us have endured the past few years of lean times and uncertainty in our business while continuing to work hard to insure our survival, your Executive Director and TCA staff have stayed the course and never swayed from their duties despite the uncertain times. In 2014 we saw our industry begin to recover and we continue to see recovery going forward in both the residential and commercial markets. In 2014 we also saw important results from the persistent effort of our TCA staff and many of our committed TCA members over the past few years.

We made great progress with TDOT in terms of making the acceptance and testing process more fair for ready mix producers and we have improved the effectiveness of our working relationship with the Department. Your participation as a member in the regional and statewide TDOT meetings is a big part of preserving these gains and making future improvements possible.

TCA's long-term engagement with the design community, state regulators and contractors are

also paying dividends as the pace of work picks up. Your TCA staff continues to represent our industry and advocate for the increased use of concrete with all of these folks, and our TCA Campus has become well-known as a great place to visit when you need to learn more about concrete. Your support of TCA with your membership and your time make this kind of accomplishments possible.

All of us know what it's like to lose a valued employee that has worked with us for many years and has become like a family member. TCA is not immune from this and we will be saying good-bye to Sarah Egan as a fulltime employee at the end of December. Sarah has been with the TCA staff for over 10 years and she has been a huge asset to the organization. During her tenure at TCA she has placed and finished all kinds of concrete and she is one of only two female certified Precast Concrete Installers in the US. Many of us count Sarah as a friend and her relationships around the construction industry have been very valuable to TCA's efforts over the past decade. She will truly be missed but we wish her the very best on all her future endeavors.

Sarah will be helping out on a limited basis through the 2015 Annual Convention (February 18-19) and the 2015 Convention will mark her last event with us. Please join me in attending the 2015 Convention and let's all get together to show her our support and how much she will be missed.

Thank you for allowing me to serve as your TCA President.

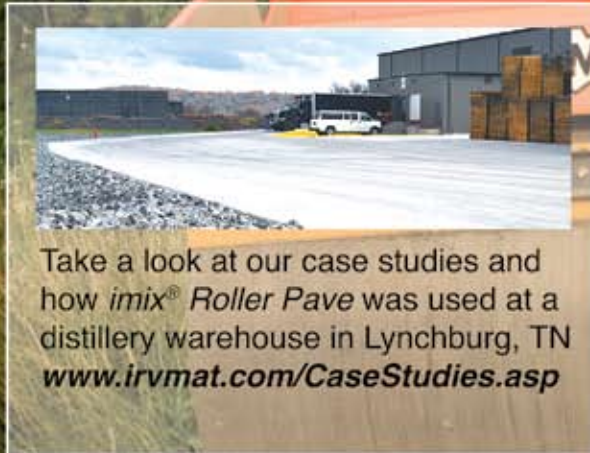
*Derris Johns*



## Roller Compacted Concrete

For heavy traffic and large rolling equipment

More durable than asphalt, high compressive strengths



Take a look at our case studies and how *imix*<sup>®</sup> Roller Pave was used at a distillery warehouse in Lynchburg, TN  
[www.irvmat.com/CaseStudies.asp](http://www.irvmat.com/CaseStudies.asp)

Placed with a paver, not forms, and roller compacted.

- Minimal down time
- Maximum strength

*imix*<sup>®</sup> Roller Pave's high density and low absorption allows very little moisture to penetrate the surface, greatly reducing the possibility of potholes due to freeze/thaw cycles.



2617 Grandview Avenue  
Nashville, TN 37211

For more information on *imix*<sup>®</sup> Roller Pave, or to talk to one of our Tennessee representatives, contact us **615-884-4935**

[www.irvmat.com](http://www.irvmat.com)



**Alan Sparkman**  
Executive Director

As I look toward 2015 and toward the end of the second decade in this new century, I do so with an overall sense of optimism about what the future holds for the concrete industry....

# MARKED IMPROVEMENT

## ...Now what lies ahead

**2014** has rapidly drawn

to a close and we can look back on a year that brought marked improvement to our industry in terms of increased construction activity and a positive climate for construction and concrete heading into 2015.

The end of a year is often a time that we pause and ponder what lies ahead in the coming year. As I look toward 2015 and toward the end of the second decade in this new century, I do so with an overall sense of optimism about what the future holds for the concrete industry, especially here in Tennessee.

We are already seeing this play out in Middle Tennessee—a recent article in *Engineering News-Record* reported that the current level of construction in the Nashville area is valued at approximately \$2 billion. This is a level higher than before the Great Recession and the level is expected to increase going forward.

While this substantial recovery for our industry is positive, the increase in business brings challenges as well as opportunities. How our industry responds to those challenges and opportunities will determine the character of our future for the coming decades. Will we take advantage of the increased opportunity to improve and elevate our industry to a professional part of the construction industry, or will we just repeat past mistakes and find ourselves mired in a high-risk, low-profit culture that dooms us to commodity status?

The answer is yet to be written and it is not a simple Yes/No question. We have seen our industry go through many recovery cycles without seeing a substantive change in our industry culture. I believe that this recovery offers a far greater opportunity than most recent economic recoveries for

our concrete industry to truly become more professional, more profitable, and more respected.

My reason for this belief actually can be found in the nature of the challenges that we face as we seek to build our capacity to take advantage of new opportunities. Building capacity—or growing your company—used to be reasonably straightforward. As business opportunities increased the demand for concrete in your area, you added new equipment (like mixers) and you hired people to drive them. Suppliers were happy to sell you more raw materials, and the supply of those materials was generally plentiful, especially on the front end of the recovery.

