Winter 2009
VOL. 23, NO. 3

TENNESSEE CONCRETE MAGAZINE

Early TCA Experiments with Self-Compacting Pervious PCC

imix XS

The Reinforcement Alternative

International Codes Council (ICC) Compliant!

(ESR-1726)

When should I use imix XS?

If you answer "YES" to any of the following, then *imix* XS is a superior alternative for your application.

- Are you looking for a product that provides consistent reinforcement throughout the entire finished slab or foundation?
- Are you in an area where contraction and expansion from temperature extremes causes concrete to crack or curl?
- Are you looking for a quick reinforcement alternative that eliminates the labor of setting chairs, placing mats, wire mesh or rebar?
- Are you trying to find a way to keep your crews more productive without compromising quality?
- Are you pouring a residential footing or foundation where you would typically use rebar or some other reinforcement material?
- Are you working a commercial slab or deck that is not engineered for rebar?
- Are you interested in using **ONLY** **ICC Compliant** concrete?

Want to know more about other *imix* products?

Contact your local sales representative or take a look at our web site: **www.irvmat.com/imix.**

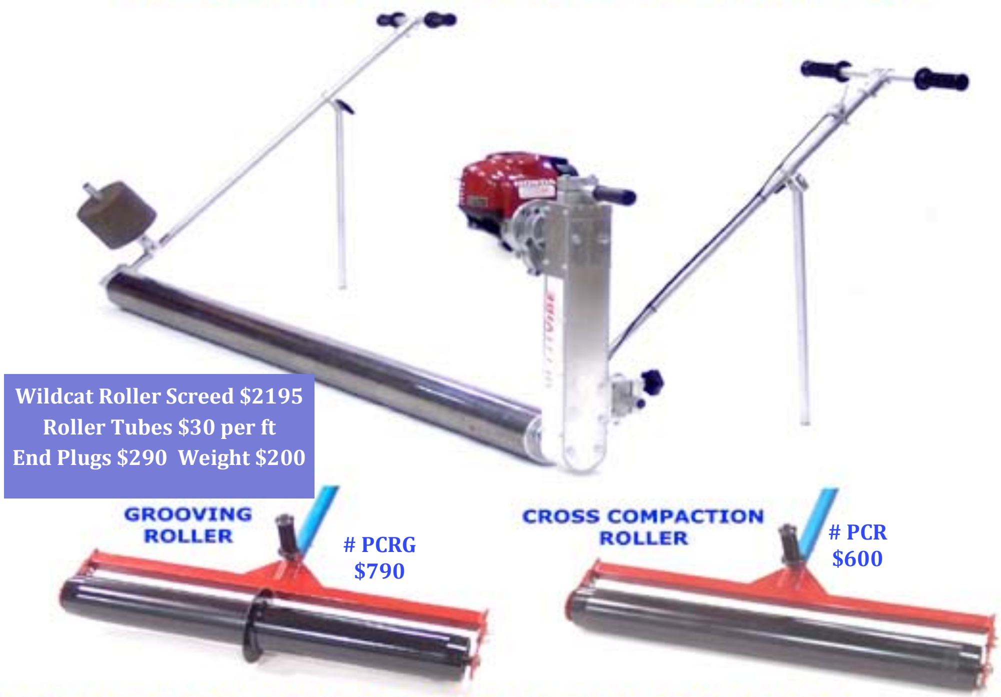
Placing Pervious Concrete

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

MULTI VIBE®



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

TENNESSEE CONCRETE MAGAZINE

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

Publisher:
The KaHoy Group, LLC

Editor:
Alan Sparkman

Advertising Director:
Morris Woods

Art Direction:
Heninger & Associates

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.

contents

Winter 2009 VOL. 23, NO. 3

Looking Deeper...

John Curtis
2009 TCA President

Challenge and encourage people in ways you never thought of before. Start with yourself and move outward to your people.

*TCA was awarded the 2008 Association of the Year award from NRMCA

Since our last visit, things seem to be relatively status quo. Whether it is business levels, unemployment, the economy as a whole, very little appears to be moving the needle as much as we had hoped. After traveling around the state with Alan Sparkman over the past six months, the concerns of producer members, associates and affiliates are predictably consistent.

The problem is that the last thing we really need to be doing right now is ***staying consistent.*** We all have "right sized" our departments, improved our operational efficiencies and "negotiated" with our suppliers and vendors. Now what do we do? Going into safe mode right now, is really not all that safe.

Like many of you, I am frequently called on by those doing business with our company or those who would like to. During these challenging times, ***a large majority have not changed mindsets, business philosophies, business plans at all!*** There is no "business as usual" anymore and the bunker mentality will not work for anyone in any business. Our industry is no exception, and quite frankly, we're worse than most!

The literary world is papered with books telling the stories of businesses that either: a) did not change, b) would not change or c) did not know they needed to change until it was too late! No one can look at today's economic landscape and realistically believe that what we have always done in the past will work in the future.

There's an old saying, "The definition of insanity is doing the same thing over and over again expecting the same results." In reality, most of us would probably ***take that*** right now. As an industry, we are doing the same thing over and over again and ***getting worse results.***

HOW DOES THAT MAKE GOOD BUSINESS SENSE?

Moving forward, we must look at the realities of the market and adjust accordingly in ways we never have had to before. Challenge and encourage people in ways you never thought of before. Start with yourself and move outward to your people, your vendors and, yes, your customers. Start with these five questions:

- What have we missed?
- What can be done differently?
- How does this affect others?
- What part of the picture don't I see; who might help me see it?
- What's the motivation?

