

TENNESSEE

AWARDS 2022
Volume 36, No. 1

CONCRETE

MAGAZINE




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CHAMPION**

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KODAK, TENNESSEE

Ready Mix Producer: Blalock Ready Mix
Project's Concrete Contractor:
Martin Concrete

See page 8





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WORKING TO UPDATE & IMPROVE COMMUNICATIONS



Sam Pittenger
TCA President

Happy to report,
we are in the
final stages of
permitting our new
office project.

.....

Looking forward to
breaking ground
by mid-year.

.....

Watch for a
'workforce blitz' to
assist TCA member
companies with
recruitment.

It is my honor to serve as TCA's President for 2022-23. For me, this is a highlight of a life-long connection to the concrete industry, and I am excited about this opportunity to work with our Board of Directors to create a stronger future for our industry.

I am happy to report that we are in the final stages of permitting for our new office project and expect to break ground by mid-year. This is the culmination of much discussion, work and persistence on the part of your Board and the TCA staff. Stay tuned for more updates and for opportunities for you to participate as we build a permanent and sustainable home for our association.

One of the results of our most recent Board meeting was the creation of a new Marketing Committee for TCA. Jaclyn Streeter with Master Builders is serving as our Chair, and I am serving on this important committee along with Duane King (Screaming Eagle Ready Mix) and Scott Eller (Mobile Materials). We will be working to update and improve the communications between TCA and each of our members, as well as improving the communication with our customers and the public at large.

One of our first projects will be assembling first person stories from the front line of our organizations — the people who are critical for any company to deliver products to customers. TCA will use these stories to bring context to the great opportunities the concrete industry can provide for people looking for careers and to highlight the vital role that we play in building the physical fabric we all inhabit. The Marketing Committee will also be coordinating a 'workforce blitz' using some of this same collateral to assist TCA member companies in their recruitment efforts to bring new talent into individual organizations. Stay tuned for more details on this important effort to help all of us address our most pressing issue!

-Sam Pittenger



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ENTERING 2022 ON A HIGH NOTE PRODUCTION CLIMBING

Experts think 2022 will be another year of growth in Tennessee.
.....
High levels of concrete production means upping our game of engaging people.

The concrete industry in Tennessee enters 2022 on a high note. Production statistics for ready mixed concrete production are just in for 2021 and Tennessee has now set new Cubic Yard production records for both 2020 and 2021!

2020 was the first year since the Great Recession that our statewide production climbed back above 8 million CY (8.383 million, to be precise) and that established a new high water mark for our state. For 2021, we blew past 9 million cubic yards (9.1 million) and Tennessee grew our share of the total US production over our numbers in 2020. This means that production growth of ready mix concrete is growing faster in Tennessee than in most other parts of the US.

Recent events in Ukraine make predictions for the remainder of 2022 difficult, but, in spite of the headwinds of war, inflation and supply chain uncertainty, most of the experts think 2022 will be another year of growth in our state. Looking further out, growth is predicted to slow and perhaps even dip slightly before once again picking up in 2025 and beyond. What I find encouraging about this is that we will be “leveling out” at record levels of production for concrete — not a bad scenario for our industry in Tennessee.

Continued high levels of concrete production also means that we have to up our game in terms of engaging people to become part of our workforce. Our new Marketing Committee will be working on exactly that and in fact that work has already begun. By the beginning of 2023, TCA should be operating from our new home in Nashville and that will allow us to ramp up our efforts in the important areas of certification, education, research and marketing of all things concrete. I encourage you to join your peers as we work to strengthen the concrete industry in Tennessee, and to help you strengthen your company and your workforce as we march into the future.

—Alan Sparkman

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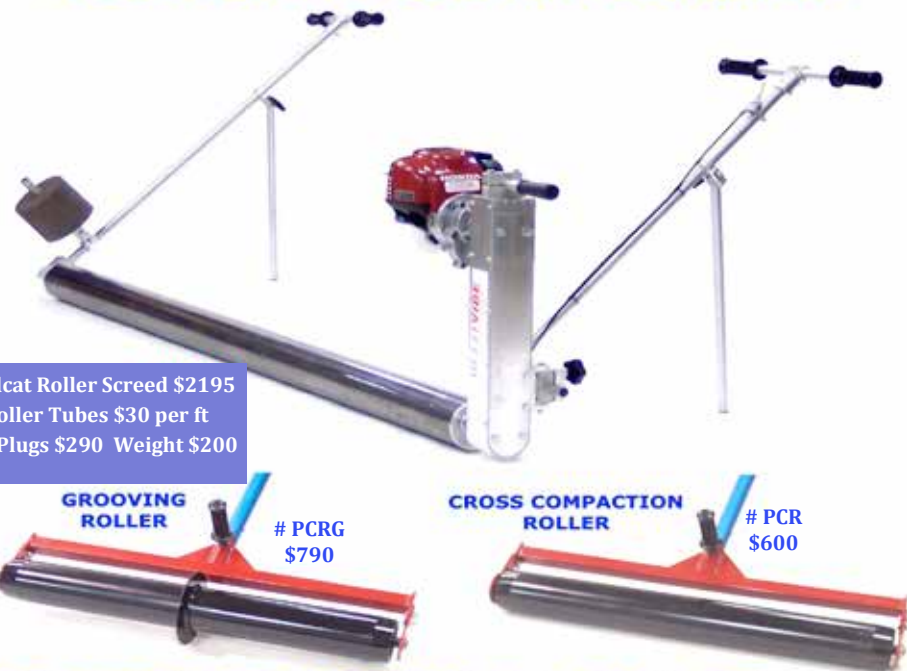


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2022 CONCRETE AWARD WINNERS



GRAND CHAMPION & BEST SPECIALTY TILT-UP FEDEX GROUND FACILITY Kodak, Tennessee

READY MIX PRODUCER: Blalock Ready Mix

PROJECT'S CONCRETE CONTRACTOR: Martin Concrete

This project consisted of a 237,000 square foot warehouse and sorting facility for FedEx Ground. The building was constructed using tilt-up wall panels that were cast off the slab in concrete casting beds that were later removed, crushed, and recycled as base and fill material. Interior slabs utilized FiberForce 750 structural fibers instead



of steel reinforcement to allow easier laser screed placement without pumping and provide better shrinkage protection. A total of 11,000 yards were provided by Blalock Ready Mix for this project.

2022 CONCRETE AWARD WINNERS



.....

BEST ARCHITECT/ENGINEER NON-BUILDING STRUCTURES (BRIDGES, DAMS, STADIUMS, ETC.)

Interstate 24 Hickory Hollow Pkwy Interchange

Ready Mix Producer: IMI

Project Owner: TDOT

Precast Company: IMI

Project's Engineer: Greg Woederman, TDOT

Project's Concrete Contractor: Jones Bros. Contracting

Project's Construction, Engineering, & Inspection: Ragan-Smith

The project along Interstate 24 at the Hickory Hollow Parkway interchange (Exit 60) in Davidson County involves modification and reconstruction of existing ramps and connector roads to create a full-access interchange. The



modifications will transform the exit into a diverging diamond interchange (DDI). The unique crisscross design allows two directions of traffic to temporarily cross to opposite sides of the roadway in order to travel across the overpass, and then cross back and resume the original travel pattern. The DDI uses concrete dividers, stop bars, traffic signals, and extensive signage to guide motorists through the interchange.



