FALL SEMINAR 2024
NORTHWEST OHIO

OHIO CONCRETE
Durable. Economical. Sustainable.

Building with Concrete

modern concrete and evolving trends in concrete construction

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National Business Development Group
Central Region Manager
Euclid Chemical, Cleveland, OH

October 29th, 2024

Modern Concrete Technology

A look at past, current and future technological and engineering advancements in the field of concrete with examples of historical and future structures around the world and here in the USA with updates to codes and standards, design of structures, sustainability, concrete shrinkage, decorative applications, fiber reinforcement and chemical admixtures.

Your Speaker

Michael A. Mahoney, M.A.Sc., P.Eng. FACI

National Business Development Group, Central Region Manager

EUCLID CHEMICAL

- Responsible for engineering and specification development for concrete working with ready-mix producers, contractors, engineers, architects and owners
- 28+ years experience with fibers, R&D, testing and concrete engineering
- President of Fiber Reinforced Concrete Association and currently serving on various committees within ACI, ASTM and NPCA

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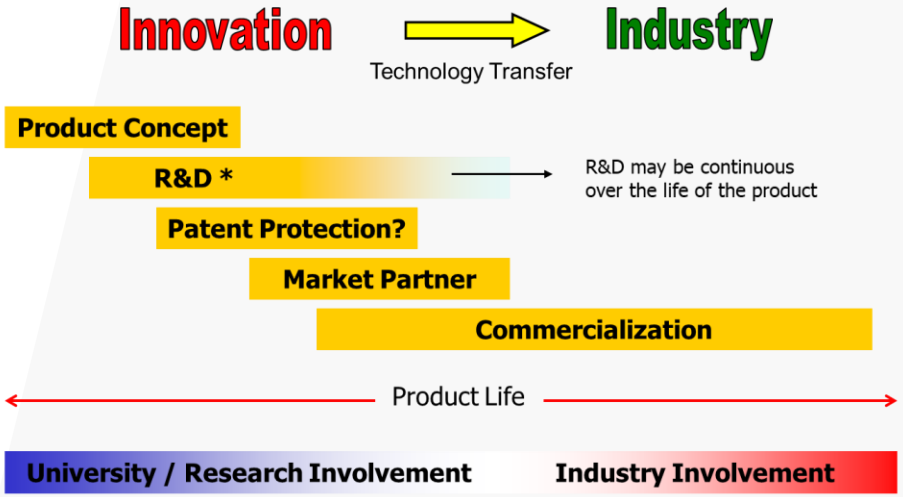
The Construction Conundrum

Why is our industry slow to adapt to new technology?

- Resistance to Change –workforce, codes
- Increased complexity – trust in technology
- Cost concerns – budget over-runs
- Labor – local v imported
- Equipment / Software
- Regulations
- Standardization
- **Immediate ROI to new implementation**



The Sustainability Challenge

How is the construction industry building for the future?

The concrete construction market needs to adopt sustainable concrete practices and technologies that can save energy, reduce CO_2 emissions, protect the environment, maximize economics.

Despite some of the “marketing”, concrete is already one of the most environmentally friendly materials available when properly used.

- Durable, cost effective, local, history

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Is Concrete Technology Evolving?

More than just “sustainability”

Challenges facing the concrete construction industry

- Population will continue to increase (10 billion by 2050)
- Natural resources are being depleted
- Cost of materials and required transport is increasing
- Infrastructure needs and demands are accelerating
    - Build and develop for population growth
    - Repair and replace aging infrastructure
    - Awareness around disaster resilience and energy efficiency

- Recognition of climate change and need to address
- Governmental regulation around carbon and greenhouse gases

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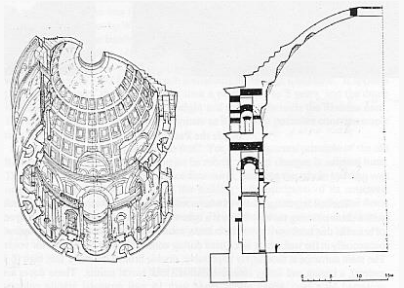
Concrete is Everywhere!

Concrete is needed to build the structures of the world

A little levity…..

Some fun facts on concrete



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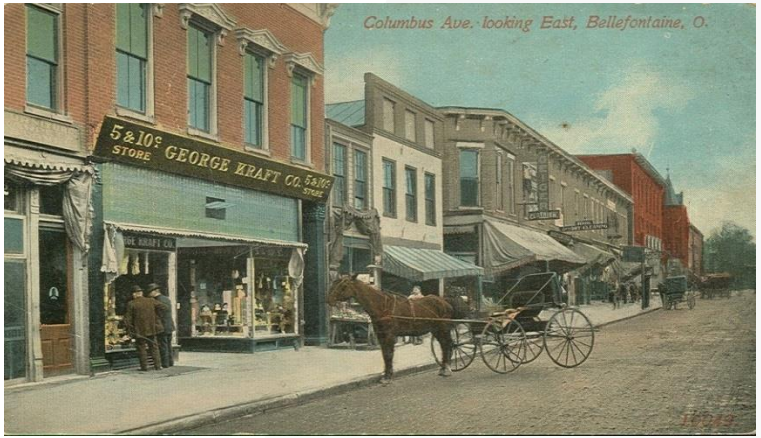
Roman Concrete