With businesses folding up faster than a house of cards, these questions need to be asked quickly and answered even quicker.

When do you get started? ASAP. How do you get started? There are two outstanding books written by author Jim Collins, **Built to Last** and **Good to Great** were national best sellers and are widely accepted as some of the very best books on business success ever published. (They are available on CD as well).

The time to start is today. If we pursue the future with different views on old problems; if we stop blaming the "other" guy; and if we look deeper inside ourselves and our people both internally and externally, endless opportunities to improve our industry, our businesses, and our lives, are out there…waiting.

Remember the words of singer Billy Joel: "The good ole' days weren't always good and tomorrow ain't as bad as it seems."

It's up to you.
Look deeper!

Alan Sparkman
Executive Director

Taking Responsibility

—the Opportunities are Real

Taking responsibility is a local phenomenon.

—

With greater privilege comes greater responsibility.

In our summer issue, I talked about our faltering economy and the fact that concrete opportunities still exist even in these difficult times. Many of us were hoping that by the end of 2009—it's now the middle of November—we would begin to see improvement in the economy. At best, it seems that we may have found the bottom but most folks I talk to aren't expecting much improvement in production volume until the middle of 2010.

So the economy is still quite weak but concrete's opportunities are still quite strong. We have witnessed a big upsurge in both interest and use of pervious concrete in Tennessee, and plain concrete parking lots are also gaining ground as more people realize that concrete is very competitive with asphalt in initial costs and far superior in terms of maintenance and the environment.

And that brings us to our topic for this issue: Taking Responsibility. The opportunities for concrete in today's marketplace are real but they will likely remain only as potential unless individual ready mix concrete producers take responsibility for carrying concrete's message to their own markets. The Tennessee Concrete Association can certainly help. We are working hard to educate specifiers and owners about concrete's many advantages, and we are helping our members with specific local projects as they request our assistance. Our friends at the National Ready Mixed Concrete Association are making great strides in delivering concrete's positive message to numerous national accounts and this is creating additional opportunities for concrete at the local level. But the fact remains that most of the concrete opportunity exists in local markets and it won't be converted from potential to reality without the effort of local ready mix industry people. **Taking responsibility is a local phenomenon.**

Responsibility also has an important role to play in society at large. Recent columns have also touched on how we can achieve a better balance between government and private enterprise. This issue is a large part of the current debate about overhauling our healthcare system as well as the debate about climate change. And here's where this 'taking responsibility' thing really gets complicated…

Like many of you, I have been discussing healthcare with friends, family and business associates. Everyone seems to agree that our current system is broken and in desperate need of change but the opinions about what to do vary wildly from there. The public debate seems only to pit one national group against another as their respective lobbyist ratchet up the volume of the debate in an attempt to protect their group at the expense of everyone else.

The standard formula for this is to make wildly exaggerated claims about the negative impacts of various changes on individuals, i.e., government rationing of healthcare (or even more egregious - Medicare death panels). Insurance companies often bring up the specter of rationing by the government while conveniently omitting the fact that they are rationing care every day under the current system. Supporters of a 'government option' tout better access for everyone if we just create yet another government bureaucracy, conveniently ignoring the considerable evidence of history about the ineffectiveness of government bureaucracies. What both sides leave out is that individuals—that would be you and me—will have their power of choice eviscerated in either scenario.

I believe that improvement in our healthcare system will come from giving individuals more power to choose, including the ability—and the responsibility—to shop competitively for medical services. For this type of change to happen all of the players in our healthcare drama will have to take responsibility for the improvement of healthcare at the individual level, instead of focusing their energy and resources solely on protecting their slice of the pie.

This will mean insurance companies actually competing in a real marketplace not sheltered by an anti-trust exemption with policies actually written to provide care to individuals instead of focusing on denial of benefits through delay and needless complication.

It will also mean doctors and healthcare providers who compete in a real marketplace by pricing their services to individuals instead of insurance companies. It will mean tort reform that prevents attorneys from holding doctors and healthcare institutions hostage with the threat of multi-million dollar judgments. It will mean drug companies that quit using the US market to subsidize worldwide profits and it will mean a host of other corporate players who quit hiding behind the worn-out excuse of their only responsibility being to their shareholders. (In case you need this corporate-speak translated, here it is in plain English: Our profits are all that matter—to &*%$ with everyone else!)

Even more importantly, it will mean that you and I take personal, individual responsibility for our healthcare decisions and purchases. Individuals like us have to quit treating health insurance as some kind of entitlement benefit where there is no relationship between lifestyle choices and health consequences and no relationship between care and cost. We clamor for more individual choice, but it's like our parents always said: **With greater privilege comes greater responsibility**.

It's pretty easy to rail against 'the healthcare system' since most of us see ourselves as not being the villain in that drama; and it's easy for the business world to get behind terms like "individual choice," "real marketplace" and "personal responsibility." In my next column we will take this one step further and talk about applying the concept of taking responsibility in the arena of sustainability. ❖

by L. K. Couch, Marcus L. Knight and Alan Sparkman—

Early TCA Experiments with Self-Compacting Pervious PCC

INTRODUCTION

Pervious Portland Cement Concrete (PCC) is proportioned with aggregates, cement (possibly with supplementary cementing materials), water, and admixtures so that an open void structure (~25% by volume) is maintained throughout its cross section. The void structure is such that water can drain freely through the concrete without significant resistance.