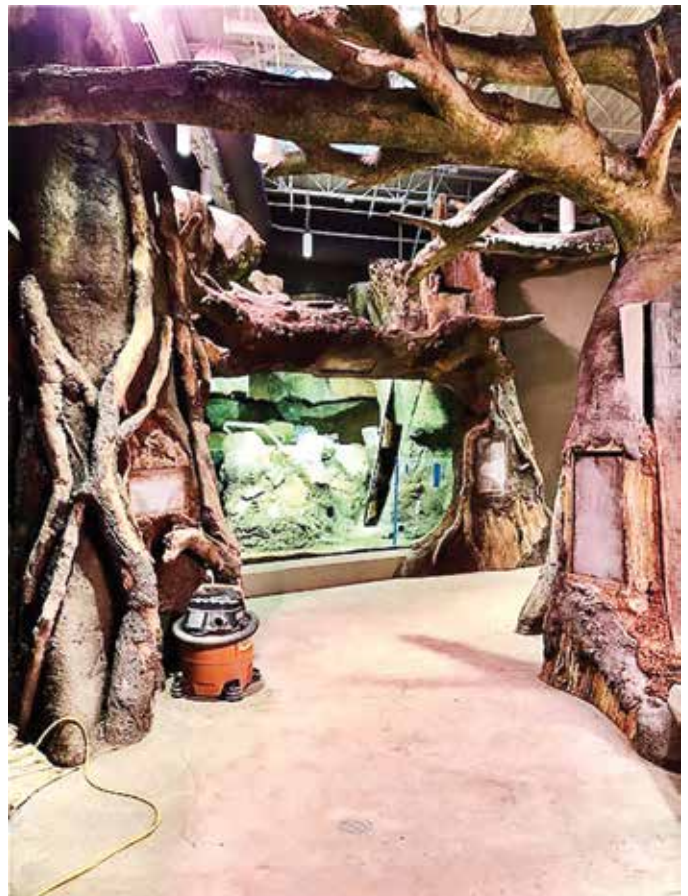
2022 CONCRETE AWARD WINNERS



BEST FINISHING COMMERCIAL DECORATIVE KNOXVILLE ZOO HERPETOLOGY BUILDING

Ready Mix Producer: Harrison Construction
Project's Concrete Contractor: Wade Rumble, Knoxville Zoo
Project Owner: Knoxville Zoo

Over the course of 2020 and 2021, crews with the Knoxville Zoo shot over 400 yards of shotcrete to create structures such as trees, rocks, and ponds within animal enclosures at the new herpetology building. Xypex additive was added for amphibian habitats both inside and outside the building.



2022 CONCRETE AWARD WINNERS



BEST FINISHING ARTISAN

Espinosa Residence

Ready Mix Producer: Memphis Ready Mix

Project Architect: Kevin Baltz

Project's Concrete Contractor: Baltz & Sons Concrete

Project Owner: Espinosa

This project demonstrates the ability to transform otherwise mundane concrete finishes into incredible works of art. For this project, Baltz & Sons Concrete first expanded the existing patio and porch area by enlarging the exterior patio with a light broom texture as well as a wood-grained landing. After an adequate cure period, Baltz then returned to score, stain and seal the various areas, tying old and new areas together into a beautiful and cohesive design. Concrete supplied by Memphis Ready Mix.





2022 CONCRETE AWARD WINNERS

BEST FINISHING RESIDENTIAL DECORATIVE EXTERIOR

Wilson Residence

Project's Ready Mix Producer: West Tennessee Ready Mix
Project Architect/Engineer: Kevin Baltz
Project's Concrete Contractor: Baltz & Sons Concrete
Project Owner: Rodney Wilson

This spectacular backyard renovation utilizes concrete in a variety of applications including multi-patterned stamped concrete, decorative microwash exposures, foundations, footers, and cast in place countertops. Designed and built by Baltz & Sons Concrete. Concrete supplied by West Tennessee Ready Mix.



2022 CONCRETE AWARD WINNERS



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BEST SPECIALTY: FLOWABLE FILL UCOR Y-12 BIOLOGY BUILDING

Project's Ready Mix Producer: Harrison Construction
Project's Concrete Contractor: UCOR
Project Owner: US Department of Energy

UCOR poured 7317 CY of flowfill in a span of two weeks. Multiple holes were drilled into the first story floor and then the flowfill was pumped into the basement. This allowed crews to safely work off of the slab while demolishing the multi-story structure. Then the basement and flowfill were removed, making room for a new building.

Demolition of the last 11 structures at the former Y-12 Biology Complex at Oak Ridge was completed in June, and the removal of the building's slab foundation is scheduled to be completed this fall. (Photo: DOE)





2022 CONCRETE AWARD WINNERS



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BEST PERVIOUS PARKING LOT FSSD SHELBY THEATER PARKING LOT

Project's Ready Mix Producer: IMI
Project's Concrete Contractor: Nsite, Inc. & Brothers
Contractors
Project Owner: Franklin Special School District

This brand new pervious parking lot was built for the Shelby Theater at Freedom Middle School in the Franklin Special School District. Brothers Contractors and Nsite teamed up on this project and poured 450 cubic yards of IMI's signature pervious concrete called "imix Eco Pave." These pictures show the craftsmanship at work on a rainy day.



2022 CONCRETE AWARD WINNERS



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BEST ARCHITECT/ENGINEER COMMERCIAL BUILDING

NEW VANCE MIDDLE SCHOOL

Project's Ready Mix Producer: Ready Mix USA
Project's Concrete Contractor: BurWil Construction
Project Architect/Engineer: Community Tectonics Architects & Engineering Consultants
Project Owner: Bristol, Tennessee City Schools

The previous Vance Middle School housed approximately 600 students in 7th-8th grades. The BTCS Board of Education had determined the new facility constructed on the existing site must accommodate a minimum of 900 students in grades 6th-8th. The new construction contains

a three-story academic wing with a "Grade-Level Learning Community" on each floor. These "Learning Communities" (9 classrooms, 3 science labs, 2 resource rooms, guidance office, assistant principal's office, teacher planning, & toilets) are supported by an adjacent "Learning Commons" offering access to a STEM lab, performing arts theater with broadcasting lab, media center, and café. Other support functions include: band, choral and art.

The existing gymnasium with over 1200 seats will be the only portion of the old school that will not be demolished. The gym was updated with new flexible seating, dressing rooms, weight room, multiple-purpose activity areas and offices. A secured school entry is also provided at the administrative /clinic /guidance suite.



2022 CONCRETE AWARD WINNERS



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BEST CONCRETE PARKING LOT

The Professional Park Condos

Ready Mix Producer: Screaming Eagle Ready Mix

Owner: E&E Properties

Project Architect: DBS & Associates

Project's Concrete Contractor: C. Wallace Concrete

Project's Engineer: Weekly Bros.