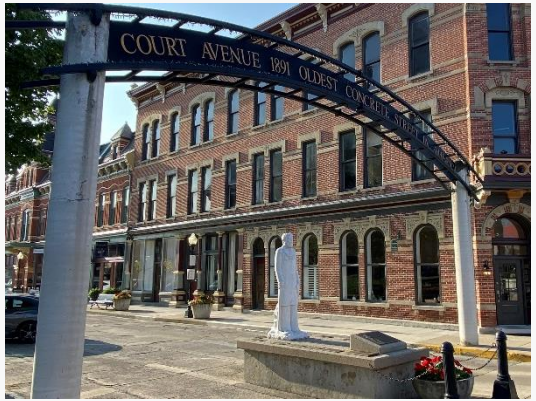
Why was it so strong?

- Limestone
- Volcanic aggregates
- Water
- “admixtures”
- Overdesigned?

Oldest Concrete Street in America



- “Artificial Stone” street in Bellefontaine, Ohio
- George Bartholemew, 1891
- Posted a 5 year bond guaranteeing performance



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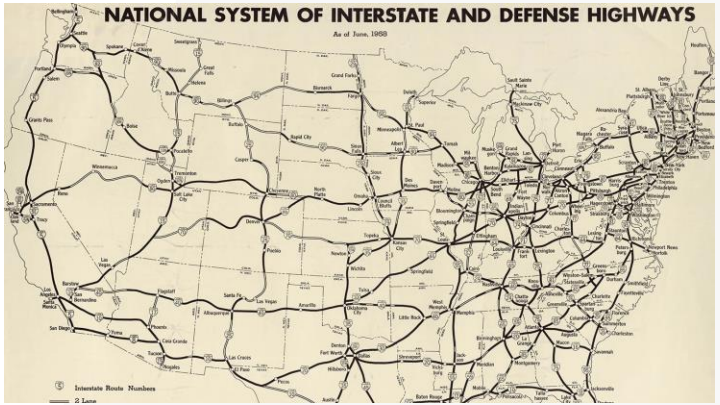
Concrete Firsts

The Federal-Aid Highway Act of 1956 called for 41,000 miles of Interstate roadways to be constructed at an estimated cost of $41 billion;

- 60% of the initial work was constructed with concrete



Worlds First Concrete Skyscraper

Ingalls Building
Cincinnati, OH

COURTYARD® BY MARRIOTT

- 16 story reinforced concrete structure, first of its kind in the world.
- Concerns that it would collapse after bracing was removed

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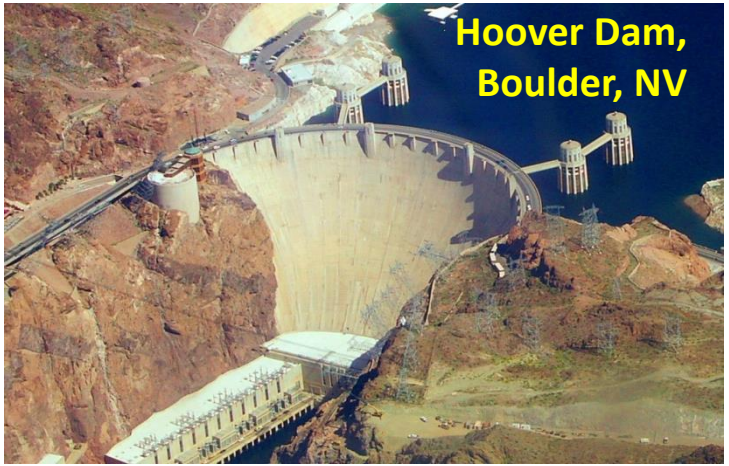
New York Concrete

‘Billionaires’ row
+ 14,000 psi concrete
Tallest residential skyscrapers in the world made possible with concrete

Dam large concrete



- Hoover Dam - 3.25M cu yd of concrete
- Three Gorges Dam - 35 M cu yd of concrete!

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The Pentagon

the office

World's second largest office building

- 6.5 M sqft.
- Completed, January 1943
- 41,000 pilings
- 435,000 yd^3 of concrete

Burj Khalifa

The world's tallest man-made structure – made possible with concrete

- Opened in January 2010
- 2722 ft (829 m), 160+ floors
- 59,000 yd^3 of concrete used in base
- 430,000 yd^3 of concrete used in structure

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Concrete Bridges

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Cool Concrete

Self-Cleaning Concrete

Church of the Year 2000,
Rome, Italy

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The Concrete Canoe Competition