Pervious PCC is very "green" (environmentally friendly) at a time when it is very important to be "green" from environmental stewardship and economic viewpoints. From an environmental perspective, pervious PCC, due to the typical open void structure, is one of the best management practices for control of storm water runoff in parking areas. The void structure allows much of the storm water to pass directly through a concrete parking slab into the sub-grade. This process, along with any filtering of the runoff that may occur in the pervious PCC and sub-grade, may reduce the amount of pollutants and debris that eventually enters storm drains or receiving waters. This is especially true when compared to similar applications of impervious pavements that force storm water to cover great distances with the opportunity to gather contaminants (oil from parked cars) and debris (trash) along the way ultimately transporting these undesirable elements to receiving waters. Finally, pervious PCC provides another possible environmental benefit in that post industrial byproducts (i.e. fly ash) may be used in its production providing a possible reduction in the amount of material that must be transported to landfills.

From an economic viewpoint, pervious PCC is also attractive. Pervious PCC applications may provide several economic benefits for a particular application including a reduction in the number, size, and ultimately cost of storm water infrastructure that is required to meet local standards. Its use may also lead to more development area on a given site, or a reduction in the size of site required for a particular development, as a possible reduction in the volume of retaining ponds may be achieved. Finally, the use of pervious PCC may provide an alternative to contractors and developers that need a competitive edge on projects where Leadership in Energy and Environmental Design (LEED) certification is desired or required.

Due in part to the environmental and economic considerations previously described, pervious PCC is one of the fastest growing markets for the ready mixed concrete industry. Unfortunately, pervious PCC engineering properties (compressive strength and effective void content) have been found to vary greatly from placement to placement and even within the same placement. Figure 1 shows compressive strengths and corresponding effective void contents for 103 cores from past Tennessee Concrete Association (TCA) pervious PCC placements.

Why is pervious PCC variability so high? American Concrete Institute (ACI) Committee 522 Report [1] indicates that pervious PCC engineering properties are dependent on compactive effort as well as mixture proportions. Further, previous research at Tennessee Technological University has shown that to achieve the desired pervious PCC engineering properties the mixture must be proportioned for a particular compactive effort application. If too much compactive effort is applied to a mixture proportioned for a low compactive effort, low effective voids, low permeability and paste drain down often result. If too little compactive effort is applied to a mixture proportioned for high compactive effort, low compressive strength and raveling of the surface aggregate often result. These facts leave the ready mix producer with few options. The ready mix producer must maintain several pervious mixture designs for different compactive efforts and spend much valuable time coordinating with placement contractors or share in the negative publicity of a placement with inadequate engineering properties.

Haselbach and Freeman [2] report that pervious PCC engineering properties even vary with depth in a single placement. The vertical variation in compressive strength, porosity and permeability was attributed to the surface compaction technique. The compaction was much more effective near the surface than at depth, even for six-inch deep slabs. Brown [3] states that an attempt to standardize compaction equipment for pervious PCC is an important research need. Can pervious PCC compaction equipment be standardized to provide effective, uniform compaction? Unfortunately, standardization of pervious PCC compaction is not likely. Economics (what equipment can be obtained cheaply and easily) and the desire for innovation do not favor standardization. Further, even if standardization could be achieved, all surface compaction techniques impart more stress to the near surface than to deeper portions of the pervious PCC. Past efforts have focused on many alternative surface