As we enter 2015, the equipment question is more challenging because the market for good used equipment is extremely tight and the cost of new equipment is shocking (primarily because we haven't bought any new equipment for five or six years). The equipment problem is compounded by the fact that lending standards are noticeably tougher than in the past and most industry companies have seen balance sheets and equity shrink as a result of the severe recession.

The raw materials issue is also more complex. Prices of our primary materials didn't drop much in this recession and they are escalating more rapidly than in most past recoveries. Because this recovery has been so long in coming, there isn't the same excess capacity in most of our raw materials sources and we are seeing not only rising prices but also supply constraints that aren't typical this early in a recovery. Add in the uncertainty we are seeing with fly ash supplies and one can see that simply sourcing materials to produce more concrete is not as easy as it once was.

Both the equipment and the materials challenges pale in comparison to the people challenge. A new mixer and a large stockpile don't help when you

can't find anyone to operate the mixer. This is perhaps the largest single challenge facing our industry today and it's not likely to get better going forward. By the way, all trucking businesses face these same issues and that means its going to be tougher to get your raw materials delivered and you will be competing against your materials suppliers for a dwindling supply of drivers.

We normally think of constraints as being negative and there are some negative aspects to the dwindling supply of drivers. For many producers today, the amount of concrete they can actually deliver is being constrained by the shrinking supply of drivers. Unlike constraints we have experienced in the past due to materials shortages, I believe the driver constraint will become a permanent constraint on our industry's capacity. But in the magnitude of this challenge we find an opportunity to permanently elevate our industry.

The reality is that constraints also deliver benefits for those able to perceive and act on the new opportunities created by the constraints. I contend that the new and significant constraints we are experiencing are actually forcing a transformation of the ready mix business from a commodity business to a specialty marketplace. Many will argue that concrete has been and will remain a commodity. (For the record, I don't agree that we have always been a commodity!) Here's the key point that is being highlighted by the new reality, concrete delivered to a specific project is never generic when you consider the time factor! Besides the specifications that usually differentiate concrete mixes, every load of concrete must be scheduled to arrive at a specific time and place. The constituent materials in the concrete may be generic, but an individual load of concrete really isn't. What makes that individual load of concrete a real specialty will increasingly be whether or not a particular ready mix producer has the ability and capacity to deliver that individual load at the specific time. As long as we don't have enough drivers to satisfy the increasing demand generated by a recovering economy—at the specific time desired by the customer—no individual load of concrete should be considered as a commodity.

As our industry considers the new landscape in front of us, we have a great opportunity to hit the "Pause" button and take a fresh look at our business model. We need to understand that many ready mix producers will be forced to make choices about the customers they will choose to service because of driver constraint, and possibly other constraints from our primary materials. Contractors will most likely be facing similar choices about who they choose as clients due to labor constraints in their world, and your materials suppliers may be evaluating you as a customer for the same reasons. In short, this new landscape of constraints brings with it a much-enhanced opportunity for choice about your customers. To quote from of the Indiana Jones movies: "Choose Wisely!"



**Dennie Underwood**  
**(865) 453-4433** (phone)  
(865) 428-6083 (fax)  
(865) 654-2912  
— 1225 Parkway —  
Sevierville, TN 37862



**NUDURA**  
INTEGRATED BUILDING TECHNOLOGY  
Building Value.

Since 1979, SICALCO, LTD. has been your source of liquid and dry calcium chloride products manufactured from the Occidental Chemical Corporation.

We specialize in presenting customer solutions for concrete acceleration, dust control, ice control, enhanced aggregates, and base stabilization.

How can we help service your current and future needs?



Contact Our Service Center at 800-435-1919  
or General Offices 630-371-2655 for Customer Service

## Commitment by Lafarge

Lafarge isn't merely a producer of raw materials, but the producer of materials that make up the composition of our lives - where we live, work and play.

We hold dear the safety and development of our employees, satisfaction of our customers, harmony with our communities and respect for the environment.

We use natural resources in innovative ways to help construct the building blocks that are required to enhance, protect and sustain human life.

Tim Langelier, Middle TN  
615-330-1776 [tim.langelier@lafarge-na.com](mailto:tim.langelier@lafarge-na.com)

Bob Elliott, West TN  
901-652-6935  
[bob.elliott@lafarge-na.com](mailto:bob.elliott@lafarge-na.com)



© 2013 Lafarge North America Inc., Chicago, IL

by L. K. Crouch, Jason E. Miller, Aaron Crowley, and Alan Sparkman

# CONCRETE COMMUNITY SERVICE:

## Helping Raptors and the Upper Cumberland Area

**B**urgess Falls State Natural Area keeps two non-releasable birds of prey for wildlife education. The birds were badly in need of a new dwelling. Their previous dwelling had a crushed limestone floor which was extremely hard to clean. A less than sanitary floor could damage the birds' health in the long term (and deprive local folks of one of the more fun parts of their education). Burgess Falls Park Manager Bill Summers approached TTU Civil Engineering Concrete Materials folks and asked if we could help. Fortunately, not only do we like concrete (in the extreme) but we also know some people that can be quite helpful.