ASCE CONCRETE CANOE COMPETITION

University of Florida – 2024 Winners

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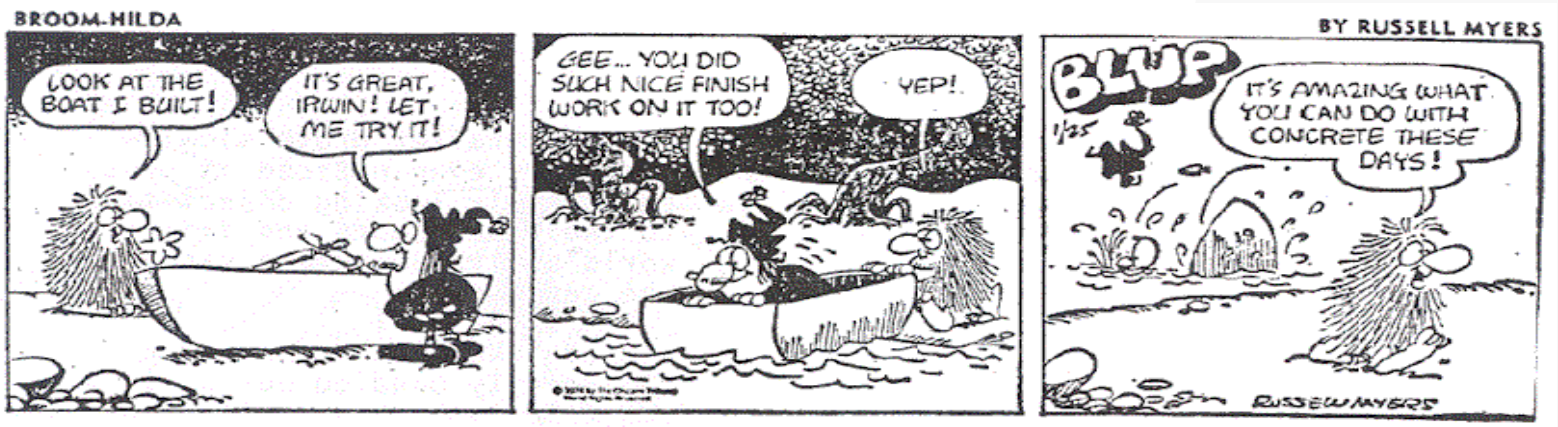
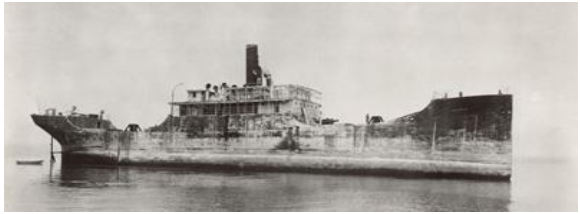
…and you thought that was crazy?

The 2025 Great Northern Concrete Toboggan Race, Montreal QC

Concrete Boats





During World War I, 14 concrete ships were built due to steel shortages - including the 130 m long U.S.S. Selma. World War II concrete ships saw widespread wartime service in battle zones. 24 of these ships were large sea-going vessels and 80 were sea-going barges of large size. Cargo capacities ranged from 3200 to 140,250 tons.

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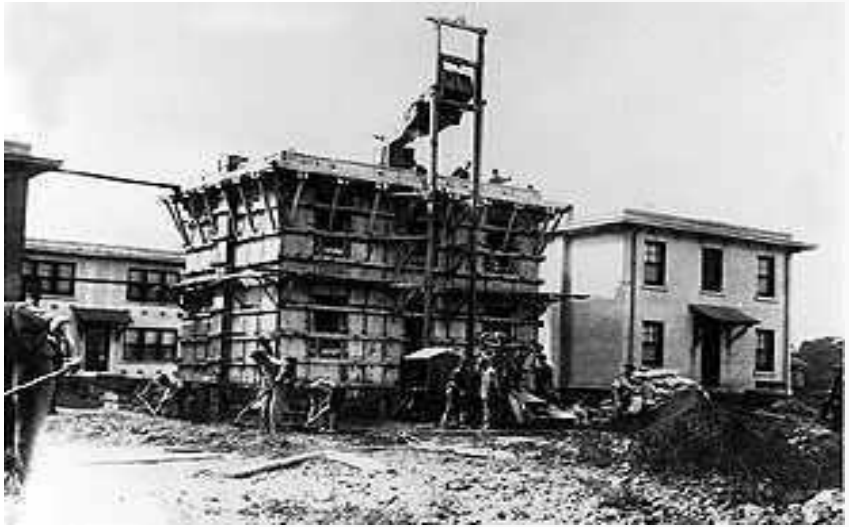
Concrete Homes



In 1908, Thomas Edison designed and built the first concrete homes in Union, New Jersey. These homes still exist today

100 years later:

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Disaster Resilience

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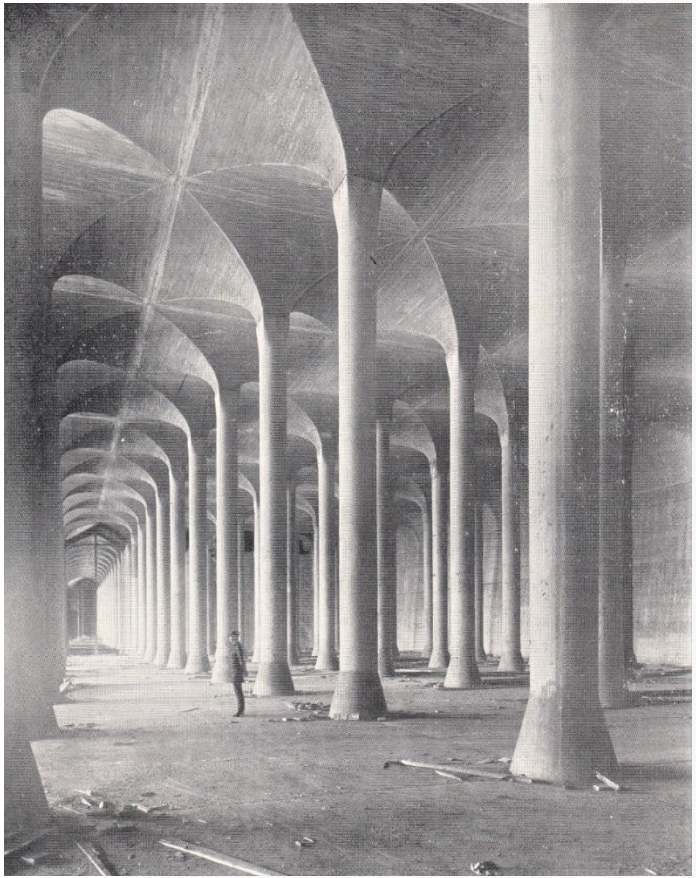
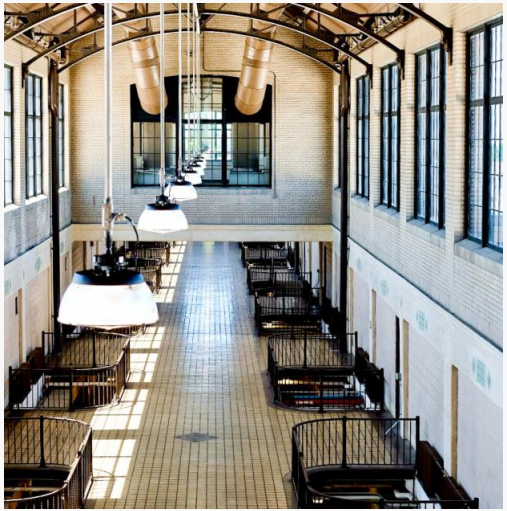
Baldwin Reservoir

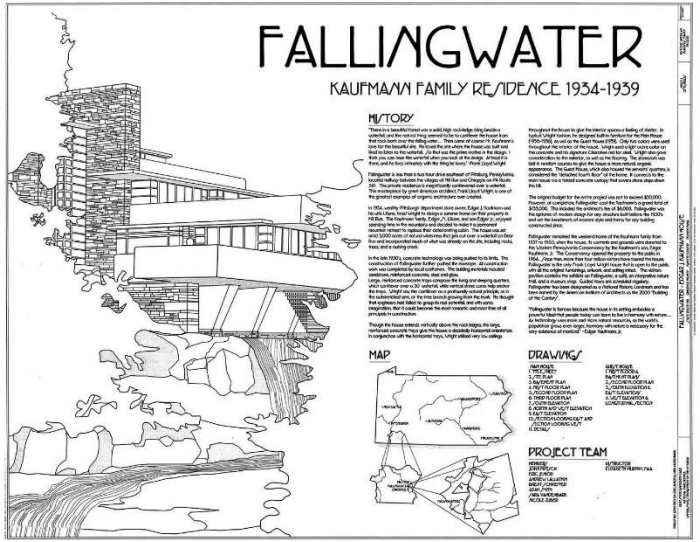




- Cleveland, OH
- Covered concrete reservoir
- Opened 1925
- 1035 x 551 ft
- 39 ft deep