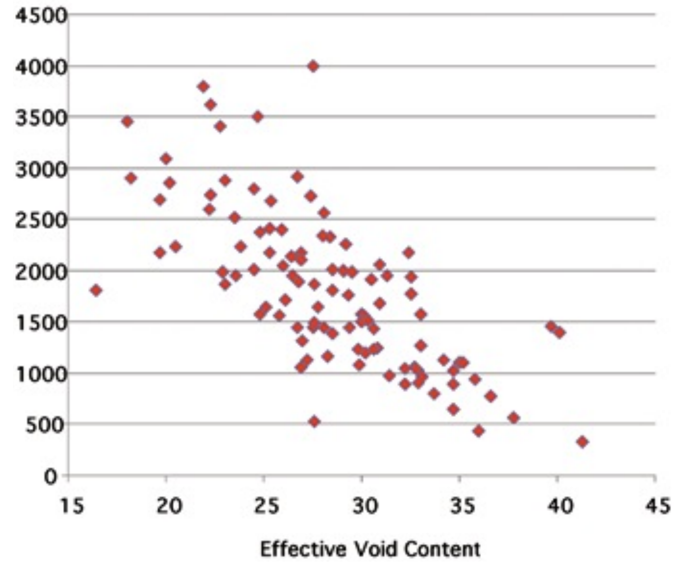


FIGURE 1: CORE COMPRESSIVE STRENGTH VS. EFFECTIVE VOID CONTENT OF TCA PLACEMENTS

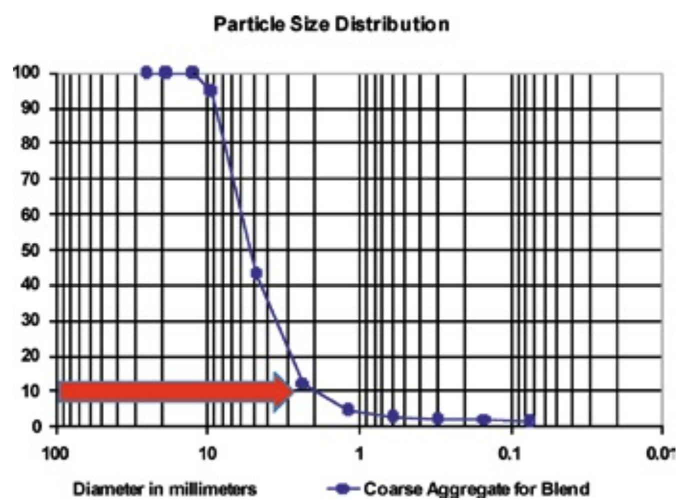


FIGURE 2: DETERMINING THE EFFECTIVE VOID SIZE (D_{10})

compaction techniques including heavier rollers, high-density pavers, vibratory plate compactors, and counter-rotating rollers. What can be done to address these problems? Since compaction techniques cannot easily be standardized and are of questionable effectiveness, TCA researchers decided to try self-compacting pervious PCC.

BACK TO SIMPLE BASICS

When gluing wood pieces together for furniture, two factors are critical for the strength of the joint: the strength of the glue and the surface area available for gluing. Previous TTU research indicated that the addition of supplementary cementing materials (SCMs) and chemical admixtures increased the strength of the "glue" for pervious PCC [4]. Surface area for "gluing" can

—*Continued on page 12*

Continued from page 11—

by L. K. Couch, Marcus L. Knight and Alan Sparkman

Early TCA Experiments with Self-Compacting Pervious PCC

be increased by using finer aggregate gradations. Fortunately, Sparkman observed, in unpublished communications, that the addition of fine aggregate also increased pervious PCC workability and made ready mix trucks much easier to unload. Further, increasing the paste content of pervious PCC makes the mixture stronger and more workable. Finally, viscosity modifiers can reduce the probability of paste drain down. Therefore, it appeared that a self-compacting pervious PCC mixture would need fine aggregate, a higher paste content, SCMs and chemical admixtures.

Permeability is the unique feature of pervious PCC and the key feature that makes it a best management practice for storm water runoff control. The research team attempted to maintain permeability by setting a minimum acceptable effective void content and a minimum effective void size. The minimum effective void content was maintained by limiting cementing materials and fine aggregate content. A minimum effective void size was established by setting a minimum D_{10} size for the combined aggregate gradation. Figure 2 shows how to locate the D_{10} size on a gradation plot. For the example shown, the D_{10} size is about 2-mm. The D_{10} size can be reduced by blending fine aggregate with the selected coarse aggregate.

LABORATORY MATERIALS AND PROCEDURE

The representative coarse and fine aggregates shown in Table 1 were obtained from across the state with TCA assistance. Coarse and fine aggregates from each part of Tennessee were blended mathematically by trial and error to produce combined aggregate gradations with a D_{10} size close to 1-mm. The 1-mm D_{10} target size was chosen for these early self-compacting pervious PCC experiments. The value may need to be altered as more information becomes available. Combined aggregate gradations are shown in Table 2.

Initial mixture proportions were chosen based on prior experience with low compaction pervious PCC mixtures. Final self-compacting laboratory mixture proportions (shown in Table 3) were chosen by trial batches to produce mixtures with effective void contents between 23 and 32 percent and 28-day compressive strengths greater than 2500-psi that did not have excessive paste drain down. All trial batches were mixed in a one cubic foot electric mixer. The mixture was then placed without compaction in a 24-by-6-by-6-inch oiled wooden beam mold and struck off level (see Figure 3). The beam specimen was then covered with plastic until the next day. The following day, the beam forms were wrecked and the beam was placed in lime-water curing tank. Four cores were extracted from the beam at seven or eight days in accordance with ASTM C 42 [5]. Two cores were used for compressive strength determination and two were used to determine the effective void content. Compressive strength as per ASTM C 39 [6] was determined using sulfur mortar capping as per ASTM 617 [7] following coring. The effective void content was determined as per ASTM D 7063 [8] after drying the cores at 230˚F for three to seven days.

Each trial batch consisted of one beam specimen. However, when a beam specimen appeared likely to meet compressive strength (2500-psi @ 28-days) and effective void content goals (23 to 32%), four additional batches were fabricated and tested to confirm the results. Results of the final laboratory mixtures for each part of Tennessee are shown in Table 4. The compressive strengths shown in Table 4 were measured at 7 or 8 days rather than 28 days, due to the sponsor's desire to take the mixtures to the field as soon as possible. Effective void contents shown in Table 4 were typically measured 10 to 15 days after beam casting. Average compressive strengths and effective void contents for all three mixtures met project goals.