The Professional Park Condos for E&E Properties required 3200 yards placed and finished by C. Wallace Concrete. Since TCA President Duane King of Screaming Eagle met Amanda Hult from NRMCA in 2017, she gave him the tools to express the positives for concrete paving versus asphalt and he was able to gain a large foothold in Clarksville, TN., for concreting apartment parking lots, and commercial business parking lots. In 2020, Screaming Eagle



Ready Mix did concrete paving of subdivisions. Concrete paving not only looks better but it costs developers less in lighting and the maintenance factors almost disappear.

2022 CONCRETE AWARD WINNERS



BEST FINISHING COMMERCIAL

First Industrial Rockdale

Ready Mix Producer: IMI

Project's Concrete Contractor: Jay-Ton

Project's Engineer: Barge, Cauthen, & Associates, Inc.

Project Owner: First Industrial, L.P.

Project Architect: Design Constructors, Inc.

The slab of this 500,000 SF spec distribution center was poured with DUCTILCRETE technology. The first layer poured was standard 4000 psi concrete, and the top layer had DUCTILCRETE fibers and admixtures included to help alleviate the need for joints. DUCTILCRETE helps increase load bearing capacities, as well as reducing curling and cracks. It was a privilege for IMI to partner with Jay-Ton, T.W. Frierson, and GCP in their contribution to the future of concrete technology.





2022 CONCRETE AWARD WINNERS



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BEST SPECIALTY SHOTCRETE

City of Dickson Skate Park

Ready Mix Producer: Irving Materials

Owner: City of Dickson

Project Architect: Spohn Ranch

Project's Concrete Contractor: Skateboard Supercross

The City of Dickson awarded Spohn Ranch the contract to build the city's only skate park. Spohn Ranch is an award-winning skatepark design build firm. Their projects span over 40 states and 15 countries with clients such as RedBull, Vans and Alli Sports with NBC for the Dew Tours. Features of the park include a large bowl up to 6' high, a half-pipe and grinding rails. The bowls and wall were all sprayed by an ACI-certified shotcrete nozzleman from the Spohn Ranch team. They utilized two different specially



designed shotcrete mixes along with standard 5000 psi mix and terracotta integral color. Skateboard Supercross finishers were hired by Spohn Ranch to complete the concrete finishing of the park. The completed park consisted of approximately 300 yards of concrete.

2022 CONCRETE AWARD WINNERS



TCA EMERALD AWARD FOR ENVIRONMENTAL EXCELLENCE SMALL 25,000 YD3 OR LESS

Boones Creek Plant - 102 Watertank Rd., Gray, TN
Plant Operator: Paul Phillips
Ready Mix Producer: Ready Mix USA

TCA EMERALD AWARD FOR ENVIRONMENTAL EXCELLENCE MID: 25,001-75,000 YD3

Morristown, TN Plant - 663 South Sugar Hollow Rd.
Plant Operator: Joel Baxley
Ready Mix Producer: Ready Mix USA



TCA'S SOFTER SIDE OF CONCRETE AWARD

SEED Energy Efficient Home

Ready Mix Producer: Ready Mix USA
Project Owner: SEED of Knoxville

TCA's Softer Side of Concrete Award and NRMCA's Concrete Cares Award were both awarded this year to Ready Mix USA and SEED Knoxville for their outstanding contribution to the community on their collaboration to build a low-carbon ICFs home in Knoxville for a low-income family. Utilizing Vertua, a low-carbon concrete, in the ICFs walls and footer, the house was created to maximize energy efficiency and environmentally conscious methods.

TCA's Alan Sparkman traveled to Knoxville to the SEED Annual Green Gala to present JD Jackson of SEED Knoxville the award from the recent NRMCA Annual Convention. NRMCA awarded SEED with a \$1,000 gift and a plaque.



GOING BEYOND ACI 332: Commercial/Residential Enhanced Durability Concrete: Phase II — **WHAT IF?**

PHASE I RECAP

Phase one of this research explored the deleterious effects of commercially-available deicing salts containing magnesium chloride and sodium chloride on commercial and residential concrete. These effects were analyzed on mixtures that covered a wide range, from readily available commercial mixtures to enhanced durability mixtures. Based on the hardened state test results and deicing salt retention from phase one, it was determined that a low-permeability mixture was the most effective in preventing damage caused by exposure to deicing salts. The best performing mixture was the commercial/residential enhanced durability (CRED) mix that went beyond ACI 332-14 requirements for supplementary cementitious material (SCM) substitution levels. CRED’s optimum use of fly ash and metakaolin created a low-permeability, high early-age strength mixture that resisted damage caused by exposure to deicing salts better than its commercial counterpart mixtures. The readily available commercial 3500-psi mixture performed the poorest in phase one, as it suffered the most damage to strength and durability properties. The mixture used in phase one that was determined to perform better than commercial 3500 was the ACI 332 mix, which was designed to fully adhere to ACI 332-14 specifications for the most stringent class of freeze/thaw (RF3). Phase one concluded that using a low-permeability mixture, such as CRED, greatly reduced both the rate of intrusion of potentially harmful deicing salts as well as the negative effect on engineering properties due to deicing salts.

INTRODUCTION TO PHASE II

The Tennessee Concrete Association (TCA) approached researchers at Tennessee Tech University (TTU) with the idea for phase one, and TTU researchers sought to extend this research by adding “what if” variables. CRED proved itself to be able to withstand the deleterious effects of deicing salts, but the TTU researchers inquired as to how the mix would perform while under the influence of deicing salts as well as common errors

seen in the field. The circumstances seen regularly in the field that were used for phase two include the addition of water at the jobsite (+2Gal/CY), the absence of curing (No Cure), and their combined effects (Both). Applying these variables to the mixtures used in phase one would require a large number of cylinders, so only three mixtures were chosen to move forward into phase two: commercial 3500-psi, commercial ACI 332, and CRED (level one from phase one). These mixtures were chosen based on the wide range of concrete mixtures they represent, from low end commercial mixtures (commercial 3500-psi) to high end enhanced durability (CRED). Even with an update in ACI 332 requirements in 2020, the CRED mixture still goes beyond the SCM substitution limits set by the code. This update, as well as the implications of the error variables used in phase two, will be further discussed in the literature review.

LITERATURE REVIEW

ABSENCE OF CURING

According to the Portland Cement Association (PCA), curing of freshly placed concrete is crucial for both strength and durability properties to develop (1). Compressive strength, a main strength factor in concrete, can be seen to decrease as much as 18% in seven days when not properly cured (2) which can lead to structural concerns. Durability concerns related to improper curing of concrete include the increase of permeability, which leads to higher levels of chloride ion penetration (3). While it is not expected that concrete in the field be cured to the same degree as concrete cured in a laboratory setting, efforts can be made to sufficiently cure freshly placed concrete to reach strength and durability requirements. These requirements, listed by ACI 308, include ponding, the use of wetted burlap, the use of plastic sheets, or any method effective creating or maintaining moisture levels adequate to promote the hydration of Portland cement (4).