- Nominated for ASCE National Historic Civil Engineering Landmark

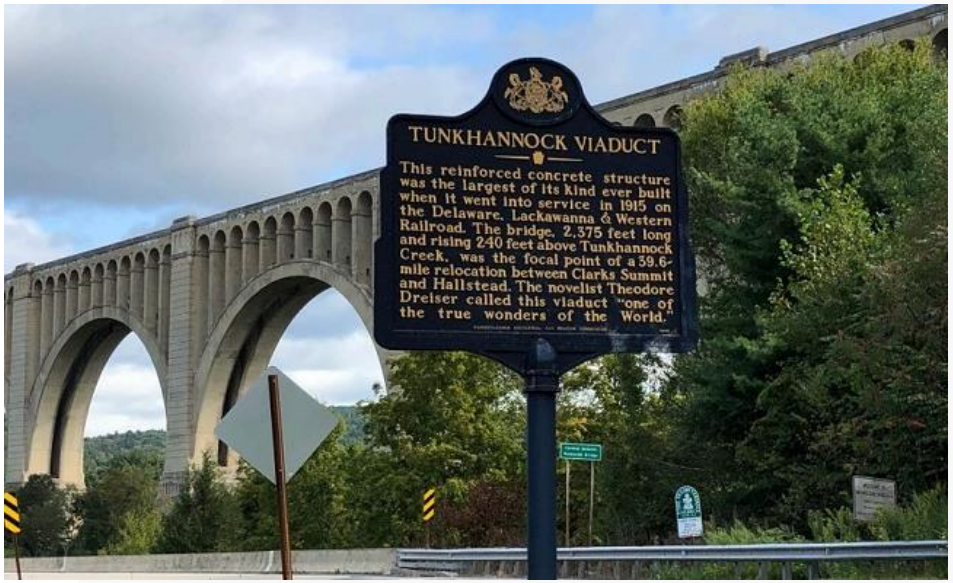
Falling Water

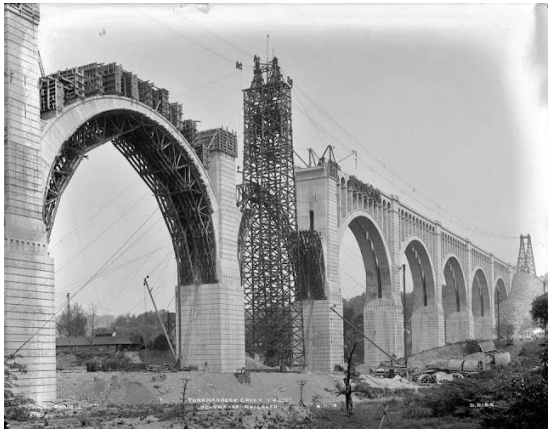


- House designed by architect Frank Lloyd Wright
- Built from 1936 – 1939, Stewart Township, PA
- Designated National Historic Landmark, May, 1976

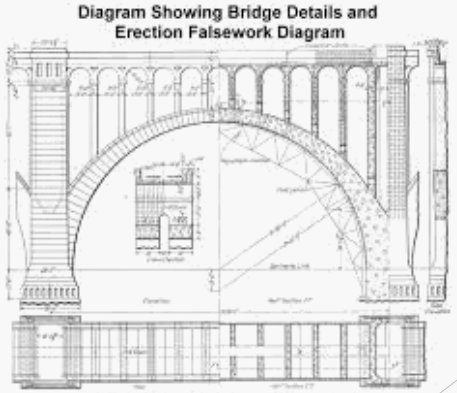
- upside-down T-shaped beams integrated into a monolithic concrete slab which formed both the ceiling of the space below and provided resistance against compression

Tunkhannock Viaduct





- Concrete Deck Arch Bridge
- Nicholson, PA
- 2375 ft length, 240 ft height
- Completed in 1915
- ASCE National Historic Civil Engineering Landmark, 1975



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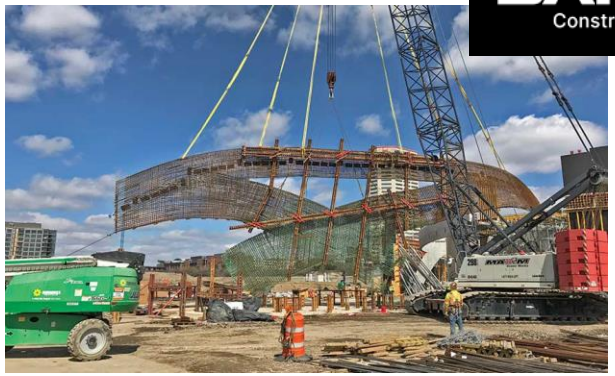
National Veterans Memorial Museum

Columbus, OH

BAKER Construction



- Built from 3D modelling, complex reinforcing details
- 8000 cu.yd. concrete
- Opened 2018

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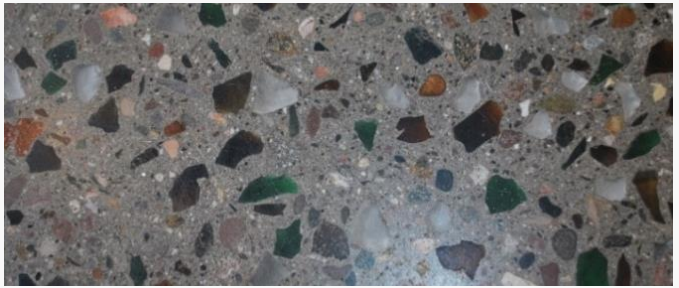
Concrete as a Building Material

CONCRETE is already one of the most sustainable building material, compared to timber, steel, asphalt, etc:

- Lower embodied energy
- Using local materials
- Better life cycle / durability
- Thermal mass and energy efficiency
- Light reflectivity
- Minimized waste
- Customized properties



We can do even more with the proper guidance, specifications and innovative material use

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Types of Concrete

Lots to say…..

Lightweight
Pervious
Self-Consolidating
Self-Healing
Fiber Reinforced
Heavy-Weight
Shotcrete
Fast-Set
Pre-stressed
3D printing

Mass
Recycled
Structural
Hot Weather
Cold Weather
Air entrained
Roller Compacted
Green (Carbon)
Decorative
Self Cleaning

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Emerging Trends in Concrete Technology

- Limestone Cements
- 3D Printing
- Pozzolans
- UHPC
- Self-healing concrete
- Internal curing
- Fiber reinforcement
- ‘Green’ construction
- Graphic concrete
- Light-generating concrete
- Translucent concrete
- Project Management Software
- BIM
- Artificial Intelligence (IoT)
- Drones
- Off-site construction

Half of all buildings in the world are made from concrete

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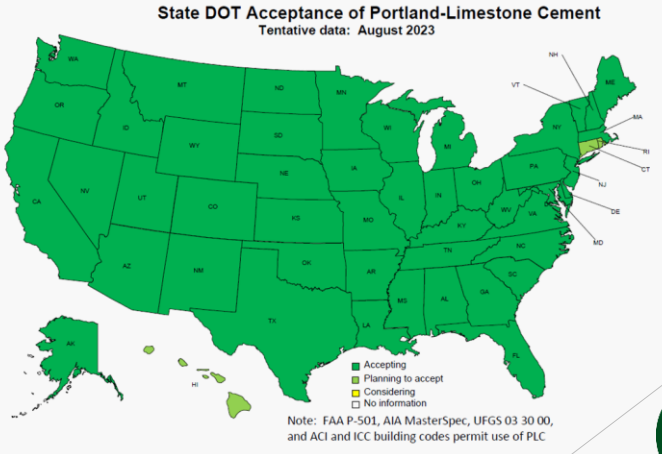
Limestone Cements