Burgess Falls Park Rangers found the birds a temporary home, demolished the current structure, and leveled the site. Mark Davis, TTU Civil Engineering Technician, took the lead on forming and grading the base for the new concrete floor for the bird enclosure. Mark was assisted by TTU Civil Engineering students Steven Salaman, Eric James and Aaron Crowley. TTU Concrete Materials folks typically research new concrete mixture designs and measure engineering properties in the laboratory for the Tennessee Department of Transportation and/or the Tennessee Concrete Association. Field placements are not part of our normal routine. Alan Sparkman, executive director of the Tennessee Concrete Association, who is very experienced with concrete field placement, was contacted. Mr. Sparkman was ideal for the job for a variety of reasons as he is a board member for Tennessee Parks and Greenways Foundation, has all the necessary tools and has long supported TTU concrete research.

The floor slab was placed on Monday, November 25, 2013, by TTU Civil Engineering Concrete Materials Graduate students Aaron Crowley and Lee Rogers under the direction of Alan Sparkman (see Figures 1 and 2). The slab was cured with plastic and straw for one week. The new slab is 25-feet in length, 11-feet wide, and 4-inches deep. The new slab is now conveniently sloped 1-inch in the 11-foot direction for easy cleaning with a garden hose. Burgess Falls Park Rangers recycled many of the components from the previous enclosure to construct the new enclosure economically and quickly (see Figures 3 through 6). Thanks to the "The Friends of Burgess Falls" for volunteering time to paint (see Figure 7).

### AUTHORS

L. K. Crouch, Ph.D., P.E. is a professor of Civil Engineering at Tennessee Technological University.

Jason E. Miller is a Park Ranger 2 at Burgess Falls State Natural Area

Aaron Crowley, M.S., E.I. is a civil engineering doctoral student at Tennessee Technological University.

Alan Sparkman, CAE, LEED AP is executive director of the Tennessee Concrete Association.



**Figure 1. Placement:** from left Mark Davis, Aaron Crowley, Alan Sparkman, Lee Rogers, L. K. Crouch, Jason E. Miller



**Figure 2. Finished Slab**





**Figure 3. Frame Construction**



**Figure 6. Nearly Completed Raptor Shelter**



**Figure 4. Further Frame Construction**



**Figure 5. Sheathing Installation**



**Figure 7. Burgess Falls State Natural Area Raptor Shelter with Construction Crew: Bill Summers, Mark Davis, Aaron Crowley, L. K. Crouch, Lucy Caruthers, Jason E. Miller, Heather Ferrell, Alan Sparkman, Erin Strauss, and Nat Garrison (not pictured Lee Rogers)**

# A CHEAPER ESTIMATE

## of Concrete Heat Evolution Due to Hydration

### INTRODUCTION AND BACKGROUND

In early 2012, the Tennessee Department of Transportation (TDOT) Divisions of Materials and Tests, Structures and Construction sponsored a project entitled “Development of TDOT Class S-LH (lower heat) Concrete Mixture”. The TDOT project is still in progress but the authors would like to share some of the results obtained thus far.

American Concrete Institute Report 207.1 (1) indicates that mass concrete causes a potential for significant temperature differentials between the interior and outside surfaces of the structure. Volume changes and restraint result in tensile strains and stresses that may cause cracking detrimental to the structure. A 2002 Concrete International article (2) indicated that “mass concrete” required a least dimension greater than 3-feet using a mixture that contained more than 564-lbs/CY of cementing materials. TDOT commonly uses many such structural elements but has no low heat of hydration mixture specifications. The current study builds on the findings of an unpublished 2004 Tennessee Technological University (TTU) study requested by TDOT Materials & Tests Division and Region 4 on heat of hydration at the Hernando Desoto Bridge in Memphis.

2006 TDOT Standard Specifications (3) Section 604.03 (Class S) requires a minimum cementing materials content of 682-lbs/CY and only allows 25% fly ash (or 35% slag) substitution for Portland cement. A PCC mixture meeting this specification has the potential to generate a lot of heat and induce thermal cracking in structural elements. The purpose of the study is to design a mix that reduces the heat generation of TDOT Class S PCC while maintaining satisfactory values of other engineering properties.

This paper focuses on one aspect of the study that addresses methods to estimate and compare concrete heat generation due to hydration. The target audience is ready mix concrete producers. However, the authors hope that other members of the concrete industry may also find it helpful.

### METHOD 1 SEMI-ADIABATIC CALORIMETRY

The Calmetrix F-Cal 4000 records the temperature of concrete in four 4x8-inch cylinder molds. The device is shown in Figure 1. Unfortunately, there is no current AASHTO or ASTM method for semi-adiabatic (somewhat insulated) calorimetry of concrete mixtures. The device records temperatures every minute for approximately seven days (depending on battery life). The manufacturer’s guide recommends comparing the temperature

trace plots for evaluation.



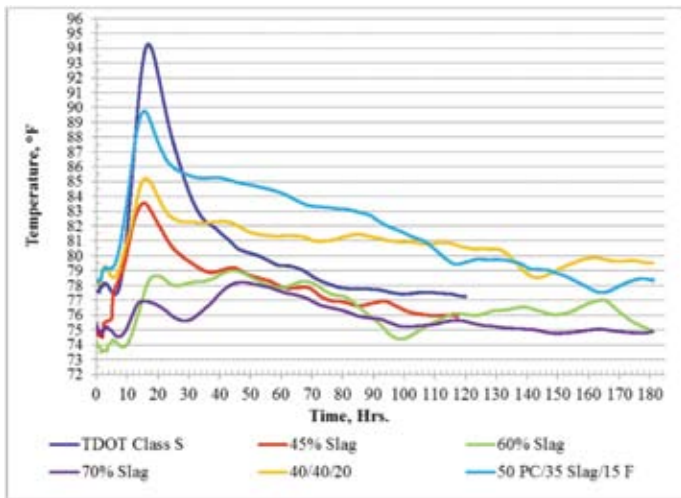
Figure 1: Calmetrix F-Cal 4000 Field Calorimeter for Cement / Concrete Professionals

### EXAMPLE OF USE: INITIAL SCREENING OF TDOT PROJECT LOWER HEAT MIXTURES

Three batches of four 4x8-inch cylinders were evaluated for each mixture in the device. The research team, with no ASTM or AASHTO guidance, decided to pay particular attention to the rise from initial temperature to maximum temperature. In hindsight, it may have been wiser to evaluate three samples of concrete and compare the rise to one cylinder of water. The mean temperature traces (average of 12 4x8 cylinders) for each mixture are shown in Figure 2.