TABLE 1. ACI 332 2014 AND 2020 REQUIREMENTS

YEAR - CLASS	MIN. 28 DAY COMPRESSIVE STRENGTH (PSI)	MIN. CEMENTING CONTENT (LB/CY)	MAX WATER/ CEMENT (LB/LB)	DESIGN AIR CONTENT (%)	SLUMP (IN)
2014 - RF3	4000	None	None	6	9 max.
2020 - RF3	4500	None	0.45	6	None
2020 - RF4	5000	None	0.40	6	None

TABLE 2: PHASE II MIX DESIGNS

MATERIALS	COMMERCIAL 3500		COMMERCIAL ACI 332		CRED	
	No Cure	+2Gal/CY and Both	No Cure	+2Gal/CY and Both	No Cure	+2Gal/CY and Both
Type I/II PC, (lbs/CY)	375	375	451	451	312	312
Class F Fly Ash, (lbs/CY)	—	—	—	—	187.2	187.2
Class C Fly Ash, (lbs/CY)	105	105	113	113	—	—
Metakaolin, (lbs/CY)	—	—	—	—	20.8	20.8
No. 57 Stone, (SSD lbs/CY)	1816	1816	1854	1854	1911	1911
River Sand, (SSD lbs/CY)	1279	1279	1215	1215	1250	1250
Water, (lbs/CY)	250	266.7	250	266.7	203	219.7
Design Percent Air, (%)	6	6	6	6	6	6
Air Entrainer, (oz/cwt)	1.05	1.05	1.05	1.05	0.6	0.6
Mid-Range Water Reducer, (oz/cwt)	4.18	4.18	7.42	7.42	8.75	8.75
High-Range Water Reducer, (oz/cwt)	—	—	—	—	7.25	7.25
w/cm (lb/lb)	0.52	0.56	0.44	0.47	0.39	0.42

ADDITION OF WATER AT JOBSITE

The water-cementitious materials ratio (w/cm) is a principal factor when it comes to the strength and durability properties of concrete (5). A change in the w/cm requires the appropriate change to other mix design characteristics as well, such as cement content and aggregate volume (6). An addition of water in the field before or during placement is often done to increase the workability of the concrete, however this action comes with serious consequences related to strength and durability properties. Water content beyond what the mix design calls for has been shown to decrease the compressive strength due to a higher w/cm (7). An excessively fluid mixture can see the segregation of mix components as well, such as fine aggregates and cementing materials (8). Durability problems occurring due to an increase in w/cm include, but are not limited to, an increase in absorption and higher levels of abrasion (9) (10). Keeping w/cm low proves to be a key way to lower the rate of intrusion of potentially harmful chemicals as well as minimize the negative effects caused by exposure to harmful chemicals. (11) (12).

UPDATE OF ACI 332

Between phase one and two of this research, ACI 332 updated its requirements for residential concrete with the potential of exposure to freeze/thaw conditions. Phase one considered the most stringent class of the freeze/thaw category in ACI 332-14, which was class RF3 (13). With the update of ACI 332 in 2020

came the addition of a new, even more stringent class in this category, RF4 (14). All of the classes in the freeze/thaw category have new requirements and even different types of requirements than were seen before, as shown in Table 1.

Most changes seen are important to this research, as we know that a low w/cm mix, such as CRED, is proficient in preventing damage caused by deicing salts. Table 1 shows that the update included the addition of a maximum w/cm, and that the now most stringent class requires the lowest maximum w/cm in its category. This further establishes the relationship between low w/cm mixes and high durability concrete. Also note that the minimum required compressive strength at 28 days is now 5,000-psi for the most stringent category, which is an increase over the previous version's highest minimum required compressive strength of 4,000-psi. Since RF4 is now the most stringent class, phase two will be comparing to its requirements although it is noted that the mixes used were designed before this class addition.

TCA STUDY

CONCRETE MIXTURES

The mixtures used in phase two of this research are those that performed poorest (commercial 3500), intermediate (commercial ACI), and best (CRED) in phase one. The TCA procured these

GOING BEYOND ACI 332: Commercial/Residential

Enhanced Durability Concrete: Phase II — WHAT IF?

mixtures to TTU researchers for phase one. ACI 332-20 lists the same SCM substitution limits as it did in 2014, so CRED is still going beyond ACI 332. The commercial ACI mixture was designed to adhere to ACI 332 specifications from 2014, before the addition of a maximum w/cm, however in order to make accurate comparisons this mix design had to remain unchanged. Since the commercial 3500 mixture was not designed to meet ACI 332 specifications, it is only used to show how common low-end mixtures perform under the applied variables and deicing salts. The mix design of each mixture with the applied variables is seen in Table 2, and the comparison of commercial ACI and CRED mix design characteristics to ACI 332-20 is seen in Table 3.

Table 2 shows the differences between the Control and No Cure variables of each mixture and the +2Gal/CY and Both variables of each mixture. The applied variables only affect the water content and w/cm, which is highlighted in Table 2 and compared to RF4 specifications in Table 3. The application of +2Gal/CY caused both the commercial ACI and CRED mixtures to exceed the RF4 specifications of a 0.40 maximum w/cm.

CONDITIONING AND TESTING PROCEDURE

Due to oven size constraints, only one batch of cylinders was able to be produced per variable, leading to a total of nine batches of cylinders. Each batch contained twelve 4" x 8" cylinders and nine 3" x 6" cylinders. The conditioning and testing procedure used in phase one was also used for phase two. This entailed the durability conditioning schedule listed in Table 4, which involves a week-long soak of the cylinders in a 15% by mass solution of deicing salts followed by a week-long period of oven drying at 125°F. This conditioning cycle began at the end of the 28-day curing cycle (or lack thereof) and was continued until 280 days

of age. The hardened state testing of cylinders occurred at the same ages used in phase one as well, which were 28, 224, and 280 days of age. The detailed schedule of hardened state testing is shown in Table 5. Compressive strength, tensile strength, static modulus of elasticity, and the determination of absorption after boiling were conducted at the previously mentioned ages in accordance to ASTM C39-21 (15), C496-17 (16), C469-14 (17), and C642-13 (18), respectively. Surface resistivity (SR), done in accordance to AASHTO T358-17 (19), was performed at 7, 14, 21, and 28 days for the Control and +2Gal/CY variables, however this method's testing schedule was modified for the No Cure and Both variables. Since AASHTO T358 specifies that the cylinders be saturated up until the time of testing, the No Cure and Both variable batches were tested only at 28 days with two previous of saturation in the curing tank. This was done so that the variable effect of the absence of curing was not undermined and that the test results could be considered accurate.