FIGURE 3: STRIKING OFF SELF-COMPACTING PERVIOUS BEAMS IN THE LABORATORY

FIELD EXPERIMENTS

General

Field experiments are far more important than laboratory results. Wonderful laboratory results are meaningless if they cannot be translated to the field. Five experimental field placements were conducted as part of this study. Field placement

TABLE 1. COARSE AND FINE AGGREGATES USED IN THE LABORATORY (PERCENT FINER BY MASS)

Sieve Size (mm)	East TN No. 8 Limestone	Middle TN No. 8 Limestone	West TN Gravel	East TN Limestone Sand	Middle TN River Sand	West TN Bank Sand
12.5	100	100	100	100	100	100
9.5	95	95	86	100	100	100
4.75	23	43	15	100	97	99
2.36	2	12	2	94	90	85
1.18	2	5	1	61	82	72
0.6	2	3	1	34	57	48
0.3	2	2	1	17	9	4
0.15	2	2	1	9	1	1
0.075	1	2	1	5.7	0.4	0.4

TABLE 2. LABORATORY COMBINED AGGREGATE GRADATIONS (PERCENT FINDER BY MASS)

Sieve Size (mm)	East Tennessee	Middle Tennessee	West Tennessee
12.5	100	100	100
9.5	96	95	88
4.75	32	48	26
2.36	13	19	13
1.18	9	12	10
0.6	6	8	7
0.3	4	3	1
0.15	3	2	1
0.075	1.9	1.6	0.6

TABLE 3. SELF-COMPACTING PERVIOUS PCC MIXTURE DESIGNS USED FOR LABORATORY EXPERIMENTS

Component	East Tennessee	Middle Tennessee	West Tennessee
Type I PC, lbs/CY	540	486	445
Class F Fly Ash, lbs/CY	98	88	81
Coarse Aggregate, SSD, lbs/CY	2016	2181	1983
Fine Aggregate, SSD, lbs/CY	274	208	319
Water, lbs/CY	201	184	152
Design Percent Air Voids	25	25	25
Hydration Stabilizer, oz/CY	26	34	21
Mid-range Water Reducer, oz/CY	32	46	26
Viscosity Modifier, oz/CY	13	0	16

TABLE 4. RESULTS OF LABORATORY EXPERIMENTS

Core Set	Number of Cores	Mean Effective Voids (%)	Effective Voids Range (%)	Mean Compressive Strength (psi)	Compressive Strength Range (psi)
SC Lab East TN	10	26.1	24.4 – 27.6	2540	2230 - 2840
SC Lab Middle TN	10	24.3	21.9 – 26.5	3080	2590 - 4420
SC Lab West TN	10	27.1	25.0 – 28.9	2610	2450 - 2830
Average SC Lab Values	30	25.8	21.9 – 28.9	2740	2230 - 4420

Continued from page 13—

by L. K. Couch, Marcus L. Knight and Alan Sparkman

Early TCA Experiments with Self-Compacting Pervious PCC

procedure was identical to laboratory procedure – place, strike-off, cover. The research team felt well prepared when field tests began, however, regardless of the level of preparation, life always manages to provide a few surprises. For example, the producer of the field mixture may not have the exact aggregates, fly ash, or chemical admixtures used to develop the mixture in the laboratory.

The results of three of the five field placements are shown in Table 5. The other two placements served well as lessons in humility for the designer (first author). Table 5 also shows several of the larger data sets used in Figure 1 to serve as a basis for comparison for the experimental self-compacting pervious PCC placements. Details are provided in the following paragraphs.

East Tennessee Mixture

The first field placement was in East Tennessee in September 2008. The coarse aggregates used were much finer than those used in the laboratory experiments and the mixture was obviously over-sanded. The resulting effective void contents were in the desired range, but the compressive strength results averaged 320-psi less than the minimum desired compressive strength. A second East Tennessee experimental placement with a mixture designed for the finer aggregates was discussed but has not been placed.

West Tennessee Mixture

The first West Tennessee experimental placement was also in September 2008. This mixture was obviously far too lean. The mixture designer leaned out the mixture too much to reduce

the possibility of paste drain down. The placement (humility lesson 1) resulted in a low strength (770-psi), high void content (40%) mixture that raveled easily. A subsequent experimental placement with materials similar to those in West Tennessee occurred at TCA headquarters in Nashville in November 2008. The mixture was revised to increase Portland cement (+9 lbs/CY), fly ash (+16 lbs/CY) and water (+8 lbs/CY). The results (see Table 5) met all project goals.

Middle Tennessee Mixture

The first Middle Tennessee experimental placement was at TCA headquarters in Nashville in October 2008. This mixture was far too wet and was removed without coring (humility lesson 2). The next middle Tennessee placement was still a little wet and over-pasted. However, it was a tremendous improvement over the first placement. The results (see Table 5) easily met compressive strength goals, but fell approximately 1 percent below the target effective void content range.

Analysis of Field Results

The purpose of Table 5 is not to show that self-compacting pervious is superior to compacted pervious PCC. The number of self-compacting data points is very small and the results of the humility lessons are not shown. Rather, comparisons were performed to determine the potential of self-compacting pervious PCC mixtures. Are self-compacting pervious PCC mixtures promising enough to pursue? Some of the advantages and disadvantages are listed below.

1. **Simplicity** – place, strike-off, and cover. The procedure is more attractive to customers and contractors.
2. **Increased producer control** – producers now control the level of compaction (none).
3. **Higher compressive strength potential** – the average compressive strength of the three more successful self-compacting pervious PCC placements was 62 percent higher than the average compressive strength of the compacted pervious PCC placements in Table 5.