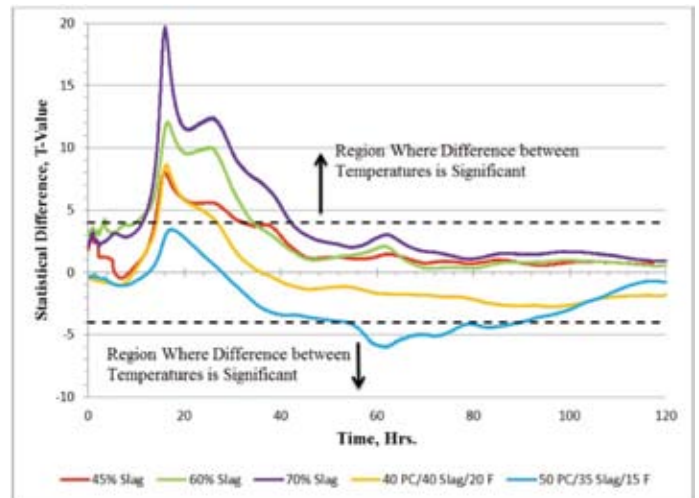
**TABLE 1. METHOD 1 SEMI-ADIABATIC CALORIMETRY SUMMARY**

Test Parameter	
Sample Size	4x8-inch cylinder (~ 0.06 cubic feet)
Number of Samples	4
Field or Lab	Either
Hardware / software requirements	Built-in nothing additional
Output	Spreadsheet file
Sampling Frequency	60 seconds
Recording Time	About 1 week
Cost	Approximately \$5000
Main Advantage	Ease of operation / clean up
Main Disadvantage	Small Sample size



**Figure 2: Mean Temperature Traces for TDOT Class S and Class S-LH Mixtures**

Figure 3 shows the statistical differences from comparing the mean temperature traces of candidate lower heat mixtures to the mean temperature trace of TDOT Class S mixture. A Student's t-test was utilized to test for the difference in temperature means of the S-LH candidate mixtures to the TDOT Class S mixture. A 5 percent level of significance was used for the test and the results are shown graphically in Figure 3. The dashed lines represent the critical t-values beyond which the temperature differences between the S-LH candidate mixtures and the TDOT Class S are statistically significant. For t-values exceeding t-critical, the greater the t-value, the greater the difference between the mean temperatures of the mixtures. The S-LH candidate which has the longest duration of significant temperature difference from TDOT Class S and which also has the largest temperature difference from TDOT Class S at any time is clearly S-LH with 70% slag.



**Figure 3: Statistical Difference in Mean Temperature Traces of Candidate S-LH Mixtures Compared to TDOT Class S Mixture**

## METHOD 2 FIELD TESTING WITH AUTONOMOUS TEMPERATURE SENSORS

The TDOT project field tests were conducted on Wednesday 8/07/13 at the TTU's School of Agriculture Farm near Cookeville, TN. Two earth-formed cubical cavities were excavated. Each cavity was approximately 8-feet in the x, y, and z dimensions. Autonomous temperature sensors were placed on a No. 3 rebar frame inside the excavations. An excavation with rebar frame and temperature sensors is shown in Figure 4. Temperature sensor quantities and locations are shown in Figure 5. A close-up of the temperature sensors in-place is shown in Figure 6.



Figure 4: Excavation with Rebar Frame and Temperature Sensors



Figure 6: Close-up of Temperature Sensors In-place

Autonomous temperature sensors (reading every 30 minutes for 56-days) were placed on a No. 3 rebar frame inside each excavation. All sensor locations used at least two temperature sensors and the geometric center used three sensors to minimize the possibility of data loss due to sensor malfunction. The amount of temperature data collected was extremely large (over 86,000 data points).

Figure 7 shows a comparison of maximum internal temperatures. As expected, maximum internal temperatures were recorded by the sensors at the geometric center of the excavations. TTU researchers reasoned that keeping the maximum concrete temperature below 150°F would help to prevent durability problems cited by Gajda (2) if temperature after placement exceeds 155 to 165°F. Class S-LH with 70% slag met the suggested requirement for maximum temperature in an 18-CY cube placement without benefit of pre-cooling of the mixture (by ice or liquid nitrogen). TDOT Class S did not meet the requirement. The maximum temperature produced by the S-LH was about 83% of the maximum temperature produced by the Class S.

Figure 8 shows the results of a hypothesis test of the equality of the mean temperatures taken in the two mixes over time. A Student's t-test is used to determine the validity of the null hypothesis of temperature means taken over time in the two PCC cube placements being equal. A 5 percent level of significance is used for this test. The results, shown in Figure 8, concisely depict Class S-LH with 70% Slag to be significantly cooler at early ages out to approximately 280 hours. The t-critical for the hypothesis test is shown in the dashed lines. Outside the region between the dashed lines, the greater the t-value, the greater the difference between the mean temperatures of the two mixes. Class S-LH with 70% slag produced a significantly lower maximum temperature than a TDOT Class S with 20% Class C fly ash in side-by-side 18-CY cube field placements.