RESULTS AND ANALYSIS

Table 6 shows the comparison of plastic property results of each variable to ACI 332-20 RF4 requirements. Note that although slump is not a plastic property requirement of ACI 332-20, it is still listed in Table 6 to show how the applied variables, mainly the effect of extra water, effect this plastic property. Also note the commercial 3500 plastic property results are listed in Table 6 but not compared to RF4 requirements. The percent weight gains of the 3" x 6" cylinders due to the retention of deicing salts were calculated using the mean weight of the batch at the beginning of the durability conditioning cycle as a control weight. Figures 1, A-1 and A-2 graphically show the relationship between the percent weight gain and the number of cycles in the conditioning

TABLE 3: COMPARISON TO ACI 332-20 RF4 SPECIFICATIONS

PROPERTY	ACI 332-20 RF4 REQUIREMENTS	COMMERCIAL ACI 332		CRED	
		No Cure	+2Gal/CY and Both	No Cure	+2Gal/CY and Both
w/cm	0.40	0.44	0.47	0.39	0.42
% Class C Fly Ash Substitution	25 Max	20	20	0	0
% Class F Fly Ash Substitution	25 Max	0	0	36	36
Total % of Fly Ash, Silica Fume, Slag, and other Natural Pozzolans	35 Max	20	20	40	40

TABLE 4: DURABILITY CONDITIONING SCHEDULE

PROCEDURE	FIRST 28 DAYS	ODD WEEKS	EVEN WEEKS
Limewater Curing	X*		
Drying at 125°		X	
Weight Determination		X	
Digital Image Taken		X	
Soak in Deicer Solution			X

*Excluding No Cure and Both variables

TABLE 5: HARDENED STATE TESTING PROTOCOL

TEST	28 DAYS	224 DAYS	280 DAYS
Compressive Strength	(2) 4" x 8" Cylinders	(2) 4" x 8" Cylinders	(2) 4" x 8" Cylinders
Tensile Strength	(2) 4" x 8" Cylinders	(2) 4" x 8" Cylinders	(2) 4" x 8" Cylinders
Modulus of Elasticity	(1) 4" x 8" Cylinder	X (1) 4" x 8" Cylinder	(1) 4" x 8" Cylinder
Absorption After Boiling	(3) 3" x 6" Cylinders	(3) 3" x 6" Cylinders	(3) 3" x 6" Cylinders

TABLE 6: PLASTIC PROPERTY RESULTS COMPARED TO RF4 SPECIFICATIONS

MATERIALS	ACI 332-20 RF4 REQUIREMENTS	COMMERCIAL 3500		COMMERCIAL ACI 332		CRED	
		No Cure	+2Gal/CY and Both	No Cure	+2Gal/CY and Both	No Cure	+2Gal/CY and Both
Slump (in)	—	5	8	3.5	8	5.75	9
Air Content by Pressure Meter (%)	6 ± 1.5	6.3	6.9	5.4	5.8	6.2	5.3

TABLE 7: 28-DAY SR RESULTS (KILOHM-CM) AND LEVEL OF POTENTIAL CHLORIDE ION PENETRATION

VARIABLE MIXTURE	CONTROL	NO CURE	+2GAL/CY	BOTH
Commercial 3500	12.3	8.3	11.2	7.2
	Moderate	High	High	High
Commercial ACI	12.4	10	11.5	8.5
	Moderate	High	High	High
CRED	30.3	25.8	33.7	22.8
	Low	Low	Low	Low

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process, noting that the gentler the slope of a trendline, the more constant the rate of deicing salt retention is.

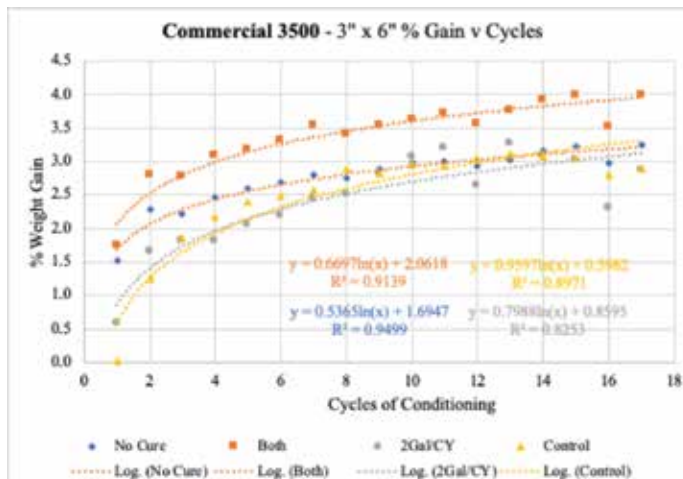


Figure 1: Mean 3" x 6" Cylinder Weight Gain vs Number of Cycles

AASHTO T358-17 explains that a higher SR value correlates to a better resistance to chloride ion penetration. Table 7 shows the designation of each variables' resistance according to AASHTO T358-17. A visual representation of how the absence of curing affects the amount of intrusion of deicing salts in all three mixtures is shown in Figure 2, while the effects of the other applied variables are shown in Figures A-3 and A-4.



Figure 2: Deicing Salt Penetration After 280 Days in 4" x 8" Cylinders (a) Commercial 3500 No Cure (b) Commercial ACI No Cure (c) CRED No Cure

Performing the hardened state tests at the same ages used in phase one allowed the calculation of percent difference in means for the respective engineering properties. The means and percent differences between the applied variable results and the control results are shown in Tables 8 through 10. A decrease in an engineering property (with the exception of absorption after boiling) shows that the applied variable negatively impacted that

engineering property at the specified testing age, and is represented by a negative number. Positive percent changes represent an increase in the engineering property, again with the exception of absorption after boiling, indicate an instance where the applied variable had a positive impact on the engineering property at the specified testing age. Since absorption after boiling results are not appropriate to be compared with a percent difference due to the high negative impact to durability caused by small increases in absorption, Table 11 shows the absorption after boiling results as well as whether or not the results are within the criteria for high performance concrete (HPC) according to Portland Cement Association (PCA), which is 2% to 5% absorption.

Table 11 shows the results of absorption after boiling as well as its relationship to HPC. If the result is within HPC limits, then it is designated as "HPC," whereas if the result is higher than the HPC limits, it is designated as "Above." Absorption after boiling has an inverse relationship with durability, because the higher the absorption, the more potentially harmful chemicals the concrete will absorb. Figure 3 shows how each variable affected the percent loss in compressive strength, tensile strength, and modulus of elasticity in the commercial 3500 mixture. Note that the percent loss is averaged across the 28-, 224- and 280-day testing ages. Figures A-5 and A-6 show the same relationship for commercial ACI and CRED.

