March/April 2024
Vol. 37, No. 2

CRB
CONCRETE REPAIR BULLETIN

PLAN — INSPECT — RESTORE

PREVENTING STRUCTURAL FAILURES

ICRI
CONCRETE REPAIR
Restore | Repurpose | Renew

Concrete Repair Bulletin
is published bimonthly by the:
International Concrete Repair Institute, Inc.
1601 Utica Avenue South Suite 213
Minneapolis, MN 55416
www.icri.org

For information about this publication or about membership in ICRI, write to the above address, phone (651) 366-6095, fax (651) 290-2266, or email info@icri.org. The opinions expressed in *Concrete Repair Bulletin* articles are those of the authors and do not necessarily represent the position of the editors or of the International Concrete Repair Institute, Inc.

ISSN: 1055-2936

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ON THE COVER: Learn how a Florida condominium solved a water intrusion problem; see page 17.

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FEATURE ARTICLES

DEPARTMENTS

The International Concrete Repair Institute is the leading resource for education and information to improve the quality of repair, restoration, and protection of concrete. Visit www.icri.org.

PRESIDENT'S MESSAGE

BRIAN MACNEIL

PLAN–INSPECT–RESTORE

Benjamin Franklin once said, "If you fail to plan, you are planning to fail." I could write this whole CRB using personal examples supporting that quote, from trying to run a meeting without a set agenda/deliverable to showing up to the grocery store without a list. From not practicing a presentation before the big show to showing up to a jobsite without the proper PPE. I am sure we could all put our pride aside for a minute and admit that there have been the odd circumstance(s) in our lives where we could have invested a bit more time in the planning portion and it would have saved us a lot of time dealing with the unanticipated result.

Experience teaches us how to weigh the potential consequences that come from improper or lack of planning. In the examples above what are the consequences? Without an agenda you waste people's time. Without a shopping list, you are potentially making another trip to the store or maybe you are feeding your kids crackers and pickles with "questionable" cream cheese for dinner. If you don't prepare for your presentation, you risk not delivering the intended message during that presentation. And you do not have to worry about not having proper PPE when you show up to a job site. Every project manager, site super, and foreman love spending the time finding you spares to wear. Don't worry. It is never a hassle. Be that person. It's fine. (Disregard the sarcastic tone in the PPE example! Just always be sure you know what PPE is required or being provided before you head to a job site. You will not get far on a job site if you are not prepared!)

For the most part, you can navigate through the consequences. But how does this relate to our concrete infrastructure? Can we as easily navigate through the consequences that arise when we do not have a plan in place for the longevity of concrete structures?

Planning and inspecting concrete infrastructure are crucial aspects of ensuring the longevity, safety, and functionality of our concrete structures. The planning phase lays the foundation for a successful project by considering various factors such as load requirements, environmental conditions, and site-specific challenges. Initial planning helps in selecting the appropriate concrete mix, reinforcement, and construction methods, contributing to the overall durability of the infrastructure.

Planning for periodic inspections over the life of the structure is a huge contributor to a project's overall success. Ongoing inspection plays an important role in maintaining the structural integrity of the concrete throughout its lifecycle. Regular inspections help identify potential issues, such as cracks, corrosion, or wear, allowing for timely intervention and maintenance. This proactive approach minimizes the risk of catastrophic failures and extends the service life of the structure. Inspections also play a vital role in ensuring compliance with safety standards and regulations, safeguarding public well-being.

Concrete infrastructure—such as bridges, dams, and buildings—is often exposed to harsh environmental conditions, including temperature variations, moisture, and chemical exposure. Effective planning considers these factors to select materials and construction methods that can withstand such challenges. Meanwhile, regular inspections assess the impact of environmental conditions over time, enabling the implementation of necessary repairs or reinforcements to mitigate potential damage.

The importance of planning and inspecting concrete infrastructure cannot be overstated. Proper planning ensures that structures are designed to meet their intended purpose and endure environmental stresses. Meanwhile, inspections serve as a proactive measure to identify and address issues before they escalate, contributing to the safety, longevity, and functionality of concrete infrastructure.

The International Concrete Repair Institute is the leading content generator for extending the life of existing concrete structures–from our guidelines and webinars to our certifications and new budding applicator training program. If you tap into your ICRI resources while planning a project, you are tapping into the proven best practices that have been vetted and used by the best in the industry.

Speaking of the best in the industry, I would like to take a moment and thank ICRI staff and volunteers for their extremely successful execution at the World of Concrete trade show this past January. The ICRI booth and presence were well planned out. It was examined and adjusted in real time during the show. The ICRI membership appreciation kickoff party and CSMT program were both second to none! And the overall results have been **phenomenal** with the number of new individual, company, and supporting members that signed up during the show! Not to mention the international interest to expand our presence across the oceans and down south! Thank you for all the hard work. If that's how this year is starting, we are going to have a year for the history books!

Sincerely,

Brian MacNeil

Brian MacNeil
President, International Concrete Repair Institute

DIRECTOR'S MESSAGE

ERIC HAUTH

After more than a year of analysis, vendor selection, and build out, we are extremely proud to announce the launch of ICRI's brand-new website, coupled with a new, best-in-class membership database platform!

If you're an ICRI member and haven't done so already, check out the new site, click the blue login button (upper right), and follow the instructions to create a new username and password. This will make it that much easier when it's time to renew your membership and when you wish to take advantage ICRI events, products, and services–including registration for ICRI's 2024 Spring Convention!

We launched this new platform in time for World of Concrete 2024, where ICRI saw record attendee interest (more on that further on in this column).

As we approached ICRI's 35th Anniversary in 2023, ICRI leadership committed to upgrading our systems to power the organization's future growth and success. In preparing for this edition of the CRB, I was struck by the parallels between this technology upgrade and the theme of this CRB: Plan–Inspect–Restore. Preventing Structural Failures.

Of course, the excellent technical articles in this magazine focus on infrastructure and buildings. And yet, as a professional association, we also need to "plan, inspect, and restore" our own organizational systems to ensure the best possible member experience. With this new website and database platform, we're excited to have the technology tools in place to thrive well into the future!

As noted above, we launched this new platform just in time for World of Concrete 2024. I have to tell you, the exhibit traffic at the ICRI booth and interest in the organization was off the charts! It's very clear that ICRI's mission, guidelines, training, and products (especially the CSP chips) continue to gain traction in North America and throughout the world. ICRI volunteer leaders and staff had numerous discussions with repair professionals from the U.S., Canada, Mexico, the Philippines, China, Australia, Spain, UAE, Ghana, and other countries around the world, all interested in the tools and resources that ICRI offers. We were also able to sign up new members and sell products onsite seamlessly, thanks to the new database platform–a much improved point-of-sale experience over previous years.

A huge thank you and shout out to the incredible team of ICRI volunteers and staff who represented ICRI at the booth with tremendous positivity and professionalism. (I'm pretty sure our booth neighbors were a little jealous!)

As we now look forward to the ICRI Spring Convention in Boston, we can't wait to build on our organizational enhancements and hopefully set a new ICRI convention attendee record. With our New England Chapter hosts, this will be another exceptional convention and one you don't want to miss.

As always, we thank our many members and volunteers for your commitment to ICRI. I hope to see you in Boston or at a future ICRI event!

Sincerely,

Eric Hauth

Eric Hauth
ICRI Executive Director

COMMITTEE 120: ENVIRONMENTAL HEALTH AND SAFETY

MISSION STATEMENT

Committee 120 is dedicated to building a culture of safety through training and education. We strive to minimize accidents in our concrete repair community, and our passion for safety awareness, health, and personal responsibility promotes wellbeing and a higher quality of life.

BENEFITS OF COMMITTEE MEMBERSHIP:

- Promote, identify, and correct hazards before they can cause injury.
- Promote safe working practices and facilitate safety training.

WHAT WE DO:

- Provide our association with a learning experience that promotes a safety awareness culture.
- Provide our association members with education that mitigates safety concerns in the concrete industry.

GOALS/DELIVERABLES

1. Updating and promoting our Safety Guidelines.
2. Promoting and administering of the ICRI Safety Award.
3. Developing innovative ways to promote a safety culture among our community.
4. Working on an interactive app that will tie into our safety database and link other informational sites.
5. Developing short YouTube safety videos.

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TACTALK

MATTHEW SHERMAN

As I write this, ICRI just finished our January Board of Directors meeting and our exceptional experience at World of Concrete. The organization is gaining speed and excitement, with great accomplishments at the fall convention, a renewed focus on our members and customers, new training and education programs, and new technical offerings. The vitality is palpable and exciting.

At the fall convention the technical committees were able to get together and advance our offerings, with great strides in the rebar cleanliness app, document development, and most importantly, a dedicated Chair session that looked at how we can best serve our clients and members. At the training session, we looked at how our current offerings do (or don't) serve our members and clients and explored how we could adjust our course to better meet those needs. There is renewed interest in delivering "bite-sized" information that can help engineers, owners, contractors, and regulators understand repair/rehabilitation and accomplish their goals. Watch for some of these quick-hits to be published soon on subjects such as surface preparation, non-destructive testing, bond testing, and quantity tracking/payment. If you have ideas or want to contribute, reach out to us at TAC or a specific committee to be part of the action!

The Board meeting carried a similar theme, with our new President, Brian MacNeil, emphasizing communication as a key theme of his term. We asked the Board members to talk to our members at local Chapter meetings to help us, your technical committees, understand your needs and help you accomplish them. Several ideas from the Board meeting included training sessions (online or in person) to supplement and support our contractor members, educational material for clients to show the advantage of working with ICRI members, and supporting material to help ensure best practices of our designer members. Expect to hear from your Regional or At-Large board members on this topic.

New educational and training materials are showing great progress, with multiple webinars, presentations, and training programs (such as the pilot-tested Field Applicator Training) getting great interest and participation. TAC along with the Administrative and Technical Committees are doing all they can to support these efforts.

Lastly, our upcoming spring convention in April is sure to be a great event. As a Bostonian, I welcome you and invite you to come on up a little early and enjoy the history, character, and experience of our fine city. Once you are here, please participate in our Technical Committees, whether by joining one and sharing your expertise or by simply letting us what you need. We look forward to hearing from you.

Matthew Sherman is chair of the Technical Activities Committee (TAC).

SUPPORTING MEMBERS

ICRI would like to thank its Supporting Members, whose dedication to ICRI is greatly appreciated, and…

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CERTIFICATIONUPDATE

The ICRI Concrete Slab Moisture Testing (CSMT) Program had one of its biggest programs in January 2024 as ICRI participated once again in the World of Concrete at the Las Vegas Convention Center from January 22 through January 25, 2024.