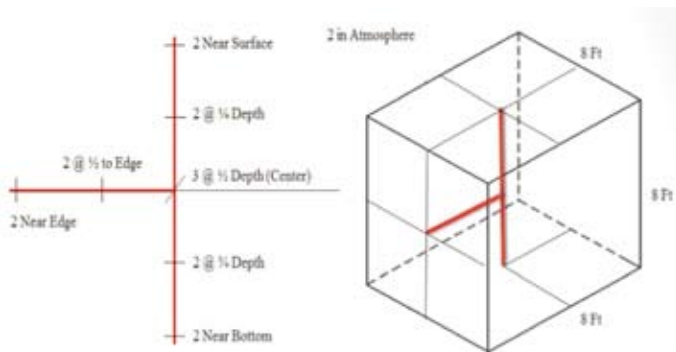


Figure 5: Temperature Sensor Number and Locations

**TABLE 2. METHOD 2 FIELD TESTING WITH AUTONOMOUS TEMPERATURE SENSORS SUMMARY**

Test Parameter	
Sample Size	8x8x8-foot (~ 18CY = 486 ft <sup>3</sup> ) excavations
Number of Samples	2 or more
Field or Lab	Field
Hardware / software requirements	Temperature sensor reader/controller
Output	Spreadsheet file
Sampling Frequency	30 minutes
Recording Time	56 days
Cost	Approximately \$10,000
Main Advantage	Real World
Main Disadvantage	Cost and finding a cooperative location

**TABLE 3. METHOD 3 PROPOSED METHOD USING 55-GALLON DRUMS SUMMARY**

Test Parameter	
Sample Size	55-gallons (7.35 cubic feet)
Number of Samples	2 or more
Field or Lab	Lab
Hardware / software requirements	Desktop or laptop computer with Windows 7 and one available USB port; National Instruments Signal Express 2010 or later
Output	Spreadsheet file
Sampling Frequency	30 seconds
Recording Time	200 hours or more
Cost	Approximately \$ 750
Main Advantage	Cheaper
Main Disadvantage	Barrel Disposal

**TABLE 4. FINAL SUMMARY COMPARISON OF CONCRETE HEAT EVOLUTION DUE TO HYDRATION**

Test Parameter	Semi-adiabatic Calorimetry	Field Testing with Autonomous Temperature Sensors	55-gallon Drums
Sample Size	4x8-inch cylinder (~ 0.06 cubic feet)	8x8x8-foot (~ 18CY = 486 ft <sup>3</sup> ) excavations	55-gallons (7.35 cubic feet)
Number of Samples	4	2 or more	2 or more
Field or Lab	Either	Field	Lab
Hardware / software requirements	Built-in nothing additional	Temperature sensor reader/controller	Computer with Windows 7 and one available USB port National Instruments Signal Express 2010 or later
Output	Spreadsheet file	Spreadsheet file	Spreadsheet file
Sampling Frequency	60 seconds	30 minutes	30 seconds
Recording Time	About 1 week	56 days	200 hours or more
Cost	Approximately \$5,000	Approximately \$10,000	Approximately \$750
Main Advantage	Easy / clean up	Real World	Cheaper
Main Disadvantage	Small sample size	Cost and finding a cooperative location	Barrel Disposal

Continued from page 12—

## A CHEAPER ESTIMATE OF CONCRETE HEAT EVOLUTION DUE TO HYDRATION

by L. K. Crouch, Aaron Crowley, Daniel Badoe, Tony Greenway, Robert Craven and Heather P. Hall

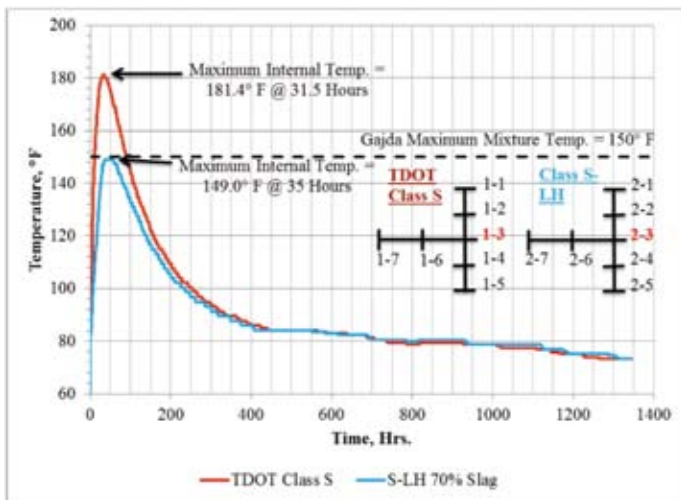


Figure 7: Comparison of Maximum Internal Temperatures over Time

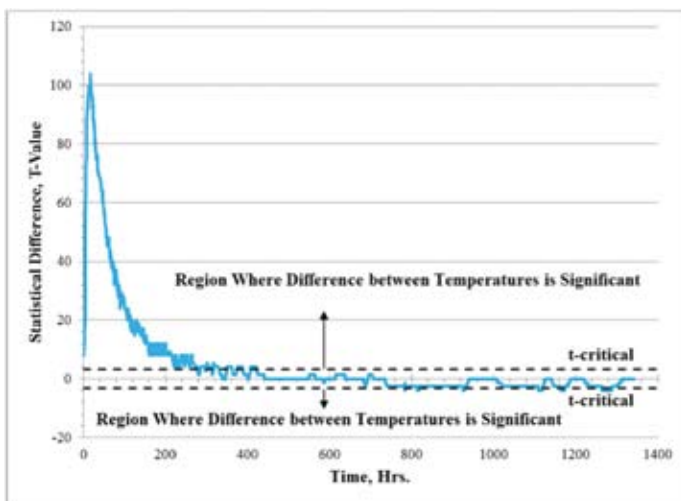


Figure 8: Statistical Difference between Mean Temperatures of TDOT Class S and S-LH with Time