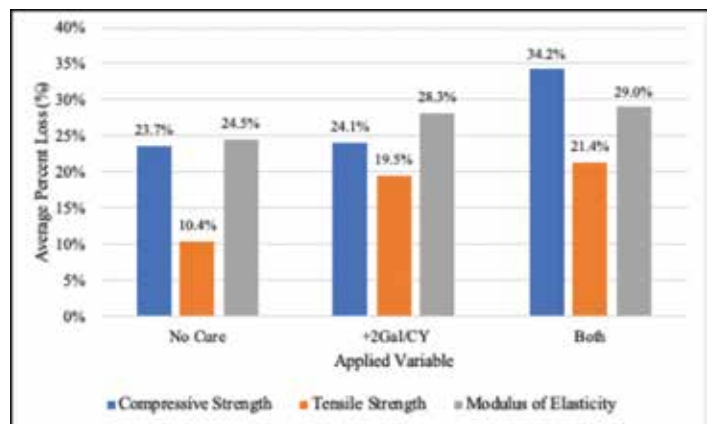


Figure 3: Average Percent Loss in Engineering Properties Due to Applied Variables in Commercial 3500

CONCLUSIONS

Based on the results shown, we can conclude that:

1. CRED, a low-permeability mixture, was able to withstand the deleterious effects of the deicing salts while under the influence of the common errors seen in the field better than the commercial mixtures used in this study.

TABLE 8: MEAN COMPRESSIVE STRENGTH RESULTS AND PERCENT DIFFERENCE FROM CONTROL

MIXTURE	VARIABLE	28 DAYS		224 DAYS		280 DAYS	
Commercial 3500	No Cure	2980 psi	-42.7%	2630 psi	-16.8%	2280 psi	-11.6%
	+2Gal/CY	3860 psi	-25.8%	2380 psi	-24.7%	2020 psi	-21.7%
	Both	2790 psi	-46.3%	2320 psi	-26.6%	1810 psi	-29.8%
Commercial ACI	No Cure	4060 psi	-38.6%	3940 psi	-29.5%	2990 psi	-14.1%
	+2Gal/CY	5370 psi	-18.8%	3120 psi	-44.2%	2450 psi	-29.6%
	Both	3890 psi	-41.1%	3690 psi	-34.0%	2620 psi	-24.7%
CRED	No Cure	5980 psi	-31.8%	9510 psi	-6.8%	9240 psi	-13.3%
	+2Gal/CY	7110 psi	-18.9%	8840 psi	-13.3%	8330 psi	-21.9%
	Both	5610 psi	-36.0%	8390 psi	-17.7%	8140 psi	-23.6%

TABLE 9: MEAN TENSILE STRENGTH RESULTS AND PERCENT DIFFERENCE FROM CONTROL

MIXTURE	VARIABLE	28 DAYS		224 DAYS		280 DAYS	
Commercial 3500	No Cure	295 psi	-33.0%	260 psi	-7.1%	245 psi	8.9%
	+2Gal/CY	350 psi	-20.5%	230 psi	-17.9%	180 psi	-20.0%
	Both	260 psi	-40.9%	240 psi	-14.3%	205 psi	-8.9%
Commercial ACI	No Cure	375 psi	-29.2%	275 psi	-15.4%	295 psi	-3.3%
	+2Gal/CY	550 psi	3.8%	265 psi	-18.5%	250 psi	-18.0%
	Both	350 psi	-34.0%	240 psi	-26.2%	275 psi	-9.8%
CRED	No Cure	495 psi	-12.4%	550 psi	-10.6%	545 psi	7.9%
	+2Gal/CY	605 psi	7.1%	430 psi	-30.1%	475 psi	-5.9%
	Both	455 psi	-19.5%	480 psi	-22.0%	480 psi	-5.0%

- The combined effects of the absence of the curing and the addition of water at the jobsite created the “worst-case scenario” in terms of loss in engineering properties when compared to the control variable.
- The addition of water at the jobsite caused more instances of average percent loss in engineering properties than the absence of curing.
- The +2Gal/CY variable had some positive effects on CRED, leading to the conclusion that CRED’s original w/cm may have been slightly low.
- +2Gal/CY allowed further penetration of deicing salts into the cylinders, however at a lower concentration than the other variables.

DISCLAIMER

The opinions expressed herein are those of the authors and not necessarily the opinions of the Tennessee Concrete Association (TCA).

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APPENDIX A

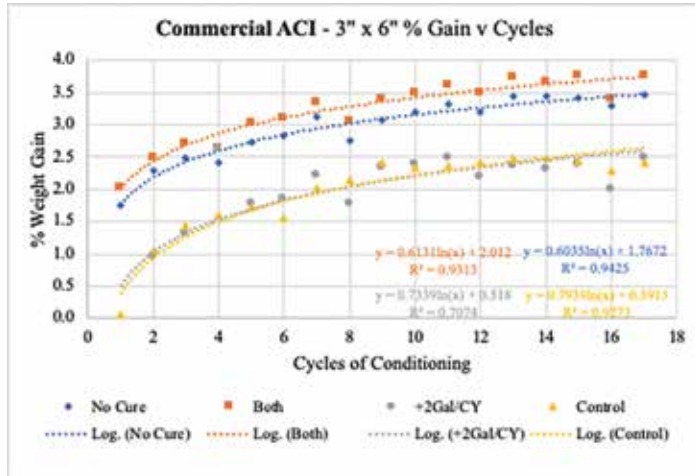


Figure A-1: Mean 3" x 6" Cylinder Weight Gain vs Number of Cycles

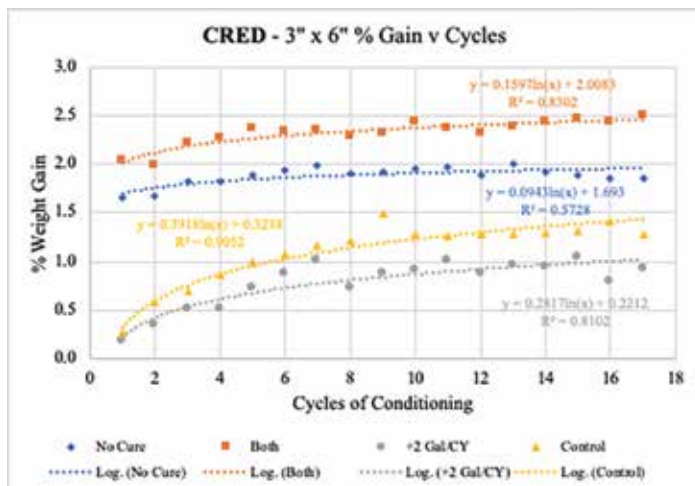


Figure A-2: Mean 3" x 6" Cylinder Weight Gain vs Number of Cycles



Figure A-3: Deicing Salt Penetration After 280 Days in 4" x 8" Cylinders (a) Commercial 3500 +2Gal/CY (b) Commercial ACI +2Gal/CY (c) CRED +2Gal/CY



Figure A-4: Deicing Salt Penetration After 280 Days in 4" x 8" Cylinders (a) Commercial 3500 Both (b) Commercial Both (c) CRED Both