ICRI hosted 30 people at World of Concrete, including six people who were re-certifications (after five years) and 6 people performing their 2nd recertifications (after 10 years) and one person who attended for the Education portion only. That left 18 individuals who went through the entire certification process including a demonstration and workshop as well as performance exams at the back of the South Hall on Day 2. The only way ICRI could certify and re-certify 24 people at an event like this is with the help of our amazing instructors. Thanks from ICRI goes out to lead instructors Peter Craig and Scott Tarr who helped with the class and the performance exams, and our friend Roland Vierra who joined us to help get all 24 people through the performance exam process. It was a fully engaged class with everyone passing both the written and performance exams. ICRI would like to congratulate our World of Concrete Drilling Contest winners Matthew Wilson, Chris Bates, Adam Shutt, and Julia Glendenning who all did an excellent job of hitting closest to the 2-inch mark.

If your company or your Chapter wishes to schedule a CSMT Program, please contact Dale Regnier (daler@icri.org) and provide him with contact information for the point person who will be in charge of coordinating the event, the proposed exam location, and potential date(s).

A group of 24 at the very back of the South Hall at the Las Vegas Convention Center for the demonstration and workshop with instructor Peter Craig front and center!

The winners of the drilling contest that accompanies the testing for ASTM F2170 during the CSMT program are (left to right) Adam Shutt (3rd place), Julia Glendenning (4th place), administrator Dale Regnier (center), Chris Bates (2nd place), and Matthew Wilson (1st place)

ICRI and the North Texas Chapter Team Up on Field Applicator Training Program

by Mark LeMay

Over the past six months, ICRI has been hard at work developing a pilot version of an exciting new program to better meet the needs of contractors in the field doing the hands-on work of concrete repair and restoration. After extensive preparation, ICRI, in conjunction with the North Texas Chapter, launched the pilot version of this new Field Applicator Training Program on December 13, 2023, at RTC Glass & Restoration facility in Carrollton, Texas. The all-day event was attended by 20 participants from NTX Contractor member companies (Fig 1). All participants are relatively new to the field of concrete repair and the majority were not familiar with ICRI guidelines.

Fig. 1: Group participants–Class photo

The training program is being developed by a Task Group of ICRI's Professional Development Committee to provide basic knowledge about reinforced concrete, substrate and surface preparation, repair materials and methods, and hands-on experience placing concrete repair materials in horizontal, vertical, and overhead applications. It is hoped that the program can eventually be conducted by ICRI Chapters and member companies under the guidance of ICRI's Subject Matter Experts.

BASIS OF TRAINING PROGRAM

The Field Applicator Training program is based upon industry best practices as outlined in ICRI's published Technical Guidelines and utilizes much of the basic information contained in ICRI's Concrete Surface Repair Technician (CSRT) program. By developing the program in tandem with the local chapter's support, the implementation and scalability of rolling it out to more chapters is being evaluated.

Another benefit to this training program is that it complements the CSRT certification by targeting the repair applicator in addition to expanding ICRI'S offering to the repair industry. As a one-day, in-person training program, the classroom sessions alternated with hands-on workstations, educating, and demonstrating the various aspects related to the proper repair of concrete surfaces.

PILOT PROGRAM

The first pilot program started with a classroom session presented by Stephen Grelle, PE, to review the components that make up reinforced concrete, the modes of concrete deterioration, and how to identify and properly remove areas of unsound concrete (Fig. 2). Special topics included identifying the locations and depths of embedded metal elements in a concrete element, using properly sized tools for the job, and outlining concrete removals around reinforcing bars, and proper repair geometry.

Fig. 2: Stephen Grelle, PE, presenting first classroom session

This session was followed by the first "workstation," where attendees had to acoustically sound a concrete slab using chain dragging, hammers, metal-sprocketed wheels, and steel rods to find and mark the delaminated and unsound sections of concrete (Fig. 3).

Surface preparation was the topic at the second workstation. The ICRI concrete surface profile (CSP) chips were on display, along with various tools and equipment used for surface preparation, including a shotblaster, scarifier, scabbler, and grinders with diamond cup wheels. Participants were introduced to the ICRI Guidelines on

Fig. 3: Mark LeMay demonstrates a sounding board at the Sounding Workstation

surface preparation (ICRI 310.1R and ICRI 310.2R) and instructed on the concrete surface profiles that can be attained with each piece of equipment.

The third workstation provided participants with the opportunity to chip out concrete around steel reinforcing bars located near the top surface of a concrete slab (Fig. 4). Valuable tips and techniques were provided by ICRI Surface Preparation Committee Chairperson Pete Haveron.

Fig. 4: Removing concrete from around reinforcing bars

Following a wonderful lunch provided by RTC, the second classroom session was presented by Dave Tepke, PE. This session was a review of the various methods of concrete placement, important properties of concrete repair materials, and the critical aspects of mixing, placing, finishing, and curing concrete repair materials.

Special emphasis was placed on reviewing items such as "saturated surface dry" (SSD), scrub coats, bonding agents, proper consolidation and timing for finishing and curing. Importance was placed on reviewing and understanding the product data sheets for each material planned for use on a project to know the application temperature and layer thickness limits, set times and cure times, etc.

At the fourth workstation, led by Dan Wald, Patrick Jorski, and Ben Koehler, participants were instructed on proper mixing techniques using drill and paddle mixers and a drum mixer. Separated into four teams of five, each team had the opportunity to mix the material they would be placing at the horizontal, vertical, and overhead workstations (Fig. 5).

Fig. 5: Participants mix repair material under the watchful eye of Ben Koehler

Jeff Welty, Pete Haveron, and Patrick Jorski provided valuable instruction and demonstrated proper techniques at each of the three placement workstations including horizontal with rebar embedment, vertical (Fig. 6), and overhead applications.

Fig. 6: Patrick Jorski and Pete Haveron provide instruction at the Vertical Placement Workstation

PROGRAM EVALUATION AND FUTURE

Once all teams had completed installing material at each workstation, a written quiz (provided in either English or Spanish) was given to the participants to help the Task Group evaluate comprehension levels for the presented material. The results indicated what the Task Group had expected: that while printed handout material was available in Spanish, native Spanish-speaking participants would benefit from classroom instruction in Spanish. Ideally, the plan is to offer the training program in Spanish once the content has been finalized.

Each participant was provided with a take-home binder (in English or Spanish) containing copies of several ICRI Guidelines and the classroom session slides (Fig. 7). All participants received a "Certificate of Completion" for the Training Program.

Fig. 7: Take-home program binders provided to each participant

A questionnaire was provided at the end of the program, and the Task Group obtained valuable feedback. Modifications are already in progress to shorten the classroom sessions and change some of the workstations, including having each team chip out and repair a mock-up concrete slab as part of a team competition.

A second pilot program is being planned for February 29, 2024, in Raleigh, North Carolina, in cooperation with the Carolinas Chapter. Based on the results of these two pilots, the Task Group will seek approval of the Professional Development Committee and ICRI leadership to provide this program in partnership with ICRI chapters and member companies.

If you wish to see videos taken during the event or want additional information, contact Mark LeMay at mlemay@jqeng.com.

ACKNOWLEDGMENTS

Special thanks to RTC for hosting this important event and constructing several of the slab mock-ups–Dan Andres, Karl Guderian, Mariano Rodriguez, Mike Tolson, Drake Daly, and Ligia Clark; to Ben Koehler and Patrick Jorski from Sika for donating material and supplies and constructing the vertical and overhead mock-ups; to Pete Haveron from Texas Concrete Restoration for bringing numerous pieces of equipment and tools to display; and to the North Texas Chapter for authorizing reimbursement expenses up to $3,000 to support the event.

ICRI Professional Development Committee Task Group Members: Mark LeMay, Dave Fuller, Dave Tepke, Stephen Grelle, Pete Haveron, Patrick Jorski, Dan Wald, Jeff Welty, Matthew Carter, Dan Andres, Karl Guderian, and Mariano Rodriguez.

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2. ICRI Committee 310, "Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair (310.2R-2013)," International Concrete Repair Institute, Minneapolis, MN, 2013, 54 pp.

Mark LeMay, AIA, FICRI, is a Past President of ICRI and an Institute Fellow. Recently retired from full-time employment with JQ Engineering, he continues to consult on various concrete repair projects and remains active nationally with ICRI and with the North Texas Chapter.

Marina Place Condominium Building Rehabilitation

Water Intrusion and Structural Strengthening

by Matt Dougherty, P.E.

Fig. 1: Completed project after structural strengthening and new stucco and waterproofing system

With a 40-year-old mid-rise condominium building, there are certain challenges faced when it comes to maintaining the structure. For years, this 7-story condominium (Fig. 1) located in Dunedin, Florida, on the Gulf of Mexico had been dealing with significant water intrusion, especially with the significant storms and hurricanes that impact the Gulf Coast of Florida (Fig. 2). Wanting to find a solution to the leaks, the condominium association hired a building envelope and structural engineering consultant to investigate the water intrusion.

INVESTIGATION AND EVALUATION

The first step in the water intrusion investigation was to gain a better understanding of the building by reviewing original construction documents and previous repair documents. The structure consists of cast-in-place concrete slabs, CMU walls, stucco-clad façade, and punched windows. With insight from the documents, the consultant performed an initial visual assessment to compare the construction with the existing conditions and determine potential leak paths.

Fig. 2: Water intrusion from Hurricane Eta adjacent to the ceiling fan

Next, water testing was performed on windows and exterior walls to identify sources of water intrusion (Fig. 3). For the areas where water intrusion was observed during testing, a contractor removed exterior stucco to gain a better understanding of the underlying element conditions. Visual observations identified the corrosion of reinforcing steel and metal studs that led to the formation of cracks and spalls (Fig. 4).

Fig. 3: Water testing at building exterior to replicate Hurricane Eta

Fig. 4: Concrete spall due to corroded reinforcing steel at precast concrete window sill

Based on the collective water testing and invasive exploratory opening observations, the most apparent leaks were caused by water entering the wall assembly through cracks in the exterior stucco and CMU, traveling down through the hollow cells of the CMU blocks until reaching the top of the concrete floor slab, and either leaking along the base of the wall or traveling laterally along the top of the slab (below the flooring materials) to other floor cracks causing leaks into the level below (Fig. 5). In a similar manner, water was also observed leaking into the metal stud-framed cavities above the windows, damaging the framing and potentially contributing to the water ingress on the interior.