- A blended cement with additional limestone content, optimized for performance
- The easiest way to reduce your carbon footprint by up to 10%
- Suitable for buildings, bridges, pavements, geotechnical applications
- Readily available throughout the U.S. and Canada

2004: – ASTM International approves the inclusion of up to 5% limestone in all ASTM C 150 cements

2012: - Inclusion of up to 15% limestone approved in ASTM C 595 (Blended Hydraulic)

2022: - Major cement producers announce intention to stop producing ASTM C 150 Type I cement!



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Type IL is here to stay

Type IL is an incremental change,
Any / all cement changes would require adjustments to the mix

- Preplanning should include discussion with RMC producer
- Admixture doses may slightly change
- Reduce your variables, check weigh batch tickets, cement, admix?
- Bleeding – decreases with increased fineness, impact for flatwork
- Setting time – can be slight increase with increased fineness

PART 2 - PRODUCTS

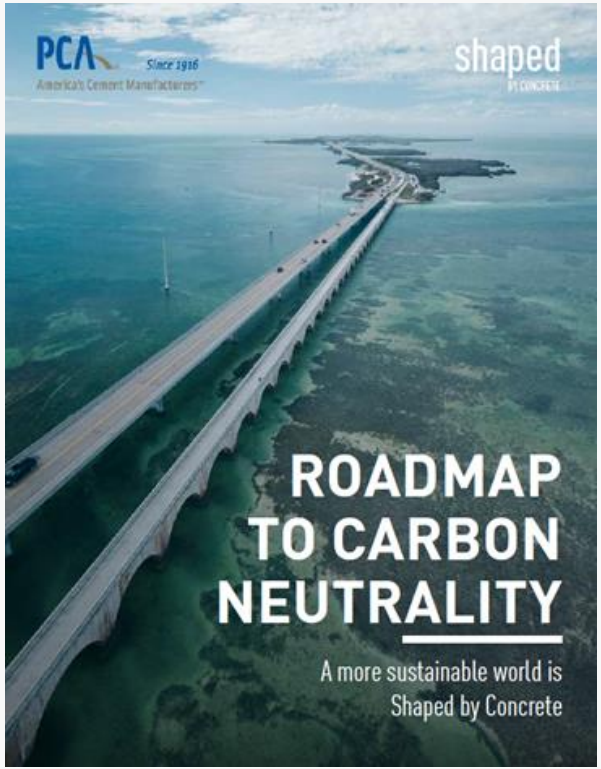
2.1 CONCRETE MATERIALS AND PRODUCTION

A. Portland Cement:

1. ASTM C150, Type I or Type II
2. ASTM C150, Type III, High-early Strength Portland Cement may be used subject to review and approval of the SER. The specified 28-day concrete compressive strength shall occur within 7 days for concrete using Type III Portland Cement.
3. ASTM C150, Type V
4. Provide the same brand of Portland Cement from a single source throughout the project, as required to meet Design Professionals' requirements.

B. Blended Hydraulic Cement:

1. ASTM C595, Type IL, Portland-Limestone Cement
2. ASTM C595, Type IS, Portland-Slag Cement
3. ASTM C595, Type IP, Portland-Pozzolan Cement
4. ASTM C595, Type IT, Ternary-Blended Cement
5. ASTM C595, Type IT (HS) plus pozzolan or slag cement for Exposure Class S3]



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3D Concrete Printing

3D printing is not just limited to plastic and metal. 3Dconcrete printing offers the possibility in the quick build of affordable homes and communities.

It is faster, safer, and less expensive, providing more durable and energy efficient structures. Architectural and artistic appeal can be customized. Soundproofing and other insulating features are inherent to build. Material is resistant to pests, floods, wind, fire

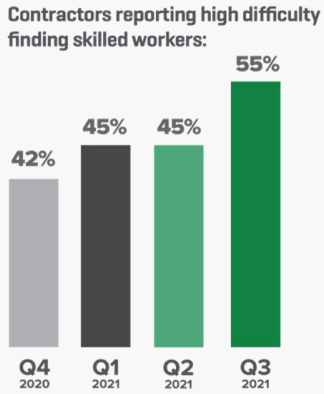
- Best fit to small and mid-sized buildings
- Reading blueprints for optimized material use
- Construct complex designs
- Reduce production time

Market Drivers for 3D Printing

◆ WSJ NEWS EXCLUSIVE | PROPERTY REPORT

3-D Printed Houses Are Sprouting Near Austin as Demand for Homes Grows

Project would be biggest 3-D printed housing development in U.S.