Continued from page 15—

by L. K. Couch, Marcus L. Knight and Alan Sparkman

Early TCA Experiments with Self-Compacting Pervious PCC

TABLE 5. RESULTS OF TCA FIELD PLACEMENTS

Core Set	Number of Cores	Mean Effective Voids (%)	Effective Voids Range (%)	28-day Mean Compressive Strength (psi)	Compressive Strength Range (psi)
Chattanooga	18	32.0	28.5 - 35.8	1230	940 - 1760
Williamson C	5	25.9	22.2 - 28.5	2200	1870 - 2600
Williamson F	6	28.2	24.8 – 31.4	1300	970 - 1570
Burgess Falls	5	27.2	24.7 – 29.2	2790	2260 - 3500
Tunica	6	18.8	16.4 – 20.5	2610	1810 - 3450
Kingsport	6	23.6	21.9 – 25.4	2980	1950 - 3790
Knoxville	10	28.3	25.9 – 32.9	1370	530 - 2400
Erwin	5	28.5	19.7 – 41.3	1790	330 - 2860
Average Compacted Field Values	61	27.1	16.4 – 41.3	1820	330 - 3790
SC Field East TN	4	28.3	23.6 – 31.6	2180	2140 - 2250
SC Field Middle TN	4	22.3	22.0 – 22.9	3280	2960 - 3680
SC Field West TN	4	24.7	23.4 – 25.8	3420	2850 - 4690
Average SC Field Values	12	25.1	22.0 – 31.6	2960	2140 - 4690

4. **Water content sensitivity** – this is actually neither an advantage nor a disadvantage, all pervious PCC is sensitive to water content.
5. **Gradation sensitivity** – self-compacting pervious PCC is more sensitive to aggregate gradation than compacted pervious PCC.
6. **Paste content sensitivity** – self-compacting pervious PCC typically needs a high paste content due to the additional surface area of the fine aggregate. Caution must be exercised to not over or under paste the mixture (the first author learned this in the humility lessons).
7. **Aesthetics** – the third author expressed some concern that self-compacting is not as aesthetically pleasing as typical compacted pervious PCC.

RECOMMENDATIONS FOR FUTURE SELF-COMPACTING PERVIOUS PCC RESEARCH IN TENNESSEE

Self-compacting pervious PCC had some start up problems but showed great potential for increased compressive strength and simplicity of placement. The three major difficulties (paste content sensitivity, gradation sensitivity, and aesthetics) can all be addressed by increasing the D_{10} target size from 1-mm to 1.5 to 2-mm. The target compressive strength of 2500-psi will probably still be achievable depending on the aggregates, chemical admixtures and SCMs available to the local producer. In many cases a 2000-psi target compressive strength may be adequate. Another major lesson learned from the early self-compacting pervious PCC experiments is that these mixtures should be designed and trialed with the specific materials that will be used in the field placements.

One possibility not explored in this research, is the use of self-compacting pervious PCC as a wearing course. The increased compressive strength (a 3000-psi minimum is possible with the right materials) and higher paste content of self-compacting pervious PCC may open up new applications for the material. The TCA research team and the Transportation Research Board are interested in highway applications of pervious PCC. If the asphalt folks can produce an open-graded friction coarse to reduce splash, spray and noise, the PCC folks can make a stronger, more durable, and longer lasting one.

REFERENCES

ACI Committee 522, "Pervious Concrete," (ACI 522R-06), American Concrete Institute, P.O. Box 9094, Farmington Hills, MI, 48333-9094, www.concrete.org.

"Vertical Porosity Distributions in Pervious Concrete Pavement," **American Concrete Institute Materials Journal**, Title No. 103-M50, V. 103, No.6, November-December 2006, Liv M. Haselbach and Robert M. Freeman.

"Pervious Concrete Research Compilation: Past, Present and Future," Dr. Heather J. Brown, RMC Research Foundation, available at www.RMC-Foundation.org.

Phillips, Jason B., **Pervious Concrete Paste Composition**, Master of Science Thesis, Tennessee Technological University, Cookeville, TN, May 2009.

"Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete[1]," (ASTM C 42/C42M-03), American Society for Testing and Materials, **Annual Book of ASTM Standards**, Vol. 04-02, 2004, pp 28-32.

"Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens," (ASTM C 39-05), American Society for Testing and Materials, **Annual Book of ASTM Standards**. Vol. 04.02, 2006. pp. 21-27.

"Standard Practice for Capping Cylindrical Concrete Specimens," (ASTM C 617-98 [2003]), American Society for Testing and Materials, **Annual Book of ASTM Standards**. Vol 04.02, 2006. pp. 321-325.

"Standard Test Method for Effective Porosity and Effective Air Voids of Compacted Bituminous Paving Mixture Samples[1]," (ASTM D 7063-05), available at www.astm.org.

PROJECT SUPPORT

The project would not have been possible without the financial support provided by TCA members Blalock, BASF, Multi-Vibe, Metro Ready Mix, SEFA Group, Memphis Ready Mix, Cemex, Inc., Grace Chemicals, and IMI-TN.

ACKNOWLEDGEMENTS

We sincerely appreciate the assistance provided by former TTU students Jason Phillips, Derek Godwin and J.D. Self. We greatly appreciate the materials provided by Denny Lind of BASF Admixtures, Inc., Bob Fuller of W.R. Grace, Inc., Brian Strevel of SEFA Group, and Clark Simpson of Builder's Supply. We also gratefully acknowledge the financial support, financial project management, and computer assistance of the TTU Center for Energy Systems Research.

AUTHOR INFORMATION

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

Marcus L. Knight, Ph.D., P.E. is an assistant professor in the Concrete Industry Management Program at Middle Tennessee State University.