Fig. 5: Investigative exploratory opening inside condo unit revealing water intrusion

Repair recommendations were provided to the owner who wanted to phase the repairs over a three-year period. The repair scope included select removal and replacement of the existing stucco and waterproofing system. The consultant developed construction documents for façade waterproofing and performed construction administration services during the repairs, which included site visits and quality control.

SUPPLEMENTAL INVESTIGATION AND DESIGN

During the removal of the existing stucco, the contractor discovered that the CMU block wall was completely ungrouted and unreinforced. To resist code-prescribed wind loads at the time of construction, the exterior CMU block wall should have been grouted and reinforced with reinforcing steel. The consultant verified a structural deficiency dating back to the original construction with the recommendation to review the balance of the building to determine if the condition existed throughout the building. With additional testing, it was determined that the issue existed across the entire building, and because this was an issue of structural integrity, the consultant recommended that structural strengthening be implemented before the façade waterproofing work commenced.

As such, it was critical to work closely with owners to discuss these issues that will impact construction costs, taking the time to walk the owner through the issues, showing original construction drawings, and educating them on the issues. It is critical to take the time to explain "the why" behind a project and issues that arise so that projects can be better understood and the importance of implementing repairs.

Fig. 6: Structural strengthening installation at the exterior of the building

Fig. 7: Completed structural strengthening at the exterior of the building

REPAIR CONSTRUCTION

In close coordination with the contractor, the consultant designed repairs to address the structural deficiency in a way that minimized impact to the unit owners. This included cutting the CMU block wall at the exterior and installing rebar which was drilled and epoxied into the concrete floor slab above and below (Fig. 6). The CMU cells were then grouted solid (Fig. 7). Aesthetically, the reinforced CMU was visible from the exterior but because a new stucco system was installed, the repairs were concealed. The new direct applied stucco system was then installed (Fig. 8) followed by the elastomeric waterproofing system (Fig. 9). Installation of new sealants around fenestrations, concrete spall repairs at the precast lintels and sills, and repairs to the exterior CMU walls were also included in the project which rounded out the comprehensive restoration of Marina Place Condominiums. With great communication between the owner, consultant, and contractor, the issues were resolved in a timely manner with minimal impact to the condominium unit owners. The project was completed in 2023 at a total cost of US $1,850,000.

SUMMARY

A project that began as a water intrusion investigation led to the discovery of structural issues that were resolved with the help of a consulting engineer and contractor. In collaboration, the engineer and contractor orchestrated a complex restoration process. The teamwork and coordination between the contractor and engineering consultant was key in seamlessly integrating new repair designs with ongoing construction work, ensuring minimal disruption. This synergy between the consultant, the contractor, and the owner was instrumental in not just fixing the immediate issues but in fortifying the building against future problems. Now, the condominium building's CMU structure is strengthened, and a new waterproofing system installed that will protect the building and owners' homes from water intrusion in the future.

Fig. 8: Stucco installation in progress

Fig. 9: Elastomeric coating installation in progress

Matt Dougherty, P.E. is a Principal at Walker Consultants and Director of Building Envelope, Forensics and Restoration for Walker's Florida offices. Matt received his BS in Civil Engineering from the University of Iowa. He has more than 15 years of experience in the evaluation, design, and renovation of various building types including façades, parking garages, stadiums, and plaza systems. Matt has extensive experience performing condition assessments, including non-destructive and destructive testing, developing restoration designs, and managing projects. Matt is a licensed professional engineer in 3 states. He maintains membership in ICRI and is a former Board Member for the Florida West Coast Chapter.

Project: Marina Place Condominium Building Rehabilitation—Water Intrusion and Structural Strengthening

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From Hard Hats to Helmets: The Evolution of Head Protection in the Workplace

by Scott Greenhaus

In the realm of occupational safety, head protection has come a long way from its beginnings as a simple hard hat. The transition from hard hats to helmets represents a remarkable evolution in the goal to keep workers safe in a wide range of industries. This article explores the history and technological advancements that have reshaped head protection, emphasizing the importance of safeguarding workers in the construction industry.

BIRTH OF THE HARD HAT

Hard hats made from leather, canvas, or steel first made their appearance in the early 20th century. The first hard hat, patented in 1919, was called the "Hard Boiled® Hat" (Fig. 1) because of the steam used in the manufacturing process. The first designated "Hard Hat Area" enforced with the threat of dismissal was set up at the San Francisco Golden Gate Bridge construction site.[1] Hard hats were primarily used in the construction industry to protect workers from falling debris and head injuries. Over time, hard hats became more standardized and began to include suspension systems for added comfort and impact absorption. The iconic design, with a protective brim and a solid crown, became a symbol of safety in construction sites worldwide.

Fig. 1: Hard Boiled® Hat (Image courtesy of WaveCel)

TRANSITION TO HELMETS

The transition from hard hats to helmets is marked by significant advancements in technology and materials. The concept of a helmet, while similar to a hard hat in terms of providing protection, brought several key improvements to the table. The primary distinctions between hard hats and helmets include:

- **Improved Impact Resistance**: Helmets are designed with advanced impact-absorbing materials like high-density foam and polycarbonate shells, which provide enhanced protection against head injuries. This advancement is particularly crucial in industries where workers face high-impact risks, such as professional athletes and military personnel and now, construction crews (Fig. 2).

Fig. 2: Construction helmet (Image courtesy of Milwaukee)

- **Customized Fit**: Modern helmets are adjustable and come in various sizes to ensure a snug and comfortable fit for each user. This customization minimizes the risk of a helmet falling off during an accident or interfering with the wearer's field of vision.
- **Versatility**: Helmets are used in a wide range of activities, including sports, motorcycling, mountaineering and firefighting. Each field has specific helmet designs tailored to the unique demands of the job. The best attributes of these helmets have been incorporated into the construction helmet.
- **Enhanced Safety Features**: Helmets often incorporate additional safety features such as engineered chin straps, impact sensors, and ventilation systems to provide users with a more comfortable and secure experience. These features help users stay safe while maintaining comfort during extended periods of use.

TRAUMATIC BRAIN INJURY (TBI) AND ROTATIONAL IMPACT

Traumatic brain injury (Fig. 3) remains a significant concern in various industries, especially those where high-impact accidents are more likely, such as construction. The transition to helmets has brought significant improvements in TBI protection through:

Fig. 3: Traumatic brain injury

- **Impact-Absorbing Materials**: Helmets use advanced impact-absorbing materials, such as high-density foam and honeycomb, cellular materials, and liner systems that reduce rotational impact forces, each design incorporating elements that reduce the risk of TBI.
- **Customization**: A well-fitted helmet minimizes the potential for brain injury by effectively absorbing and dispersing impact forces. The adjustability of helmets ensures a snug and secure fit for each user, optimizing protection.

Rotational impact, often overlooked, is also a critical factor in head injuries (Fig. 4). It occurs when the head is subjected to both linear and rotational forces during an impact, causing strain and damage to the brain. The traditional hard hat design was not effective in addressing these rotational forces, leading to concerns about brain injuries.

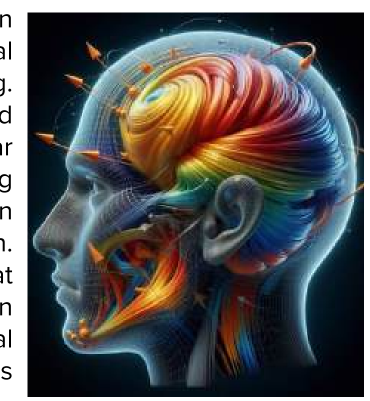

Fig. 4: Rotational impact

REGULATORY REQUIREMENTS

To address the limitations of hard hats and improve head protection, regulatory bodies like the Occupational Safety and Health Administration (OSHA) and the American National Standards Institute (ANSI) established comprehensive standards and regulations for head protection in the workplace.

- **OSHA Standards**: OSHA, a federal agency in the United States, sets and enforces workplace safety standards. OSHA's standards for head protection are outlined in 29 CFR 1910.135.[2] These standards require employers to ensure that employees wear head protection when working in areas with potential head injuries from falling objects or electrical hazards. OSHA-approved helmets must meet specific design and performance requirements.
- **ANSI Standards**: ANSI, a non-profit organization, develops consensus-based standards for various industries, including head protection. ANSI/ISEA Z89.1[3] outlines the performance requirements for protective helmets used in industrial and construction settings. This standard categorizes helmets into two classes—Type I and Type II—and specifies requirements for impact and electrical resistance.

Regulatory bodies are currently evaluating how requirements might be changed/augmented to recognize the benefits of a wel-designed construction helmet. All helmets must meet the current requirements of ANSI Type I and Type II.

HELMET COMFORT AND FIT

While hard hats were a significant step forward in occupational safety, they often lacked the comfort and adjustability required for extended use. Workers frequently complained of discomfort due to rigid materials and insufficient padding. The transition to helmets has brought a substantial improvement in this aspect. Modern helmets are designed with user comfort in mind, featuring:

- **Customized Fit**: Helmets come in various sizes and are often equipped with adjustable components such as straps and interior padding. This customization ensures a secure and comfortable fit for each user, reducing the likelihood of discomfort and fatigue.
- **Ventilation Systems**: Helmets often incorporate ventilation systems that allow air circulation, preventing heat buildup and discomfort. These systems are especially vital for workers in hot and humid conditions.
- **Accessories**: Helmets are designed for easy and secure attachment of accessories such as head lamps, earmuffs, and face shields.

ARE HELMETS HOTTER THAN HARD HATS?

The perception that helmets are hotter than hard hats is a common concern among workers. However, the truth depends on several factors:

- **Ventilation**: As mentioned earlier, many modern helmets feature ventilation systems that help dissipate heat (Fig. 5). While hard hats have solid crowns that can tap heat, helmets are designed to counteract this issue, making them more comfortable in warm environments utilizing vents as well as channels in the foam protection layer and suspension systems that allow for air flow within the helmet.

- **Material**: The type of material used in helmets also plays a role in heat retention. Lightweight materials, helmet color and advanced design features help reduce heat buildup in helmets.

Fig. 5: Thermal gradients of hardhats compared to helmets
(Image courtesy of KOROYD)

Manufacturers and testing labs are currently evaluating heat effects with an eye toward better understanding actual vs. perceived heat retention differences between hard hats and helmets. This information will help dispel myths and misunderstandings and, in some cases, may lead to modifications to the helmet designs.