- Global labor shortages / high construction costs
- Productivity: machinery can work 24/7
- Cost savings – no formwork
- Machine-driven: avoids construction mistakes
- 3D concrete teams require 1/3rd of typical construction workforce: SIGNIFICANT LABOR COST SAVINGS

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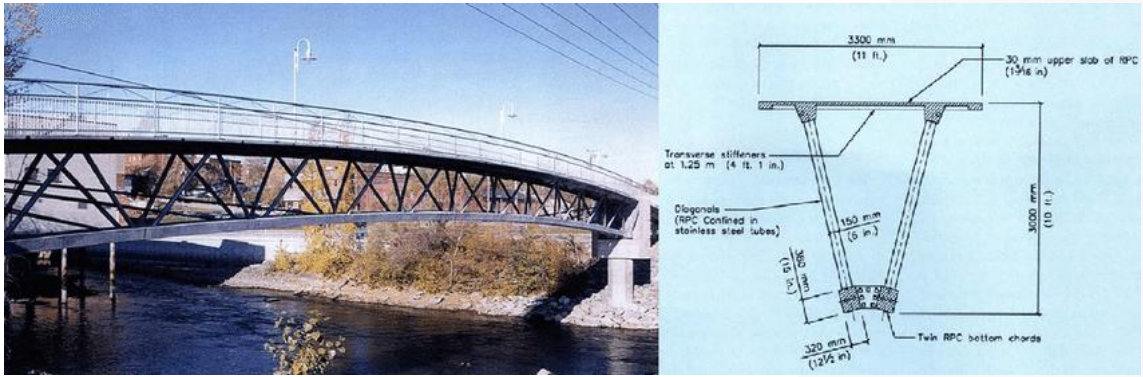
Ultra High Performance Concrete (UHPC)

“new-ish” technology

Ultra-High Performance Concrete has been around for over 2 decades but is still relatively under-used. UHPC contains advanced mix design technology, fibers and other concrete practices to make more durable and high-strength concrete. It is estimated that UHPC can last well over 75-100 years. The United States is currently one of the key market players for UHPC.



Sherbrooke Pedestrian Bridge, Sherbrooke, Quebec, Canada
Constructed 1997

— extended usage life
— improved durability
— improved resiliency
— decreased member thickness
— reduced maintenance/out of service
— simplified construction techniques
— speed of construction

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Self-Healing Concrete

Durability through longevity

Self-healing concrete contains limestone producing bacteria that can seal a crack when it comes into contact with air and water. The mechanism is that the free lime will create hydrated cementitious materials within the crack sealing them from further water penetration. It can be used in new construction or to repair existing concrete

There are also crystalline materials that can be integral or topically applied to concrete structures creating the same process.

Internal Curing

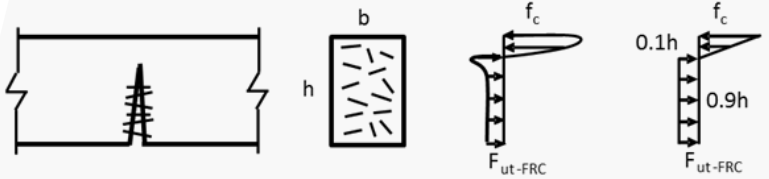
Another oldie but goodie!

The American Concrete Institute (ACI) defines internal curing (IC) as a process that supplies water to a freshly-placed concrete mixture to aid in hydration

Curing concrete from the “inside out”

- prewetted expanded shale, clay or slate (ESCS) lightweight aggregate
- improves hydration, reduces early cracking, reduces chloride ingress, reduces curling and improves durability

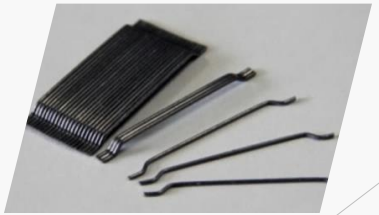
Fiber Reinforced Concrete

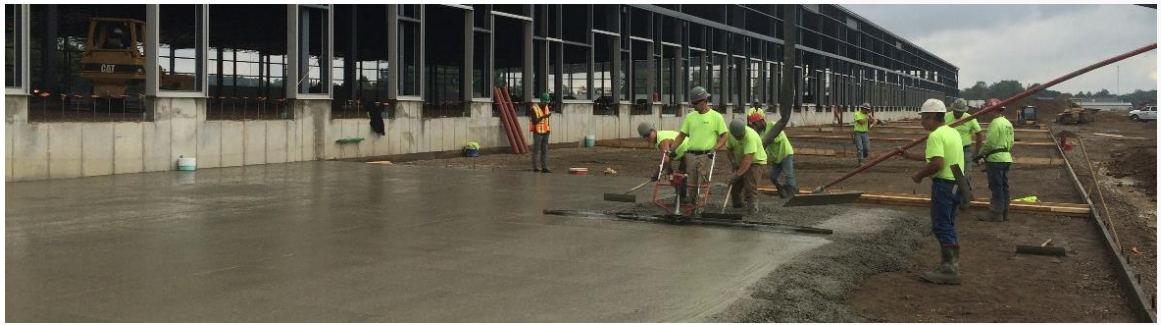


A strong future

Although modern FRC has been used since the 1960's, there has been tremendous growth and acceptance over the past decade

- Design Codes and Test Criteria
- Environmental Product Declarations
- National Owners and DOT acceptance
- Reduced labor, decreased costs