Alan Sparkman is executive director of the Tennessee Concrete Association. ❖

CONCRETE COMPRESSIVE STRENGTH TESTING ROUND ROBIN

MIDDLE TENNESSEE ROUND ROBIN SPRING 2009

By Mark Niemuth, Technical Services Engineer for Lafarge and chair of the TCA Technical Committee
Contact Information: 615-771-1220, Mark.Niemuth@Lafarge-NA.com.

Part of the activities of the TCA Technical Committee in 2009 was to host a concrete compressive strength testing round robin. The round robin was conducted with middle Tennessee Laboratories that do concrete compressive strength testing. The participants were from various groups including private labs, commercial labs, and research labs.

There is inherit variability in testing of concrete cylinders. In day-to-day testing of concrete it is difficult to determine if these variations are related to systematic error or random error. The purpose of this project is to provide a means for each laboratory to measure it's error and analyze the cause of this error. The program is not designed for analysis all the variables in casting, curing and testing of concrete cylinders but focuses on the final curing outline in section ASTM C31, 10.1.3.1 and compressive strength outlined in ASTM C39. Additional information on the factors that effect strength results can be found in NRMCA Publication No. 179 Review of Variables that Influence Measured Concrete Compressive Strength by David Richardson.

Concrete was sampled, tested, and cast in concrete compressive strength cylinders out of a single batch of concrete. The concrete design was similar to Tennessee DOT, Class A

TABLE 1: STATISTICAL COMPARISON WITH ASTM C 39

	Individual 7 Day	Reported 7 Day	ASTM	Individual 28 Day	Reported 28 Day	ASTM
N	22	11		21	11	
Mean	2420	2420		3604	3608	
Range		520	339		660	505
Total Std Dev	154	148		220	190	
Coefficient of Variation	6.4%	6.1%	5.0%	6.1%	5.3%	5.0%
Std Error	75			160		
Within test CV	3.1%		2.9%	4.4%		2.9%
Variation from between labs	24%		34%	53%		34%
Variation from within lab	76%		66%	47%		66%

TABLE 2: RANGE OF INDIVIDUAL RESULTS

Lab	7 Day Range (psi)	ASTM range (psi)	28 Day Range (psi)	ASTM range (psi)
12	50	172	50	280
13	120	204	280	279
14	51	200	340	288
15	90	196	50	280
17	0	202	540	290
18	50	179	30	268
19	160	195	70	287
20	140	189	130	278
21	20	185	-	-
22	110	194	50	320
23	190	214	20	310

concrete design except with higher water content. The cylinders were kept at standard lab temperature until they picked up by the participants. The following day participating labs picked up four 6" x 12" cylinders, except for two sets of cylinders which were picked up four days after casting. Those two sets were stored in an undisturbed, 70 degree Fahrenheit controlled environment. Two cylinders were tested at 7 days and two at 28 days. Each lab anonymously submitted their results to the technical committee for compilation of results.

OVERALL RESULTS

ASTM C 39-05 states in the precision and bias statement that the within lab coefficient of variation is 2.9 percent and the between lab coefficient of variation is 5.0 percent. This means that results between two labs should not differ by more then 14 percent of the mean for a five percent coefficient of variation and two cylinders should not differ by more then eight percent of the mean.

With this round robin there was a higher coefficient of variation at seven days then what is allowed in ASTM C 39 while at 28 days the coefficient of variation is close to the ASTM value as seen in Table 1. The range of results is higher then what is in ASTM C 39.

INDIVIDUAL LABS RESULTS

The results of the individual labs can be seen in Figure 1 and Figure 2. These figures also show the bias between labs. None of the labs were outside of the ASTM C39 range of individual results at 7 days, while three of the labs were outside of ASTM C39 range at 28 days as seen in Table 2.

—Continued on page 20

Continued from page 19—

CONCRETE COMPRESSIVE STRENGTH TESTING ROUND ROBIN

MIDDLE TENNESSEE ROUND ROBIN
SPRING 2009

THE DIAMONDS ARE CENTERED ON THE LABS AVERAGE REPRESENTING 95 PERCENT CONFIDENCE INTERVALS FOR THE POOLED STANDARD DEVIATION.