NEW TECHNOLOGIES FOR HEAD AND BRAIN PROTECTION

The transition from hard hats to helmets has led to the development of innovative technologies that address rotational impact and offer improved head and brain protection:

- **MIPS (Multi-directional Impact Protection System)**: MIPS is a revolutionary technology incorporated into many modern helmets (Fig. 6). It consists of a low-friction layer between the outer shell and the inner liner, allowing the helmet to move slightly upon impact. This movement helps reduce rotational forces and the risk of traumatic brain injury.
- **Improved Materials**: Advanced materials like Koroyd (Fig. 7) and WaveCel (Fig. 8) have been integrated into helmet designs to enhance impact absorption and reduce rotational forces during accidents.

Fig. 6: MIPS

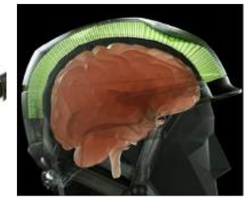

Fig. 7: Koroyd

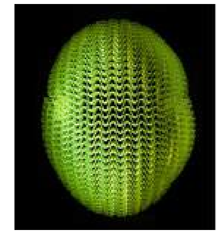

Fig. 8 WaveCel

CONCLUSION

The transition from hard hats to helmets marks a remarkable evolution in head protection. From their origins in the sporting and adventure industries to their growing use in construction, helmets are becoming a symbol of safety, innovation, and caring for the health of the workforce. The integration of advanced materials, improved design, and custom-fit options has significantly enhanced the protection offered to workers. As technology continues to advance, we can expect even more innovative solutions to further improve head protection and safety in the workplace and beyond.

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Historical Advancements in Corrosion Control of Existing Conventionally Reinforced Concrete Structures in the United States: Towards a Sustainable and Viable Future

by David G. Tepke and Jose M. Mandry-Campbell

The history of durability and material provisions in codes and industry knowledge provide bases for planning and conducting structural investigations (Tepke[1]). This article explores the historical development of maintenance and corrosion control methods of existing concrete structures in the United States and touches on related topics that will likely be important in the future. For the purposes of this article, "corrosion control" applies to techniques that reduce the ingress of deleterious substances and reduce or effectively arrest corrosion. Corrosion control techniques employed both prior to and after the onset of corrosion will be considered. Specialty repair materials, contaminated concrete removal, and repair methodologies may also impact corrosion behavior and control, but are not included in the scope of this article.

This article intends to highlight the development of corrosion control for conventionally reinforced concrete and show generally what was available to practitioners at various times, as they may be encountered when investigating existing structures. It provides a brief and general overview of some of the more impactful corrosion control developments in the United States. However, some advancements elsewhere in the world are included to provide context. While several corrosion control technologies and advancements are discussed, it is not the intent of this article to be exhaustive in description or comprehensive in inclusion, nor is it the intent to promote any specific technologies or methods or comment on efficacy. Indeed, appropriate methods for corrosion control depend on a variety of factors requiring both theoretical knowledge and practical experience. As such, a specialist should be engaged to evaluate and determine appropriate strategies unique to each situation. Common variable factors to consider may include environmental conditions, structural characteristics, site access, level of future expected owner engagement, budget, safety, and desired service-life extension.

REPAIR AND SERVICE-LIFE EXTENSION ARE NOT NEW CONCEPTS

The industry's understanding of rehabilitation and service-life extension of concrete structures has considerably advanced since the latter part of the 20th century, but the general concepts of structural repair and preservation are not new. For instance, the structural condition assessment, maintenance, and repair of Rome's aqueducts and infrastructure were topics of interest to Marcus Vipsanius Agrippa (circa 63-12 BC), Sextus Julius Frontinus (circa 40-103 AD), and their contemporaries, as described in De Aquaeductu Urbis Romae (circa 97-98 AD) by Frontinus[2] (translated by Rodgers in 2003). Among the more interesting descriptions of condition, maintenance, the role of experts, and repair are:

> *"...In the same year Agrippa reconstructed the conduits of Appia, Anio, and Marcia, which were in very poor condition..." (Section 9.9)*
>
> *"...He [Agrippa] had also a personal work crew for maintaining the conduits as well as delivery-tanks and basins..." (Section 98.2)*
>
> *"...Many, sometimes large-scale, tasks are constantly arising, which should have prompt attention before extensive remedy may be required..." (Section 119.2)*
>
> *"He ought not only to consult the engineers in his own office, but also to call upon the reliable judgment and expertise of numerous others, that he may in the end determine which tasks are to be undertaken without delay and which are to be postponed... (Section 119.3)*
>
> *"Maintenance tasks arise for the following reasons: damage occurs from wear and tear, from wrongful behavior on the part of landholders, from violent storms, from faulty workmanship (which happens rather often in the case of recent works)." (Section 120)*

While these conditions are not related to corrosion of reinforcing steel, they demonstrate similar difficulties faced more than 2000 years ago in addressing repair and service-life extension. Figure 1 shows Marcus Agrippa,[3] a recent picture of the remains of historic aqueduct constructions that includes the Aqua Maria,[4] and Sextus Ilulius Frontinus.[5]

Fig. 1: (a) Marcus Agrippa, (b) the remains of several aqueduct constructions including the Aqua Maria, and (c) Sextus Julius Frontinus (photos a and b permitted by license in references and photo c in public domain)

CORROSION OF REINFORCING STEEL, CORROSION CONTROL, AND SOCIETAL IMPACTS

Reinforcing steel in concrete is typically well protected from corrosion due to a passivation layer that develops on the steel surface as a result of the high pH of pore solution. This passivation layer can be destroyed, however, and render the steel vulnerable to corrosion in certain conditions. While there are other conditions not discussed herein that may lead to depassivation, the two most notable and frequently encountered conditions in typical structures are associated with reduction in pH from carbonation and attack from chlorides.

Carbonation progressively advances into the concrete from exposed surfaces to reduce pH through the reaction between atmospheric carbon dioxide, moisture, and calcium-bearing hydration products. Chlorides can be present within the concrete from contaminants or admixtures that were introduced during initial placement, particularly in older structures (Tepke[1]). Chlorides can also penetrate externally into the concrete over time from exposure to deicing chemicals, industrial or manufacturing chemicals, seawater (including its spray or airborne deposition), or other sources. Once present in sufficient amounts at the level of reinforcing steel, chlorides promote pitting and severe corrosion. In addition to the reduced cross-section of structural reinforcement from the corrosion process that can eventually compromise structural integrity, the conversion of steel to iron oxides and hydroxides produces expansive stresses from within the concrete that may result in cracks, delaminations, and spalls that can present tripping hazards, overhead spalling hazards, and reduced fire resistance.

Implications of reinforcing steel corrosion include potential safety hazards, costly repairs, and impacts to the environment from carbon demand associated with repairs. In severe cases, replacement may be necessary or more economical than otherwise extensive widespread repairs. The reader is referred to ACI PRC 222R[6] and ACI PRC 201.2R[7] for more complete review of mechanisms and implications of corrosion, including effects of cracking, stray currents, and specialized exposures. Figure 2 shows a schematic of the corrosion initiation process for chloride-induced corrosion and Figure 3 shows some examples of distress in structures.

Tuutti[8,9] proposed a two-stage service-life model for reinforcing steel corrosion caused by penetration of external contaminants (Fig. 4) that has formed the basis for many other models that have since been developed. The first phase of the model, initiation, describes the time prior to the onset of corrosion and is generally governed by the time it takes for corrosive agents to reach the steel, the properties of the steel, and the properties of the concrete, including possible presence of corrosion-inhibiting admixtures. The second phase, propagation, describes the time after the onset of corrosion towards a "limit state". The limit state represents the upper limit on acceptable corrosion, and was defined as cracking by Tuutti. The time to reach the limit state is influenced by temperature, moisture, oxygen, material properties, and the associated corrosion rate. Some newer models include a tertiary phase which depicts an exponential increase in associated costs and structural depreciation from corrosion-induced concrete damage that persists beyond the point where cracking initiates. Other models also sometimes define limit states associated with serviceability or end of safe use, etc.

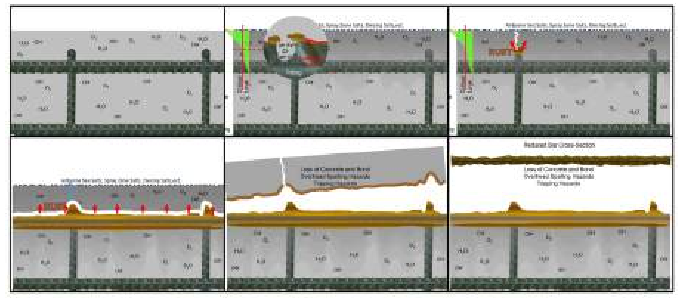

Fig. 2: Schematic of corrosion process for chloride-induced corrosion

Fig. 3: Corrosion-related distress: (a) pitting from chloride-induced corrosion (after bar cleaning), (b) corrosion products compared to bare steel, (c) corrosion-induced cracking, (d) cross-section of delamination, (e) overhead delamination and spalling hazard, (f) horizontal spalling and tripping hazard, and (g) reinforcing steel disintegration

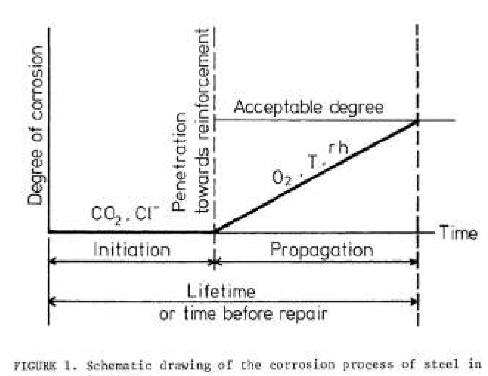

Fig. 4: Corrosion initiation and propagation model presented as Figure 1 in Tuutti (reproduced with permission from the American Concrete Institute)

The corrosion initiation phase can be prolonged through surface-applied protective coatings or treatments that effectively retard the ingress of deleterious species and moisture, and inhibit or delay initiation. Once corrosion begins (propagation phase), short-term or long-term electrochemical mitigation techniques can abate or drastically slow down the rate of corrosion in most situations. Electrochemical chloride extraction (ECE) and realkalization are acute electrochemical techniques applied for short periods that remove chlorides from the vicinity of the steel or increase concrete alkalinity, respectively. Cathodic protection (CP) is an electrochemical technique that depresses the potential of the steel, equilibrates potential differences along the steel surfaces, forces cathodic reactions, and modifies the concrete environment near the steel over an extended period to arrest corrosion using more moderate protection current densities. Galvanic cathodic protection (GCP) is accomplished through connecting embedded steel to anodes made of more active metals at higher natural energy states (such as zinc, aluminum, or their alloys). The more active metals protect the steel through the inherent generation of protective current when dissimilar metals are connected in an electrolyte. The more active metal is sacrificially consumed as it protects the steel. Impressed current cathodic protection (ICCP) uses anodes, typically inert or practically so, and an external power supply to generate and maintain protective current. Both CP techniques may also be used prior to corrosion initiation as a preventative approach, sometimes termed cathodic prevention. GCP is sometimes used in this manner as part of concrete repairs to reduce the "halo effect" or "incipient anode effect" (Fig. 5) which are phrases used to describe the propensity for corrosion to begin in contaminated existing concrete adjacent to new patch repairs.