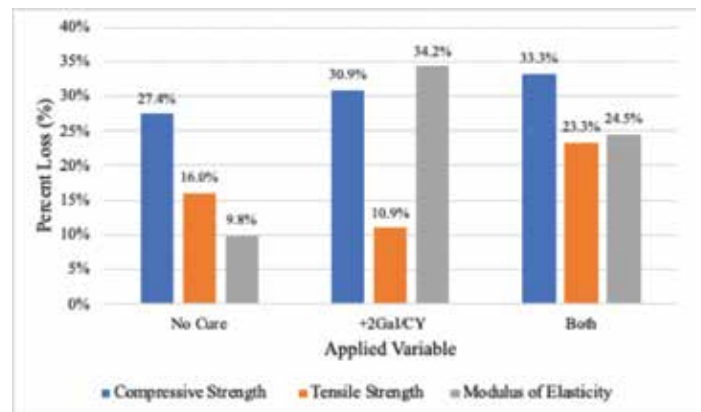


Figure A-5: Average Percent Loss in Engineering Properties Due to Applied Variables in Commercial ACI

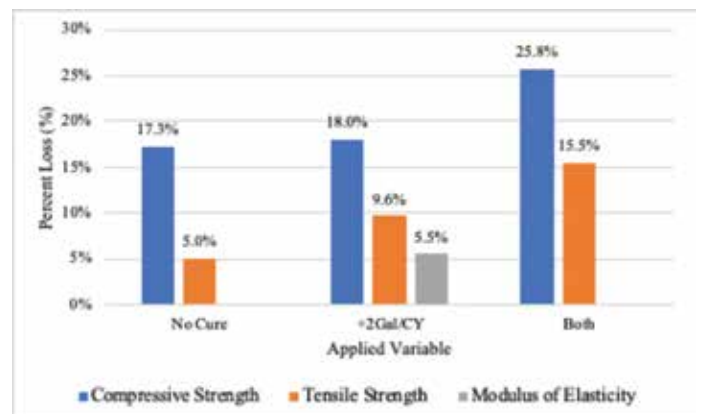


Figure A-6: Average Percent Loss in Engineering Properties Due to Applied Variables in CRED

TABLE 10: MEAN STATIC MODULUS OF ELASTICITY RESULTS (10⁶) AND PERCENT DIFFERENCE FROM CONTROL

MIXTURE	VARIABLE	28 DAYS		224 DAYS		280 DAYS	
		Modulus (10 ⁶ psi)	% Diff	Modulus (10 ⁶ psi)	% Diff	Modulus (10 ⁶ psi)	% Diff
Commercial 3500	No Cure	3.65 psi	-7.6%	1.60 psi	-39.6%	1.20 psi	-26.3%
	+2Gal/CY	4.10 psi	3.8%	1.00 psi	-62.3%	0.70 psi	-26.3%
	Both	3.45 psi	-12.7%	1.10 psi	-58.5%	0.80 psi	-15.8%
Commercial ACI	No Cure	3.95 psi	-8.1%	2.15 psi	-14.0%	1.25 psi	-7.4%
	+2Gal/CY	4.20 psi	-2.3%	1.10 psi	-56.0%	0.75 psi	-44.4%
	Both	3.95 psi	-8.1%	1.70 psi	-32.0%	0.90 psi	-33.3%
CRED	No Cure	4.90 psi	5.4%	5.10 psi	4.1%	5.05 psi	4.1%
	+2Gal/CY	4.60 psi	-1.1%	4.45 psi	-9.2%	4.55 psi	-6.2%
	Both	4.85 psi	4.3%	4.85 psi	-1.0%	4.85 psi	-1.0%

TABLE 11: ABSORPTION AFTER BOILING RESULTS AND HPC CRITERIA DESIGNATION

MIXTURE	VARIABLE	28 DAYS		224 DAYS		280 DAYS	
		Absorption (%)	HPC Designation	Absorption (%)	HPC Designation	Absorption (%)	HPC Designation
Commercial 3500	No Cure	5.0%	HPC	5.9%	Above	6.1%	Above
	+2Gal/CY	5.7%	Above	7.9%	Above	7.6%	Above
	Both	6.1%	Above	6.8%	Above	7.1%	Above
Commercial ACI	No Cure	5.1%	Above	7.0%	Above	6.5%	Above
	+2Gal/CY	5.1%	Above	7.1%	Above	6.9%	Above
	Both	5.5%	Above	7.4%	Above	6.6%	Above
CRED	No Cure	4.1%	HPC	4.1%	HPC	3.3%	HPC
	+2Gal/CY	3.9%	HPC	4.0%	HPC	3.9%	HPC
	Both	4.7%	HPC	4.3%	HPC	3.9%	HPC

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1ST
STORMPROOF

by Annabella Wooten



“Mom?
Mom,

I-I don’t know what to do . . . I can see it, it’s almost at the shed. Dad’s still at work and Taylor’s

at her friend’s. Mom, please come home, I can’t — I don’t think I can do this.”

Twelve-year-old Cassie sat huddled in the corner of her room, clutching her phone, tears running down her face. Her mom’s voice came over the little speaker:

“Oh, sweetie, I know, but I can’t come home right now. The tornado is picking up speed and it just wouldn’t be safe honey, you know that. But hey, I have a little secret for you. Do you know what material our house is made out of?”

“Well, no. I don’t.”

“Then I’ll be the first to tell you. When we moved here, we sacrificed a lot of things to invest in a fully concrete house. Do you know what that means?”

Little Cassie sat silent for a moment, then whispered, “That we’ll be safe? That . . . that I’ll be safe?”

“That’s exactly right.”

For the first time, Cassie looked up and at the four walls surrounding her, and for the first time that night, Cassie felt at peace. Her mom’s voice came through again: “Now all you need to do is distance yourself from any windows and just get comfortable. See, we don’t have anything to worry about. Do you think you’re going to be okay?”

“I-I think so.” With wobbly legs, Cassie stood up from her corner and glanced out the window, noticing the concrete casing surrounding it. “It-It’s really bad outside

right now. Are you sure I’ll be okay?”

“Positive.”

50 Years Later

“I lost my sister that day,” Mrs. Cassandra told the group of students attending the school assembly. “By the time we found out about the tornado, it would be too dangerous and too late for her to come back home. I wish there was something I could have done. My mother was stuck at work. The tornado passed by them before it got to our house, and the roof of their building collapsed on them, but my mom, along with many others that avoided the collision, stayed to clean up the mess and help those that were injured. My dad and his co-workers were all in their underground concrete storm shelter and avoided any injuries. I was safe at home, but there was nothing that I could have done to save my sister., Taylor. So, in honor of her, I started advocating for people to invest in more stable and stormproof housing. Even in my sixth grade, I wanted everyone to know the importance of concrete and how it had saved my life. When I graduated college, I immediately took up a job with our local concrete plant, and now I volunteer at schools and workplaces to share my story.”

Mrs. Cassandra looked around the auditorium as a single student raised his hand.

“Mrs. Cassandra? My grandmother was a close friend of Taylor’s. She’s told me the story before — of how you came to school talking about concrete. Everyone thought you were crazy, but she knew. She moved to the coast after high school and started a nonprofit that built concrete homes for low-income households in hurricane-zones that couldn’t afford it. I can’t tell you how much of a difference you and your story made in

my grandmama’s life, and in turn, so many others. So, I guess what I’m trying to say is . . . thank you.”