### METHOD 3 PROPOSED METHOD USING 55-GALLON DRUMS

The research team wanted to do a test much larger than a 4x8-inch cylinder (used in the semi-adiabatic calorimeter) but avoid the expense of 18-CY cubes in the field. Figure 9 shows the compromise solution. Two fifty-five gallon drums were used (most PCC producers have 55-gallon drums readily available). Each drum had a thermocouple wire secured at the geometric center of the drum. One drum was filled with water and one drum was filled with the concrete being evaluated. The research team reasoned that the difference in temperature between the sensors would be due to hydration heat. The thermocouple output was sent to a

data acquisition system (see Figure 10) and subsequently stored on a computer hard drive. Temperatures were recorded every 30 seconds for approximately 200 hours. Large but not immense quantities of data were generated at a much lower expense.



Figure 9: Less Expensive "Field" Test for Heat of Hydration Comparison

### HARDWARE AND SOFTWARE REQUIREMENTS

Thermocouples were chosen as the temperature sensor because simply joining two dissimilar metals causes a voltage to be generated proportional to the temperature at the point of the junction. This makes for an inexpensive temperature sensor that can be readily left embedded in the concrete. There are three junctions in a thermocouple measuring system as shown in Figure 10 and there is an equation for each pair of metals (junction) in the system. If the temperature of the cold junctions at the data acquisition system is known, the voltage contribution of these two junctions can be compensated for to permit calculation of the temperature in the concrete. Fortunately all the equations, cold junction measurements etc. are built into the National Instruments thermocouple measuring system purchased for this study.

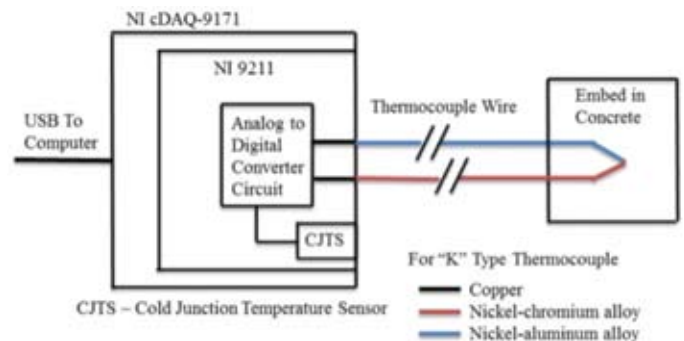


Figure 10: Three dissimilar metal forming three junctions for a thermocouple measurement system.

# Placing Pervious Concrete

Pervious Concrete Allows Rainwater to seep into the ground. It is instrumental in recharging groundwater and reducing storm water runoff.



**Pervious is a Special Mix...  
It Requires Special Tools to Place It**

## WILDCAT ROLLER SCREED

**M  
U  
L  
T  
I**

**VIBE**

Wildcat Roller Screed \$2195  
Roller Tubes \$30 per ft  
End Plugs \$290 Weight \$200

**GROOVING  
ROLLER**

# PCRG  
\$790

**CROSS COMPACTION  
ROLLER**

# PCR  
\$600

## COMPLETE PERVIOUS PACKAGE

*"The Wildcat Screed has become my preferred placement method because of it's lightweight, easy to use, and produces a great finish."*

Sarah Egan  
TN Concrete Association  
NRMCA Certified Pervious Concrete  
Installer

The Wildcat Roller Screed is the easiest to use on the market and the most economical. It is also an ideal tool for concrete sidewalks, walking trails and golf cart paths.

We welcome comparison to any other brands.

For More Info Call Toll Free 877-220-6652

[www.multivibe.com](http://www.multivibe.com)

## A CHEAPER ESTIMATE OF CONCRETE HEAT EVOLUTION DUE TO HYDRATION

by L. K. Crouch, Aaron Crowley, Daniel Badoe, Tony Greenway, Robert Craven and Heather P. Hall

Monitoring of the thermocouples can be accomplished with a National Instruments NI 9211 4-channel thermocouple analog to digital converter and a single device chassis, the NI cDAQ-9171, to provide USB communication to a PC for data logging. The NI signal express LE (light edition) software comes with the hardware purchase and can be upgraded at a cost to their full version if the software is to be used for more than just data logging. For this project the data logging capability is sufficient and graphs can be produced in the Signal Express LE program or with Microsoft Excel or any similar plotting package (there are a number of free spreadsheet programs available on the internet). The cost of the National Instruments hardware was about \$750. If no computer is available an inexpensive model can be purchased since the data logging requirements are not computationally intensive. If an inexpensive \$350 computer is added to the cost of the DAQ system the total is still only \$1100.