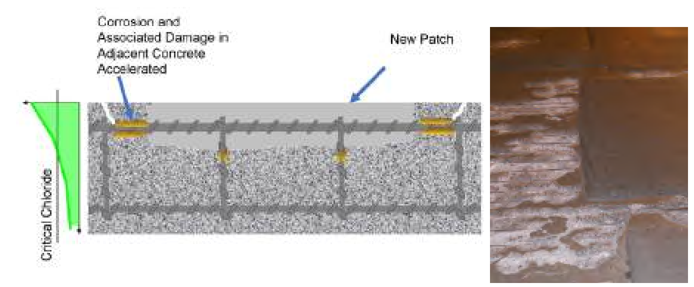

Fig. 5: (a) Schematic and (b) example of incipient anode effect after the repair of concrete

Protective coatings may additionally be used during propagation phase to limit moisture, but this is generally a temporary approach and only substantially effective when combined with other methods that arrest corrosion, particularly in aggressive conditions. Additional information on corrosion control measures, and associated benefits and limitations, can be found in ACI PRC 222R,[6] NACE SP0390,[10] NACE SP0187,[11] and NACE SP0112.[12]

In a study that considered data representative of the years 2010-2011, Angst[13] estimated that the direct costs associated with corrosion control, prevention, and repair for concrete structures in the United States was approximately US $50 billion. With inflation and the continual aging of infrastructure, this number likely exceeds US $70 billion today. While this sum alone is cause for concern, the societal impacts of concrete corrosion add even more context to the importance of proactive control. Indirect inconveniences associated with frequent repair and replacement construction, potential safety hazards in areas of severely corrosive conditions, and global warming potential from carbon-generating repairs and replacements of structures can all be decreased with the continued development and practical adoption of proactive control techniques.

EXAMPLES OF SOME MAJOR ADVANCEMENTS IN CORROSION CONTROL IN THE 20TH AND 21ST CENTURIES

General Publications and Initiatives Associated with Corrosion Control

The first ACI Committee 201 report in 1962[14] included a section on corrosion of reinforcement in concrete that briefly mentioned cathodic protection and provided some discussion on coatings for corrosion control. However, the report also indicated:

> *"Several methods of stopping or retarding further corrosion have been suggested and tried experimentally. None of these methods has been demonstrated to be completely adequate or economical." (ACI 201[14] pg. 1801)*

Tuutti reported on his service-life model in 1980[8] and the first ACI 222 committee report on corrosion of metals in concrete was published in 1985.[15] The International Association of Concrete Repair Specialists was formed in 1988 (later named International Concrete Repair Institute in 1993) with the following stated purpose:[16]

> *"To improve the quality of concrete restoration, repair, and protection through education of, and communication among, the members and those who use its services."*

The first version of the ACI 546 Concrete Repair Guide was published in 1996.[17] NACE RP0187 Design Considerations for Corrosion Control of Reinforcing Steel in Concrete was published in 1987[11] and included discussion on preventative measures, cathodic protection and monitoring, and NACE RP0390 Maintenance & Rehabilitation Considerations for Corrosion Control of Existing Steel-Reinforced Concrete Structures was published in 1990.[10] Vision 2020: "A Vision for the Concrete Repair, Protection and Strengthening Industry" was established in 2003 with one of the goals being to establish testing protocol for evaluating corrosion mitigation techniques in existing structures.[18] ACI 562 Concrete Repair Code was first published in 2013[19] (updated 2016, 2019, and 2021), has been adopted as permissible in several jurisdictions, and will be referenced as a permissible approach for repair of concrete structures in the 2024 International Existing Building Code. M-82 protocol for evaluating corrosion control technologies in repairs, was published by the Bureau of Reclamation in 2014.[18]

Figure 6 represents a timeline of some key advancements for the purpose of giving the reader a general understanding of progress. It is not meant to be comprehensive in nature. The following sections provide a brief description of some of the advancements.

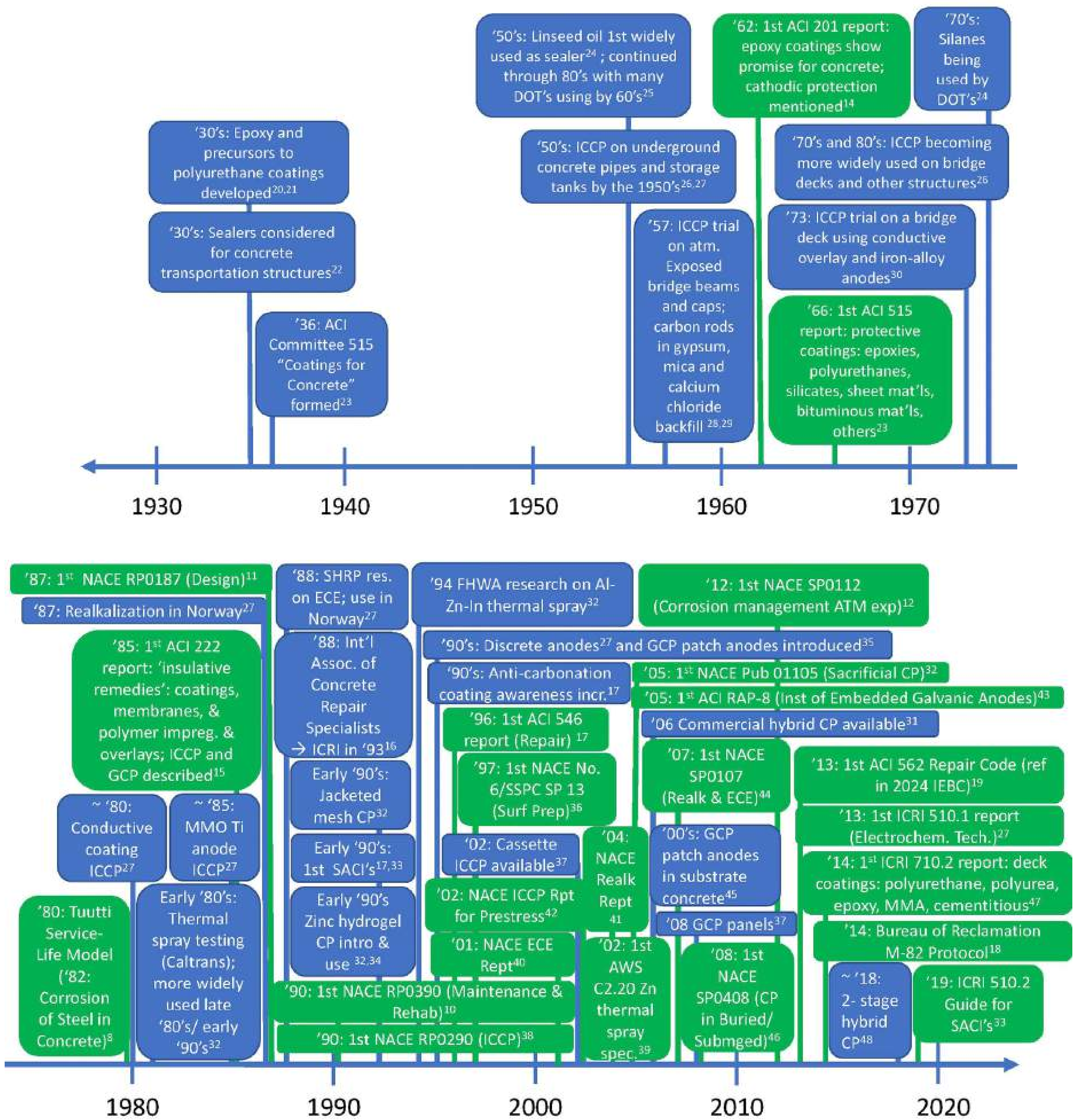

Fig. 6: Timeline with some key documents (green) and advancements (blue) [10,11,14-17,19-48] (note that this chart represents only some of the advancements, and is not meant to be all-inclusive)

Protective Coatings

Initial chemistry formulations for epoxy coatings[20] and polyisocyanate precursors to polyurethane coatings[21] were developed in the 1930s. ACI Committee 515 was formed in 1936[23] "to prepare recommended practices for the application of coatings to concrete surfaces for the purpose of decoration, dampproofing, and waterproofing, and to protect concrete against deleterious agents by externally applied materials, whether coatings, linings, chemical-resistant masonry, or chemical treatments by liquids or gases." The first ACI 201 committee report in 1962[14] included statements cautioning against the use of protective coatings to arrest ongoing corrosion, but discussed the likely benefit of protective coatings:

> *"The judicious application of waterproof coatings may serve to prolong the useful life of a structure but their indiscriminate use may increase the level of moisture within the concrete and thus accelerate corrosion. None of them offer permanent protection." (pg. 1801)*

> *"Epoxy resin paints, although recently developed, show considerable promise as protective coatings for concrete." (pg. 1813)*

Just a few years later in 1966, ACI Committee 515[23] published "Guide for the Protection of Concrete Against Chemical Attack by Means of Coatings and Other Corrosion Resistant Materials" that described a wide range of chemicals that attack concrete and steel, as well as recommendations for protective coatings for use on concrete, including epoxies, polyurethanes, silicates, sheet materials, hot-applied bituminous materials, and others.

The use of sealers was considered in the 1930s for transportation structures.[22] Linseed oil was used between the 1950s and 1980s,[24] and was commonly being used by departments of transportation (DOT's) by the late 1960s.[25] Alkyl alkoxysilanes were first proposed as a concrete sealer in Germany in 1969[49] and silanes were being used by US DOT's by the 1970s.[24] A considerable amount of research and investigation was conducted in this period on sealer materials, including those of oil and rubber, resins, petroleum products, silicones, and others.[50]

The first ACI 222 committee report in 1985[15] discussed the use of "insulative remedies" to "isolate reinforced concrete from a corrosive environment". These insulative remedies included surface coatings, membranes, polymer impregnation, and polymer overlays. The 1985 report cautioned that once corrosion is active, coatings do not stop corrosion but may provide some mitigating effects.