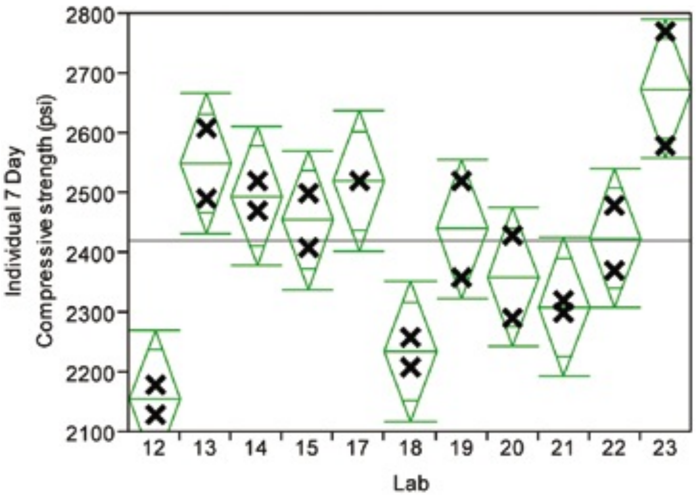


FIGURE 1: RESULTS BY LAB FOR INDIVIDUAL 7 DAY COMPRESSIVE STRENGTH RESULTS

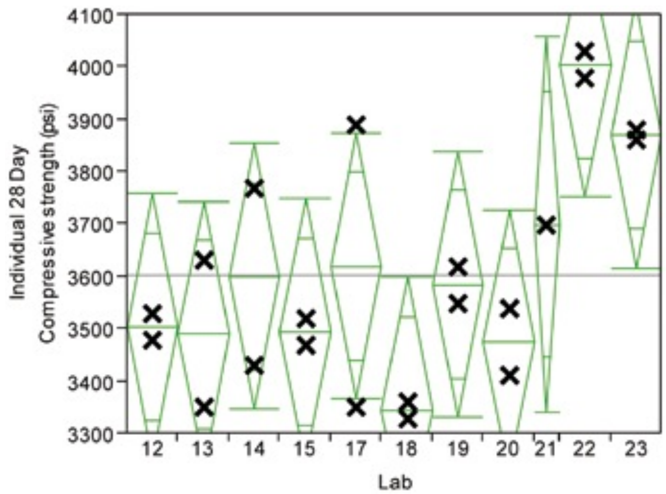


FIGURE 2: RESULTS BY LAB FOR INDIVIDUAL 28 DAY COMPRESSIVE STRENGTH RESULTS

For more information on the round robin a more detailed report is available from the technical committee. For those interested in participating in future round robins the technical committee is planning another round robin for the entire state during the winter of 2010.

ACKNOWLEDGEMENTS

Special thanks to Irving Materials for supplying the concrete, facilities, and equipment for testing, and to Ross Allen of Irving Materials, Amanda Brown of Irving Materials, Bob Fuller of Grace, Clark Gates of Sefa, and Alf Gardiner of Holcim for their time and contributions.

REFERENCES

ASTM Standard C39, 2005, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens." ASTM International, West Conshohocken, PA, 2005, www.astm.org.

ASTM Standard C31, 2009, "Standard Practice for Making and Curing Concrete Test Specimens in the Field." ASTM International, West Conshohocken, PA, 2009, www.astm.org. ❖

2010 ANNUAL CONVENTION

Nashville Marriott at Vanderbilt

FEBRUARY 19, 2010

2010 Tennessee Concrete Association

TOPICS TO INCLUDE:

8:00 a.m. – 12:00 p.m.
- Defective Concrete Lawsuits
- Elections Matter: Policy Behind the Policy
- Tennessee Legislative Update
- Success Strategies for 2010

12:00 p.m. – 1:00 p.m.
Fish Fry Lunch and Truck Rodeo

1:00 p.m. – 5:00 p.m.
Environmental Session

6:00 p.m.
Awards Banquet and Reception

Plan for *Success* in 2010.

Plan for Success in 2010

Join us at our Annual Convention

by Dr. Heather J. Brown

Decorative Council gets Creative with MTSU CIM

The Decorative Concrete Council (DCC) is an organization that was created out of the American Society of Concrete Contractors (ASCC). To further promote the use of decorative concrete, the idea to visit communities and build a demonstration site was spawned at WOC 2009. The MTSU CIM program was fortunate enough to be their first choice in putting a project on the ground.

The overall design of the slab was a CIM class assignment to determine the patterns and colors of the project. The slab was poured on the athletic complex area between Murphy Center and Floyd Stadium. It is going to be used for the TV stations to set-up their cameras and for the VIPs' to attend different events. The project consisted of approximately 1,250 square feet of decorative concrete. The perimeter of the slab consists of a 9.5 inch border of stamped concrete in an Old Chicago brick pattern. The center of the slab and the focal point is a 7 foot by 14 foot slab that has the MTSU athletic logo etched into the concrete and a water base stain used to mimic the colors of the logo. White color hardener was used for the background. This center slab also had a decorative stamped border to match the perimeter of the main slab. The main part of the slab was stamped with a seamless texture skin in the bluestone texture. Several different decorative products were used in this project such as: integral color, color hardener, powdered release agent and a solvent based acrylic sealer. The manufacturers that donated product and labor were Jim Mullins and Keith Boudart with Butterfield Color, Ed Benus with STARDEK, Dina with Fritz Pak, L.M. Scofield, and Julie Holtgrave with ASCC.

The project was fast track with only 1 week to complete starting October 26. The excavation of the area was performed by Oakley Construction with a CIM graduate, Wes Counts, heading that effort up. We also had additional help in concrete finishing from Stan Reece Concrete who has a daughter, Amanda Reece, in the CIM program currently. The work managed to get done between rain storms with the help of a large event tent. The slab was poured in stages utilizing a few CIM seniors as novice labor. On the final day of concrete work, we had Josh Cornwall with Dusty & Sons and also a CIM graduate etch the MT logo in the center of the slab. The sealing, caulking, cleanup and landscaping was completed by the students of the CIM program the following week along with Oakley Construction and Landmark Homes.

During the entire project all the CIM classes visited the site during their class time and a spokesperson would update the group on the process and methods being used. Nearly 350 students visited the site over the course of a week and there was a lot of interest in the project and a lot of really good questions asked during the visits. The CIM Program appreciates all the efforts from everyone and we are extremely proud of the transformed site. ❖

Info Link

Winter 2009 VOL. 23, NO. 3

TENNESSEE CONCRETE MAGAZINE

Tennessee Concrete Association

705 Fort Negley Court
Nashville, TN 37203

PRSRT STD.
U.S. Postage
PAID
Permit No. 212
Pulaski, TN