### FIRST EXAMPLE OF USE OF PROPOSED METHOD: CLASS A, CLASS A MODIFIED AND LGM CONCRETES

Figure 11 shows plots of the differences between temperature at the center of the concrete drum and the center of the water drum over time for TDOT Class A, Class A modified with 70% slag, and LGM mixtures (Crouch et al 4, 5). A Student's t-test was utilized to test the validity of the null hypothesis of the equality of the means of temperatures taken in the two drums over time. A 5 percent level of significance was used for the test. T-values exceeding t-critical lead to the rejection of the null hypothesis of equality of mean temperatures and the conclusion of a significant difference existing in heat evolution between each of the PCC mixtures and the water in the drum. Class A modified with 70% slag was significantly different from both TDOT Class A and LGM PCC.

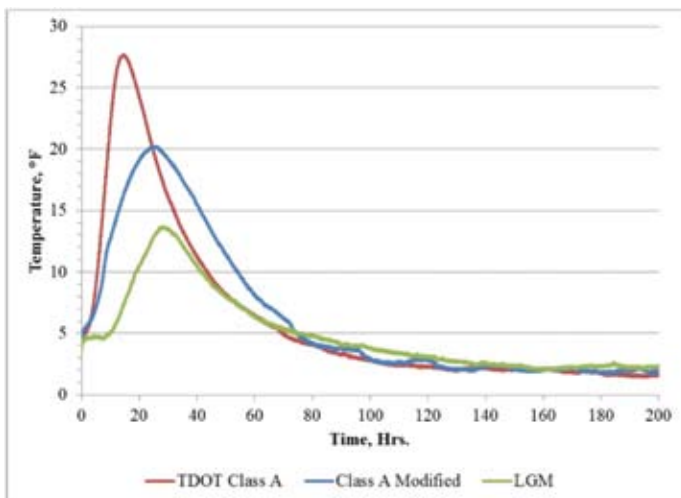


Figure 11: Temperature Differences from Water Barrel for Three Concrete Mixtures

### SECOND EXAMPLE OF USE OF PROPOSED METHOD CLASS S AND S-LH WITH 70% SLAG CONCRETES

Figure 12 shows plots of the differences between temperature at the center of the concrete drum and the center of the water drum over time for TDOT Class S and Class S-LH with 70% slag mixtures. A Student's t-test, undertaken with a 5 percent level of significance, indicated there was a significant difference in heat generation between the two mixtures.

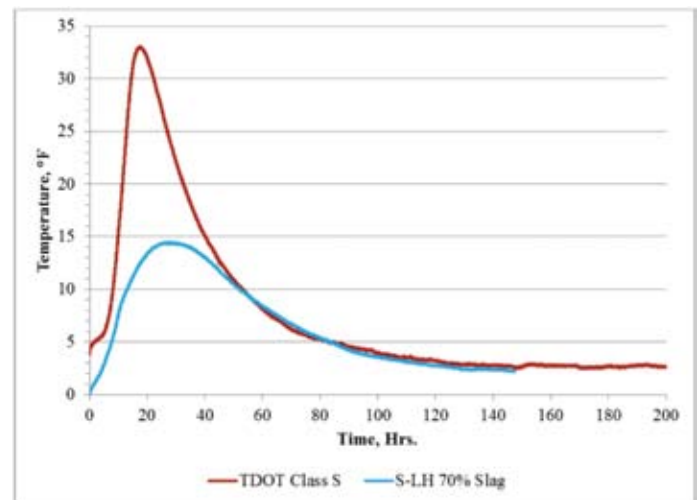


Figure 12: Temperature Differences from Water Barrel for Three Concrete Mixtures

### CAUTIONS FOR USE OF THE PROPOSED NEW METHOD

1. Make sure the initial temperatures of mixtures to be compared are very similar.
2. Make sure water (control) temperatures used with mixtures to be compared are very similar.
3. Tests should be conducted indoors so that ambient temperature does not vary too much.
4. The method does not actually measure heat evolution, but rather is only to be used for relative comparisons under similar conditions.

### SUMMARY

Table 4 shows a summary comparison of the three methods described in the paper. The proposed new method using 55-gallon drums offers an intermediate sample size at a much lower cost. Further, the new method makes use of materials that most concrete producers have in abundance—concrete, 55-gallon drums, and computers.

### DISCLAIMER

The opinions expressed herein are those of the authors and not necessarily the opinions of the Federal Highway Administration, the Tennessee Department of Transportation, or the Tennessee Concrete Association.



## REFERENCES

[1] ACI 207.1R-05. 2005. *Mass Concrete*. Farmington Hills, MI: American Concrete Institute.

[2] Gajda, John, and Martha Vangeem. "Concrete International." *Controlling Temperatures in Mass Concrete* Jan. 2002: 59-62. Print.

[3] TDOT Section 604.03, "Classification, Proportioning and Quality Assurance of Concrete," in *Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction*. Mar. 2006.

[4] Crouch, Lewis K., and Jason Phillips. "Lean Green, and Mean PCC." *Tennessee CONCRETE* Summer 2009: Vol. 23, No. 2. Pgs. 8-10. Print.

[5] Crouch, Lewis K., Pittman, Samantha, and Daniel Badoe. "Lean Green, and Mean PCC." *Tennessee CONCRETE* Winter 2012/13: Vol. 26, No. 3. Pgs. 8-12. Print.

## ACKNOWLEDGEMENTS

The authors wish to gratefully acknowledge the support of the Tennessee Department of Transportation and the Federal Highway Administration. Special thanks to Gary Head, Brian Egan, Jamie Waller, Amanda Neighbors and Bill Trolinger.

We also wish to thank Frank Lennox of Buzzi-Unicem, Denny Lind of BASF, Irving Materials Inc., and Alan Sparkman of the Tennessee Concrete Association for their extensive donations of materials to the project.