Developments into the 1990s and beyond included increased awareness for the use of anti-carbonation coatings for reducing associated penetration.[17] NACE No. 6/SSPC-SP 13, *"Surface Preparation for Concrete"*, was first published in 1997[36] (since updated multiple times). ICRI 710.2[47] was first published in 2014 to provide guidance on horizontal waterproofing including polyurethane, epoxy, polyurea, cementitious, and methyl methacrylate coatings. Environmental and health issues, such as lead and volatile organic contents, have influenced coating technologies as regulations have been imposed on limits in application and in disposal.

Additional discussion on coatings or applications for corrosion control can be found in ACI PRC 222R,[6] ACI PRC 546.3R,[51] ACI PRC 515.2R[52] and ICRI 710.2.[47] Figure 7 shows some examples of protective coatings on concrete structures.

Fig. 7: (a) Cementitious and (b) polyurethane deck coatings

Surface-Applied Corrosion Inhibitors

Corrosion-inhibiting admixtures for new concrete were first commercially available in the late 1970s.[53] Surface-applied corrosion inhibitors (SACIs) for use on existing structures were first introduced in the early 1990s[17,33] with much research being conducted in the years and decades that followed. A number of technologies have since been proposed or made commercially available.[6, 33] ICRI 510.233, a guide discussing technologies, evaluation and use, was published in 2019. ACI PRC 222R-196 and ACI PRC 546R-1617 provide information and recommendations regarding SACIs; reference to use is not included in the current version of NACE SP039010.

Figure 8 shows the application of a commercially marketed SACI at a parking structure.

Fig. 8: Application of surface-applied corrosion inhibitor to parking garage surface at test area showing sectioned installation for ensuring adequate coverage rates

Electrochemical Techniques

Sir Humprey Davy reported on the protection of copper sheathing from seawater with iron during his work funded by the British Navy in 1824;[54] however, widespread use to protect steel in concrete would not come until more than 100 years later. By the 1950s, ICCP was being used on underground prestressed concrete water pipelines and storage tanks.[26,27] The first use of ICCP in atmospherically exposed concrete in the United States might be that reported by Stratfull.[28,29] This included the use of carbon rods in gypsum, mica, and calcium chloride backfill in a trial system on bridge beams and pile caps that started in 1957. Stratfull[30] reported experimental application of ICCP on a bridge deck for Caltrans in 1973 with an electrically conductive asphalt concrete overlay using coke aggregate and iron alloy anodes. Conductive coatings with primary anode wires were introduced around 1980 and MMO (mixed metal oxide) coated titanium anodes were introduced around 1985.[27]

Thermal spray GCP was tested by Caltrans in the early 1980s and became more widely used in the late 1980s and early 1990s.[32] FHWA research was conducted on Al-Zn-In alloys for thermal spray in the 1990s[32] and the first AWS standard specification for zinc thermal spray was published in 2002.[39]

Other advancements in the 1980s include research and introduction of ECE and realkalization.[27,40,41] Discrete ICCP anodes and patch repair galvanic anodes were introduced in the 1990s with a number of patents on galvanic systems being filed in the 1990s and 2000s.[27,34,35,45] Hydrogel systems,[32] cassette systems,[37] and panel systems[37] were also among the technologies introduced in the 1990s or 2000s. Commercial hybrid ICCP/GCP and self-performing 2-stage systems were introduced after the turn of the 21st century.[31,49]

The first ACI 222 committee report in 1985[15] provided discussion and comparison of GCP and ICCP in concrete. This guide was updated 1996, 2001, and 2019. A number of NACE and ICRI guide documents and publications were introduced for the first time in the 1990s and 2000s, including NACE documents on corrosion in different environments, design for corrosion control, maintenance and rehabilitation, ICCP, GCP, and prestressed concrete.[10,11,12,32,38,40,41,42,44,46] A field guide to installation of embedded galvanic anodes was published as ACI RAP-8 in 200543. The reader is referred to Figure 6 and references[26, 27] for additional historical context, and references[6,38,44,46,55] for additional technical information. Figure 9 shows some examples of cathodic protection on existing structures.

FUTURE CONSIDERATIONS

Sustainability

Meeting the needs of today's society in an economically viable manner without sacrificing the environment of today or the future requires deliberate consideration of design and construction of new structures, as well as proactive preventative maintenance of existing structures. Embodied carbon and global warming potential of construction and construction materials must be coupled with service-life expectancy of structures to estimate the realistic long-term impact on the environment. Certainly, recent focus has been placed on decreasing environmental impact of new concrete structures through the development and implementation of initiatives such as the integration of alternative cements, use of portland-limestone cements, more judicious use of supplemental waste materials in concrete, codification for use of FRP reinforcement in concrete structures, codification of sustainability for concrete structures, and development of a durability code to extend the life of new structures.

Fig. 9: Cathodic protection systems: (a) MMO-Ti mesh ICCP, (b) thermal spray, (c) discrete anodes, (d) jacketed mesh system, (e) zinc hydrogel sheeting, (f) discrete zinc anodes inside repair, (g) discrete zinc anodes, (h) patch galvanic anode, (i) cassette ICCP system, (j) hybrid ICCP/GCP system with zinc anodes, (k) zinc anodes outside patch area, (l) zinc galvanic panel, and (m) 2-stage ICCP/GCP anode

A white paper by ICRI Committee 160[56] highlighted some of the key aspects of sustainability with respect to repairs, corrosion control, and influence of service-life extension. Corrosion control provides a sustainable option for existing reinforced concrete structures by increasing service-life and decreasing the frequency of environmentally costly repair or replacement. Within the past 30 years, standard methods have been developed which have broadened the use of corrosion control in repair and preventative maintenance. There is potential for further investigation into the economic and environmental impacts of service-life consideration and corrosion control.[57]

Safety

Safety of existing structures in coastal environments and those exposed to deicing chemicals or other corrosive conditions recently has been of increased focus. References[58-61] provide discussion on structural safety and expected future initiatives, including impact from corrosion.

Technology

The prospective future of concrete repair and corrosion control offers promise in moving toward a more sustainable future. The process of evaluating existing structures will likely advance with new technologies that assist in determining the feasibility, cost-effectiveness, longevity, and general quality of repair. However, many structures are not evaluated or considered for comprehensive maintenance until well after corrosion and damage initiate, limiting options for assessments and service-life extension techniques for the design professional. Repairing a structure with extensive deterioration generally requires added conservatism. Thus, timeliness of evaluation is a key factor in maximizing benefits of corrosion control.

There has been recent interest in the use of machine learning for better predicting concrete properties and corrosion.[62,63] Development of these principles may be able to assist in predicting the critical time for evaluation of a structure. If a reasonably large database of different structures and deterioration mechanisms is created, and dependable methods and techniques are used for generating information, machine learning technology may offer the potential to help better predict the corrosion initiation (or other distress mechanism) more accurately in new or existing structures. This data could be used to form a maintenance plan during design of a structure or as a guide for evaluation strategies. Pacheco and Tepke[64] provide discussion on best practices for corrosion monitoring, but certainly, monitoring and control systems for structural health monitoring and corrosion control will continue to advance.

A number of questions may come to mind regarding the future research needs and practices of corrosion control.

Sustainability

- How will alternative cements impact corrosion and corrosion control in the future?
- How will alternative reinforcing materials, such as corrosion-resistant steel and fiber-reinforced polymer (FRP) reinforcement, impact need and implementation of corrosion control?
- How will the industry accurately represent carbon demand and global warming potential as they relate to sustainability initiatives for service-life implications, repairs, replacements, and forecasted material use in the future? What research or information is needed?
- How will sustainability initiatives or material regulations impact corrosion control?
- How will sustainability standards for new structures (such as being developed by ACI Committee 323) impact corrosion control?
- How will new initiatives for durability code (such as being developed by ACI Committee 321) and maintenance influence service-life and implementation of corrosion control?
- How will relative cost differences associated with structural replacements, structural repair, corrosion control, and preventative maintenance influence societal norms for addressing existing structures?

Safety

- How will adoption of ACI 562 Repair Code impact repairs and corrosion control?
- How will safety regulations impact corrosion control?
- How will aging structures impact demand for corrosion control?

Technology and Technology Transfer

- How will Artificial Intelligence and machine learning impact the industry?
- How will monitoring corrosion and corrosion control advance?
- What is the best way to promote training for professionals and tradesmen implementing corrosion control?
- How will recent advancements and trends such as use of specialty concretes, corrosion inhibitors, and other materials in new construction impact corrosion control?
- What new technologies will be developed for corrosion control and how will newer technologies perform? How will new technologies associated with surface treatments, cathodic protection, specialty repair materials, evaluation, and monitoring perform?

CLOSING

Significant progress was made with respect to technologies and industry guidance for corrosion control of existing concrete structures in the 20th century. Topics and initiatives associated with building safety, economical implementation, sustainability, and further technological advancements are expected to impact research and application in the near future. The authors have attempted to provide some historical basis and perhaps some thoughts on where the industry may be going.

ACKNOWLEDGMENTS

The authors would like to thank Fred R. Goodwin, Jorge Costa (Durability, Inc.), David Whitmore (Vector Corrosion Technologies, LTD), Stephen Robinson (SKA Consulting Engineers, Inc.), and S. David Keatts (SKA Consulting Engineers, Inc.) for review of the manuscript and providing feedback and suggestions. The opinions and statements expressed in this article are those of the authors and do not necessarily reflect the position of the reviewers.

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David G. Tepke, PE, FACI, is a Principal Engineer with SKA Consulting Engineers, Inc., in Charleston, South Carolina, USA. He specializes in structural and materials evaluation, troubleshooting, repair, and service-life extension. He is a Fellow of the American Concrete Institute, a NACE/AMPP Certified Corrosion Specialist and Protective Coating Specialist, an ACI Certified Nondestructive Testing Specialist, and an ICRI Certified Concrete Surface Repair Technician (CSRT) Inspector. Tepke is Chair of ACI Committee 222, Corrosion of Metals in Concrete, and a member of the ACI Committee on Codes and Standards Advocacy and Outreach; and Committees 201, Durability of Concrete; 301, Specifications for Concrete Construction; 321, Durability Code; and 329, Performance Criteria for Ready Mixed Concrete. He is a member of ICRI Committees 160, Life Cycle and Sustainability; and 510, Corrosion. He is a licensed professional engineer in a number of states.

Jose M. Mandry-Campbell, EI, is a recent graduate from the University of Florida and Engineering Intern with SKA Consulting Engineers, Inc., in Greensboro, North Carolina, USA. He focuses on structural repairs of existing structures and is a member of ACI and ICRI organizations.