2ND
STRENGTH AND DESTRUCTION

by Rachael Sexton



I can’t believe what’s in front of my eyes. Everything I’ve ever known is gone. Debris lines the streets

and houses have been turned inside out. I’ve seen things like this in the media, but it’s always seemed so far away. Now that it’s happened, everything seems so surreal. It feels like a bad dream and in a few minutes I’ll wake up and everything will go back to normal. But as I watch the volunteers help clean up the hurricane remnants, I know just know how real it all is. I carefully pick my way through the remains of my home, past the broken picture frames and ruined family heirlooms. Nothing is salvageable. All I have left are the clothes on my back. I have nothing else to do but follow a trail of people being led by a nice volunteer. I’m being told that we’re being taken to one of the only buildings left standing. It takes a bit, but we finally reach our destination. It seems like something from a movie. Everything around us is destroyed and only one lone building is all that’s left. The volunteer ushers us in and gives us all blankets to keep us warm. Despite everything that’s happened, I can’t help but wonder why this building is the only one left standing. And apparently, I’m not the only one. I can hear the family next to me

talking about the same thing.

The small boy looks at his father, “Why couldn’t our house stay Daddy? How come they’re so lucky?”

His father looks down, “Well, Jack sometimes life doesn’t go as planned. We just have to be thankful we made it out and got as lucky as we did.”

A few people to their left had also overheard the family’s conversation and began to talk amongst themselves.

“Well, I’ll tell you somethin’ Diana, luck had nothing to do with why this place is still standing.” A man in his mid-twenties told the woman next to him.

She turned and looked at him, “What do you mean?”

“This building is made from concrete!” He said it like it was the most obvious thing in the world. “What does that have to do with anything?”

“Concrete is one of the best building materials anyone can ever use. It’s one of the most durable, fire-resistant, and stable materials out there. They’re so reliable that when concrete wall systems were tested against high winds that were designed to simulate hurricanes, there was no structural damage at all! When all of this is over, I’m rebuilding my house with concrete. I’ve learned my lesson.”

I think about the man’s words as I look around and from what I can tell, he’s right. There is no damage to the inside, in fact, it almost looks brand new. And from what I could tell from the little bit I saw of the outside, it looks pretty good too, all things considered. The difference between this building and my neighborhood is huge. Losing everything, all my personal belongings, is one of the hardest things to ever happen to me and I never want or wish this to happen to me or anyone else again. I think I’ll have to agree with the young man, I am definitely going to use concrete in my next home.

LIQUID PERMANENCE

by John Cordwell III

3RD



It was 6 a.m. On a chilly November morning when Dad woke me and drug me out of bed to assist him with another

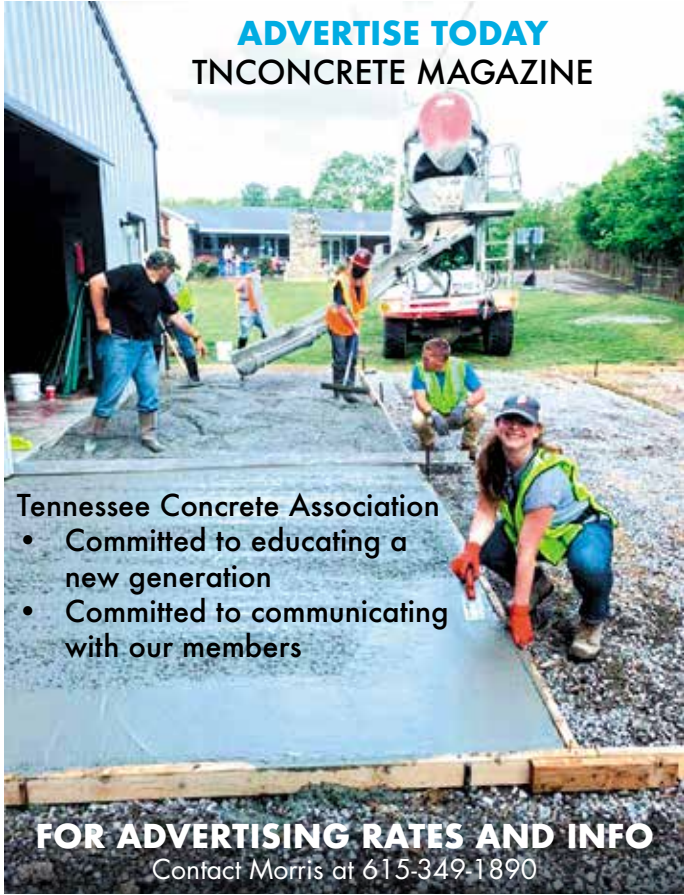
one of his “projects.” He had been up since 5:00 a.m. prepping come-alongs, trowels, spreading plastic tarps, and placing wheelbarrows. Dad always has a project or 10 queued up, and this one required three men. Dad had me. In the past, Dad recruited me to work on projects constructed out of wood and steel, but this morning would be my first foray into the world of mud. “Mud,” as Dad explained, was any substance found on a job site that was wet. However, this specific mud was different, and its permanence was almost daunting. It has the strength to withstand floods and hurricanes; it is an integral part of every modern building, and the foundation of every skyscraper, stadium, and industry. This substance has met the demand of architectural design for centuries, but—more importantly—it has met the need for growth and flexibility even in its inflexible state. Its versatility is found in the millions of cubic yards of curves, arches, bridge supports, and dams around the world. Dad’s project paled in comparison to these legacies of society, but today, as we prepared to pour a slab, sidewalk, and 6 piers, I was to become a humble participant to this age-old trade. As I pondered the maze of wood and stakes laid out on the ground, I marveled at the

thought of the protruding steel structures about to be encased in this heavy, soon to be solid, man-made rock.

The purveyor of our day’s labor arrived just after 6:30 a.m. In short time, we were shuffling wheelbarrow loads 50 feet to the first of several locations where the mixture would spend the next 100 years or more. I thought to myself how these structures would outlast me and how they had the potential to outlast anyone I knew or may ever know. I recognized the significance of this small project which I was to play a role. Twenty-two loads later, the chute could now reach the large excavated holes where steel reinforcing bars awaited their forever friend and protector. The next hour was a flurry of screed boards, bull floats, and orders for shovel loads in low lying areas followed by Dad quickly troweling the surface flat.

A mere hour and a half after arriving, the massive delivery vehicle lumbered back down the road to fulfill another mission. I relaxed thinking things could only get easier from here. “Grab that edger!” I heard Dad shout, “She’s going to fire-off! His instructions were simple: “Run this trowel around the edge, don’t gouge, and stay clear.” I edged with the trowel for what felt like hours. Initially, my work seemed easy, but I soon learned the effects of the chemical reaction happening below me; the mud was setting up. Before long, the hogs and dips were flat, the edges were round, and the surface was brushed smooth and straight. As the greenhorn, I was tasked with cleaning the equipment in the now dwindling daylight. It may have only been 8 cubic yards, but it might as well have been 100 for my tired body. I could hear Dad muttering, tapping form boards, and removing errant leaves while wearing the greatest look of satisfaction. “Good job, buddy” he said. “You worked hard today, I’m proud of you.” ✱

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