In addition, the authors would like to thank Mark Davis, Jeff Holmes and Perry Melton for their patience and skill in fabrication, maintenance, and repair of the equipment. We would also like to thank James Locum, Jacob Brooks, Sarah Dillon, and Caleb Smith for their help in the field and/or laboratory.

Further, we appreciate the support of the Tennessee Technological University Department of Civil and Environmental Engineering.

Finally, the authors appreciate the administrative support provided by the Tennessee Technological University Center for Energy Systems Research, particularly Etter Staggs and Linda Lee.

## AUTHOR INFORMATION

L. K. Crouch, Ph.D., P.E. is a professor of Civil Engineering at Tennessee Technological University.

Aaron Crowley, M.S., E.I. is a civil engineering doctoral student at Tennessee Technological University.

Daniel Badoe, Ph.D., is a professor of Civil Engineering at Tennessee Technological University.

Tony Greenway is an Information Technology Associate in the Center for Energy Systems Research at Tennessee Technological University.

Robert Craven is a Research and Development Engineer in the Center for Energy Systems Research at Tennessee Technological University.

Heather P. Hall, P.E. is Assistant Engineering Director of Tennessee Department of Transportation Materials and Tests Division.

**SOUTHERN  
CONCRETE  
PRODUCTS**

"Serving the South Since 1943"

[www.southernconcrete.com](http://www.southernconcrete.com)

Corporate Office: 731-968-8394

PO Box 1090 • Lexington, TN 38351



Radio Dispatched GPS Trucks  
For Fast Dependable Service



Bolivar	(731) 658-6105
Dyer	(731) 692-3462
Humboldt	(731) 784-5696
Henderson	(731) 989-9723
Jackson	(731) 422-3358
Lexington	(731) 968-2537
Milan	(731) 686-2288
Oakland	(901) 465-6611
Paris	(731) 642-6672
Sardis, MS	(662) 487-1635
Union City	(731) 885-7060

*"Building the South with top quality ready mix concrete  
& masonry products at a reasonable price."*

**We're  
reinforcing  
our reputation  
one job  
at a time!**

**Durafiber™ inc.**

4825 Trousdale Drive, Suite 205 • Nashville, TN 37220

(615) 333-9882 Fax

**(615) 333-9883**

# CIM UPDATE



*Jason Crabtree*

**J**ason Crabtree is the newest addition to our staff. He has been hired as the Lab Manager for the Concrete Industry Management program at Middle Tennessee State University. He received his Bachelor of Science degree in CIM from MTSU in the spring of 2009. Jason has a diverse construction background that made him a great candidate for working with our students. Jason was born and raised in Murfreesboro learning the family cabinet business. He interned with the CIM program in the lab working on concrete research in 2008. After graduation he worked for a concrete contractor in the field as a laborer and manager. He moved over to roof construction for a couple of years working the Rutherford County market. Jason brings a great level of practicality and common sense to the day to day operations of the lab. Since being hired in the summer of 2014, he has enjoyed teaching students how to perform ACI Field tests and sharing his flatwork finishing skills. He looks forward to contributing to the success of the students in the program, recruiting new students, and advancing the program. Jason has already been instrumental in placing 180' of sidewalk at Blackman High School Baseball Stadium and an outdoor pitching box for the MTSU Baseball Stadium.



*Jason Crabtree, Lab Manager, MTSU CIM Program*

*Mid South  
Concrete Inc.*



P.O. Box 1220  
1750 Braly Lane  
Pulaski, TN 38478  
2408 Hwy, 43 South  
Leoma, TN 38468

Phone (931) 363-0690  
Fax (931) 363-5326  
Cell (931) 309-9115  
Toll Free (800) 705-5326

**Email: [midsouth@smwb.net](mailto:midsouth@smwb.net)**

**[www.midsouthconcrete.com](http://www.midsouthconcrete.com)**



[www.amgeo.com](http://www.amgeo.com)

**TEMPERATURE CONTROL SOLUTIONS**

for Ready Mix Producers

**800.776.8039**

# Info Link

Winter 2012/13 VOL. 26, NO. 3

American Geothermal, Inc. ....	19
Blalock Ready Mix .....	7
Carolina Stalite Company .....	2
Durafiber Inc. ....	17
imix.....	5
Lafarge North America .....	7
Mid-South Concrete, Inc.....	19
Multi-Vibe.....	15
Ready Mix USA .....	4
Sicalco, LTD.....	7
Southern Concrete.....	17
Systems & Controls.....	20
Vulcan Material .....	19

# Vulcan Materials Company

Outstanding Quality & Customer Service



**Crushed Stone**

**Kingsport**

**(423) 245-4136**

**Knoxville**

**(865) 577-2511**

**Chattanooga**

**(423) 510-2600**

**Nashville**

**(615) 361-8550**

**Jackson**

**(731) 668-7357**

# Systems & Controls

CONCRETE PLANT SALES, SERVICE, PARTS AND CERTIFICATION



Concrete Plants  
Radial Stackers  
Truss Conveyors  
Batch Computers  
Dust Collectors  
Binfill Systems  
Water Meters  
Moisture Probes  
Aeration Blowers  
Valves  
Cylinders  
Silo Level  
Calibration Services

Systems & Controls  
11450 Shaw Ferry Road  
Lenoir City TN  
37772

Phone: 865-988-8583  
Fax: 865-988-0397  
Mobile 865-250-8855

E-mail:  
concreteequipment@gmail.com

[www.systemsandcontrols.net](http://www.systemsandcontrols.net)