WOMEN IN ICRI

SPOTLIGHT— Joni Jones

JONI JONES

Meet Joni Jones, a professional engineer and rising star in the concrete repair industry. She recently joined Braun Intertec as a Director, bringing her expertise and passion to the company. She is also a dedicated member of ICRI-Chicago, serving as a Director for the Chicago Chapter for the second year in a row. She has been involved in ICRI for more than three years, contributing to various committees such as 310-Surface Preparation, Marketing, Conventions, and Women in ICRI. Joni is now Region 5 Representative on the ICRI Board of Directors.

Joni knows how to grow and improve concrete laboratories. She enjoys finding and implementing solutions to enhance productivity while building rapport with her colleagues. Joni has worked in a laboratory environment for over 20 years and has learned to be a respected consultant to concrete ready mix professionals, engineers, and suppliers. She can handle multiple projects across different construction sectors with skill and experience. She enjoys sharing her knowledge and skills with the next generation of technical staff through teaching and presenting opportunities.

The career achievements that Joni is most proud of are playing a key role to develop, build, and accredit a successful laboratory from a blank slate. Joni is not just a lab rat managing a laboratory. She is also proud to have served as president twice for the Illinois Chapter of ACI, and organizes and plans memorable social events for both ACI-IL and ICRI-Chicago. Joni is a queen of concrete camaraderie. When it comes to off-duty shenanigans, Joni's the social engineer, the one who builds bridges (metaphorically, of course) between colleagues with her legendary event-planning skills.

Joni lives in the heart of Chicago in a quaint neighborhood called Printers Row. When this engineer needs a recharge, she laces up and hits the pavement to explore her concrete jungle. Exploring the world also becomes an adventure for the palate and the soul when she travels with family and friends, savoring new cuisines and immersing herself in diverse traditions.

Work may fuel her brain, but her 11-year-old triathlete son fuels her heart. Joni's the loudest cheerleader on the sidelines, her cheers rivaling the city's sirens. And don't forget her pint-sized sous chef, her 3-year-old son who keeps her on her toes with his colorful energy.

Joni is a role model and a leader for women in the field, inspiring others with her charisma, achievements, and vision.

PEOPLE ON THE MOVE

WHITE

WALTER P MOORE PROMOTES PETER WHITE TO MANAGING DIRECTOR IN CHARLOTTE

Walter P Moore announces the promotion of Peter White to the role of Managing Director for the Diagnostics Group in the Charlotte office. White brings 20 years of experience in all aspects of Diagnostics Engineering, including parking restoration, enclosure diagnostics, restoration renovations, and Forensics to his new role. As a Principal, White plays a pivotal role in assessing, designing, and managing repairs for building envelope and structural systems of large-scale structures across various construction types. His expertise spans buildings in Charlotte, Washington DC, and across the mid-Atlantic and southeast regions of the country.

"Peter has shown exceptional leadership in our Charlotte office as a Senior Project Manager," said Dilip Choudhuri, President and CEO. "The breadth of his knowledge in all facets of Diagnostics makes him an excellent choice to lead our team there and we are excited to see him further develop and expand the practice."

Throughout his career, White has been involved in all aspects of project development, from the conceptual phase to forensic investigation, generating technical repair specifications, bidding, and construction administration for restoration projects. His diverse project portfolio includes notable assignments such as Atrium Health Wake Forest Baptist's garage repair, the University North Carlina Charlotte exterior envelope repairs, and the Foundry Point Apartments building enclosure forensic/litigation. "Peter's promotion is a well-deserved recognition of his exceptional talent and dedication," said Dr. Gabriel Jimenez, Executive Director of Diagnostics. "His ability to manage multifaceted projects and his deep understanding of building systems make him an invaluable asset to our team. We are delighted to see him taking on this new leadership role."

INTERESTED IN SEEING YOUR NEWS LISTED HERE?

Email your 150-200 word news to editor@icri.org. Content for the March/April 2024 issue is due by February 1, 2024, and content for the May/June 2024 issue is due by April 1, 2024. One (1) high resolution product photo may be included. ICRI reserves the right to edit all submissions.

PRODUCT INNOVATION

PRESERVING CAPITAL SPARES: A STRATEGY FOR CONCRETE-COATED PIPELINES

Subsea oil and gas pipelines are frequently constructed by joining concrete-coated segments together. During construction, concrete-coated pipe may sit for six months to several years before installation. Capital spares are often ordered at the same time as the initial pipes but with a designed preservation life measured in decades of idle time. To ensure that these capital spares do not deteriorate prematurely, Cortec® shares several technologies and tips for preserving concrete-coated pipes from corrosion.

Learn about preserving concrete-coated pipe spares in our press release: https://www.cortecmci.com/press-release-preserving-capital-spares-a-strategy-for-concrete-coated-pipelines/.

SCANNING FOR REBAR IN CONCRETE WHEN IT'S "EVERYWHERE"

Advanced handheld metal scanning tools from Zircon, a leading manufacturer of sensor technologies, detect rebar and other metal deep within concrete to increase worker safety and reduce costs on replacement bits and blades

Ground penetrating radar (GPR) is quite effective at locating rebar deep within a concrete structure, although the equipment requires extensive training and can be very expensive.

Zircon addresses the issues of locating rebar in concrete through innovative handheld scanning devices such as the MetalliScanner® MT 7 and the MetalliScanner® MT X metal locators.

The MetalliScanner MT 7 metal detector can be used to locate rebar, pipes, and other metal before sawing or drilling. The scanner can locate metal, including half-inch rebar, up to six inches deep. It offers users two scanning modes–Standard and DeepScan® modes–with position accuracy to within ± half-inch for #4 rebar.

The MetalliScanner MT X metal detector is designed to address the difficult task of locating the spaces between rebar in tight grid patterns. In DeepScan mode, the MT X can locate rebar or metal pipes up to four inches deep.

For more information visit www.zircon.com.

CORTEC® SHARES COATINGS IDEAS

Are you getting ready to paint a new industrial facility for the first time or touch up an aging plant?

MCI®-2026 Floor Coating is an excellent choice as a 100% solids, 2-component novolac epoxy coating with a high degree of chemical and abrasion resistance. It can be used in areas with strict VOC limits and meets all USDA/FDA guidelines for use in federally inspected facilities.

Indoor metal walkways, railings, and stairways often need extra corrosion protection. Cortec® suggests these direct to metal (DTM) coatings:

- CorrVerter® Rust Converter Primer is a low VOC water-based rust converting primer that can be used on previously rusted surfaces where sandblasting or grinding is not a good option.
- VpCI®-395, a water-based 2K epoxy primer, is an excellent primer for many metal surfaces, serving as a strong base for topcoats.
- VpCI®-396, a Solvent-Based One-Coat System, is another primer option that may be preferred by workers who want to avoid the hassle of mixing a 2K system.
- EcoShield® VpCI®-386, a water-based acrylic topcoat, can topcoat VpCI®-395 and VpCI®-396 and is one of Cortec's top performing water-based acrylic Micro-Corrosion Inhibiting Coatings™ that can be applied clear or matched to many custom colors.

Visit www.cortecvci.com for more information.

V2 COMPOSITES LAUNCHES A NEW WEBSITE DEDICATED TO THE PARKING GARAGE INDUSTRY

V2 Composites, Alabama-based manufacturer of the patented T-Biscuit® repair solution for damaged or failed shear connections in precast concrete parking garages, recently launched a new website to help parking garage design professionals and contractors access the company's innovative carbon-fiber-reinforced polymer (CFRP) repair material.

With over 200,000 units of T-Biscuit® technology already installed by V2 authorized installers, V2 Composites recently launched a dedicated website to facilitate growing sales to the parking garage market. The product category is currently represented by a market-dedicated sales force, and the new website is expected to expedite the sales cycle for this groundbreaking product.

The revolutionary carbon-fiber-reinforced polymer (CFRP) T-Biscuit repair solution uses a highly engineered, proprietary carbon laminate. It is a low-cost repair option that can be easily installed in new and existing precast concrete structures. The T-Biscuit solution meets or exceeds both ACI and PCI precast concrete code requirements.

Visit https://v2tbiscuits.com for more information.

CHAPTER CALENDAR

ICRI Chapters are hosting events in 2024. Be sure to check with individual chapters by visiting their chapter pages to determine if they have made any plans after this publication went to print. You can also contact a chapter leader from any chapter about added events.

CAROLINAS
May 16 & 17, 2024
SPRING CHAPTER CONFERENCE
Hotel Indigo
Mount Pleasant, SC

CHICAGO
March 21, 2024
MARCH MADNESS SOCIAL EVENT
Location: TBD

FLORIDA WEST COAST
April 12, 2024
DEMO DAY/TECHNICAL PRESENTATION
Location: TBD

GREAT PLAINS
April 4, 2024
OPENING DAY AT BALLPARK VILLAGE
Technical Session: Expansion Joints
Lowe's Ballpark Village
St. Louis, MO

GULF SOUTH
April 10 & 11, 2024
SPRING TECHNICAL CONFERENCE & GOLF TOURNAMENT
Conference: IP Casino Resort Spa, Biloxi, MS
Golf Tournament: Hickory Hills Country Club, Gautier, MS

METRO NEW YORK
May 8, 2024
ANNUAL SYMPOSIUM
Concrete in a Sustainable World
Club 101
New York, NY

MICHIGAN
March 22, 2024
DEMO DAY
Elcometer Offices
Warren, MI

MINNESOTA
March 21, 2024
ICRI CURLING FUNSPIEL
Chaska Curling Club
Chaska, MN

ANNUAL GOLF TOURNAMENT
July 16, 2024
Bunker Hills Golf Club
Coon Rapids, MN

NORTH TEXAS
April 3, 2024
SPORTING CLAY CLASSIC
Elm Fork Shooting Sports
Dallas, TX

SOUTH CENTRAL TEXAS
March 7, 2024
SEAoT and ICRI SCT JOING EVENT
K1 Go Kart Racing
K1 Indoor Karting
Austin, TX

VIRGINIA
March 28, 2024
SPRING CHAPTER SYMPOSIUM
Colonial Heritage Golf Club
Williamsburg, VA

INTERESTED IN SEEING YOUR CHAPTER NEWS & EVENTS LISTED HERE?

2024 Chapter News & Event Deadlines

MAY/JUNE 2024 CRB
Deadline: March 1, 2024

JULY/AUGUST 2024 CRB
Deadline: May 1, 2024

SEPTEMBER/OCTOBER 2024 CRB
Deadline: July 1, 2024

NOVEMBER/DECEMBER 2024 CRB
Deadline: September 1, 2024

Send Chapter News and Events by the deadlines above to Program Director Dale Regnier at daler@icri.org.

ICRI CONCRETE REPAIR CHAPTERS

CHAPTER NEWS

NORTH TEXAS LEARNS ABOUT BRIDGE REPAIR

The ICRI North Texas Chapter welcomed speaker Doug Beer, PE, to their Membership Meeting on November 29, 2023, at the Terracon office's training room in Dallas. Mr. Beer, who is the Construction & Maintenance Branch Manager for Texas Department of Transportation (TxDOT), presented a range of topics related to bridge repair and maintenance in Texas. The topics included current and forecasted bridge letting, funding sources for bridge rehabilitation and preservation, common structural repair methods, and recurring challenges associated with repair. The Chapter appreciated the opportunity to meet Mr. Beer and learn more about the massive effort associated with maintaining Texas's bridge inventory.

Doug Beer, PE (center), discusses TxDOT bridge maintenance and repair at the NTX Membership Meeting

CHAPTER NEWS

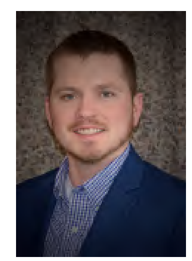
PITTSBURGH KICKS OFF 2024 WITH A CUTTING EDGE

The ICRI Pittsburgh Chapter kicked off the construction season with their first event of 2024, their annual "Freeze-Thaw Ball" held at Lumberjaxes in Mt. Lebanon, PA. The group had fun networking, ax-throwing, introducing the new board, and meeting new members. Congrats to the ax-throwing lane winners: Greg Heddaeus, Tom Fallon, and Jon Roberts! A huge thanks to all those companies and individuals who helped out by sponsoring this exciting event. The Chapter was thrilled to have a really great turnout to start what they hope will be a busy and energetic year in Pittsburgh! If you are ever in the area–be sure to try to join us.

Safety first! The ICRI Pittsburgh group getting coached on ax throwing to ensure a fun and safe night for all

The ICRI Pittsburgh crew enjoyed a fun night out with old friends and new friends. Overall ax wielder Jon Roberts is seen kneeling in the middle of the crowd–congratulations Jon!

CHAPTERS COMMITTEE CHAIR'S LETTER



DAVID GRANDBOIS
Chapters Chair

Hello ICRI!

For those of you who do not know me, my name is David Grandbois, I reside in Shakopee, Minnesota, and am currently the Branch Manager at the Minneapolis office of Western Specialty Contractors. As of 2024, I am the new Chapters Committee Chair as well as a newly appointed Board Member at Large.

I know there are very large shoes that still need to be filled from when Michelle Nobel was at the helm; Jon gave it a valiant attempt! Just kidding Jon. If you have not already, please take a moment to reach out to Jon and thank him for his valued input to the Chapters committee over the last 18 months and his overwhelming support for ICRI.

I started my ICRI journey in 2014 with the Minnesota Chapter, where I have worn many hats over the years including President in 2019. I attended my very first convention in none other than the great city of Omaha, "The Good Life," a city I hold near and dear to my heart as that is where I first moved after graduating college to start my professional career. Since then, I have had the opportunity to grow locally with the Minnesota Chapter, and attend multiple ICRI events and conventions across the country. There is so much about this industry and the ICRI organization that I love, but most of all it is the people.

I am honored to have been given this opportunity to help better the industry and grow the ICRI organization. This truly is an amazing group filled with passionate, proficient, and professional individuals.

I look forward to seeing you all at the next convention this coming spring in Boston. Please stick around for the Chapters Committee Meeting to let me know how you really feel about Jon.

David Grandbois, ICRI Chapters Committee Chair
Western Specialty Contractors–Minneapolis, MN

CONCRETEREPAIRCALENDAR

MARCH 20, 2024
The Concrete Durability Webinar Series #6
Surface Applied Cathodic Protection
Website: www.icri.org

MARCH 24–28, 2024
ACI Concrete Convention
New Orleans, Louisiana
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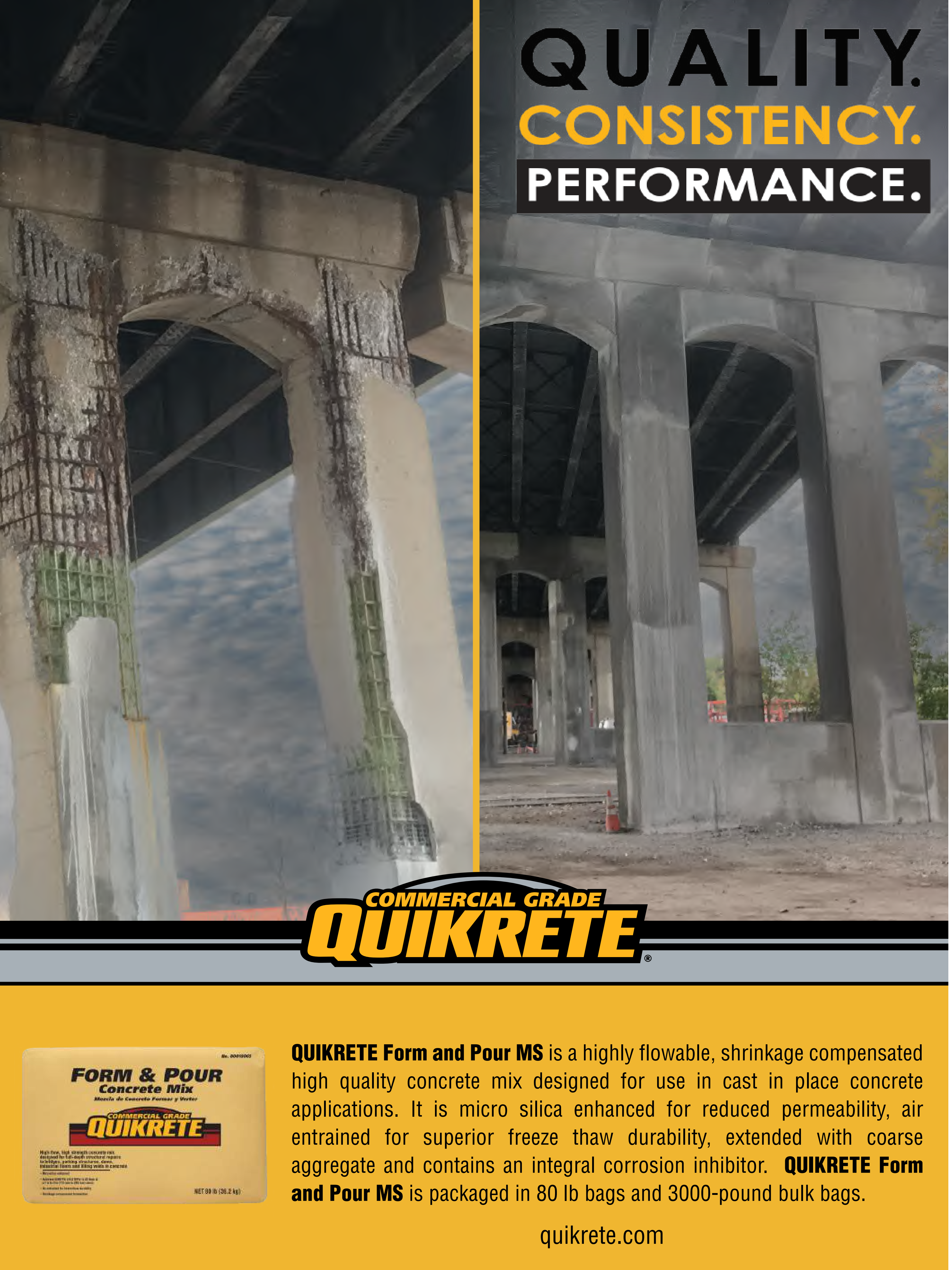

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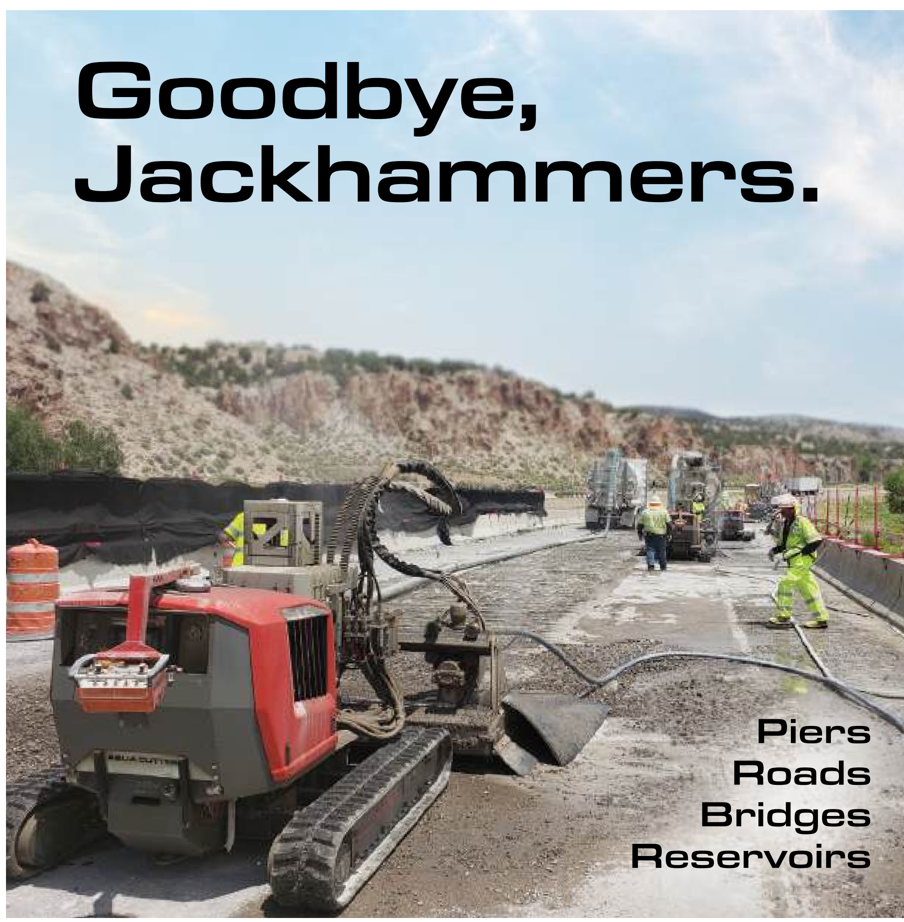

Goodbye, Jackhammers.
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