Green Building Codes and Specs

Requirements are now being written into projects

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating post-consumer and pre-consumer recycled content and cost.
2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
3. In-situ carbon dioxide mineralization in Concrete: Supply concrete that has undergone in-situ carbon dioxide mineralization, such that post-industrial carbon dioxide (CO_2) is injected into the concrete during mixing and chemically converted into a mineral. The concrete may undergo mix optimization whereby the strength enhancement property of CO_2 is utilized to optimize cementitious content, pending that the CO_2 – mineralized and optimized concrete mix meets concrete performance requirements as outlined in this specification document.
   a. Acceptable Technologies: CarbonCure Ready Mix Concrete Technology
      1) ~~CO2 mineralization is compliant with ASTM C494 Type S.~~
4. Concrete Mix Optimization for Embodied Carbon Reduction: Supply concrete that has undergone an optimization to reduce the Global Warming Potential (GWP) of concrete mixtures that meets concrete performance requirements as outlined in this specification document. Provide documentation of the reduction in GWP, expressed in kg CO_2/m3, for each concrete mixture to be used and the reference mix for comparison. The concrete producer waives any rights to carbon credits as part of the concrete mix optimization
   a. Acceptable Technologies: Concrete -AI, Inc.

C. Design Mixtures: For each concrete mixture, include the following:

1. Mixture identification.
2. Minimum 28-day compressive strength.
3. Durability exposure class.
4. Maximum w/cm.
5. Slump limit.
6. Air content.
7. Nominal maximum aggregate size.
8. CarbonCure

- Green materials are healthier and safer
- International Green Construction Code
  - Regulates impact of buildings on environment
  - Promotes sustainable construction practices

ZERO ENERGY CERTIFICATION
estidama
BCA GREEN MARK
ENERGY STAR
WELL GOLD 2015
BREEAM
Certified Passive House
Passive House Institute
U.S. GREEN BUILDING COUNCIL LEED USGBC
GREEN GLOBES
Enterprise green community

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Graphic Concrete

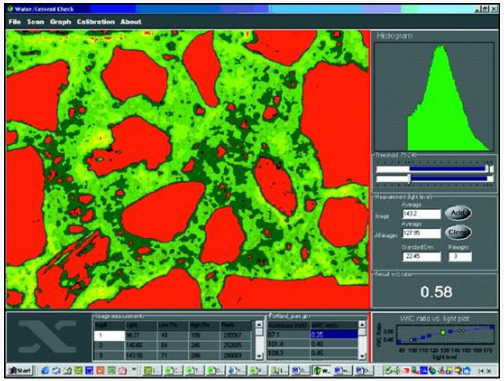
Graphic Concrete offers architects the versatility to deliver distinctive, intriguing, and iconic imagery to precast concrete surfaces without having to apply additional membranes or coatings. This technology is the printing of a visual idea on a specific membrane and transferring it to a concrete surface. Customized patterns, combined with colors, can allow imagination to be the limitation on appearance.

can also help developers reduce the exterior paint budget in their construction costs.

Light Generating Concrete

Solar construction?

Light-emitting cement is a green construction material designed to illuminate highways, roads, and bicycle lanes without using electricity. Light-emitting cement absorbs solar energy during the day and radiates light at night



This material is made out of sand, silica, industrial waste, alkali, and water. To give it the light-emitting property, the materials go through a polycondensation process performed at room temperature. The chemical reaction between these raw materials produces a gel that can radiate solar energy.

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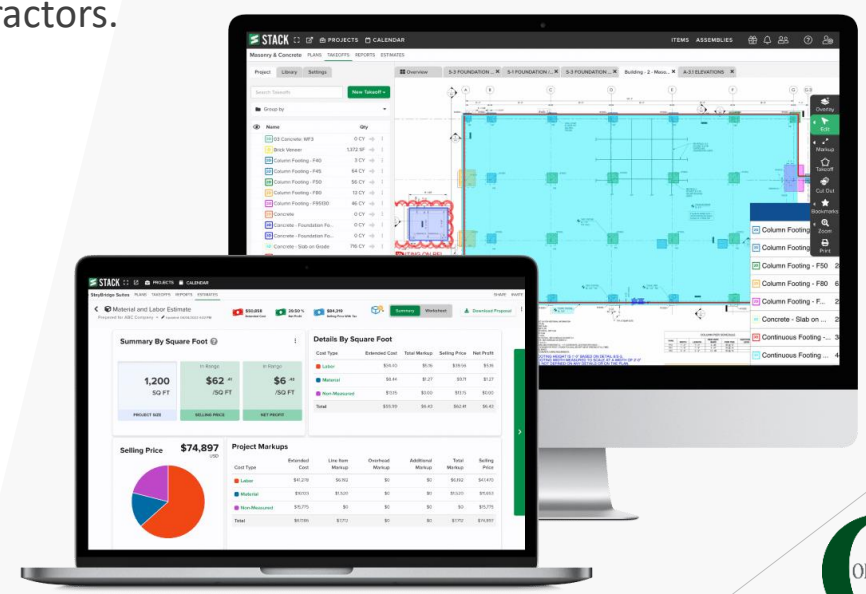
Project Management Software

Data Driven Decisions

There are construction management software tools made specifically for concrete contractors.

Services provided include:

- Site preparation needs
- Specification review
- Change orders and time impacts
- Material delivery schedules
- Quality assurance
- Payroll and accounting services
- Reporting



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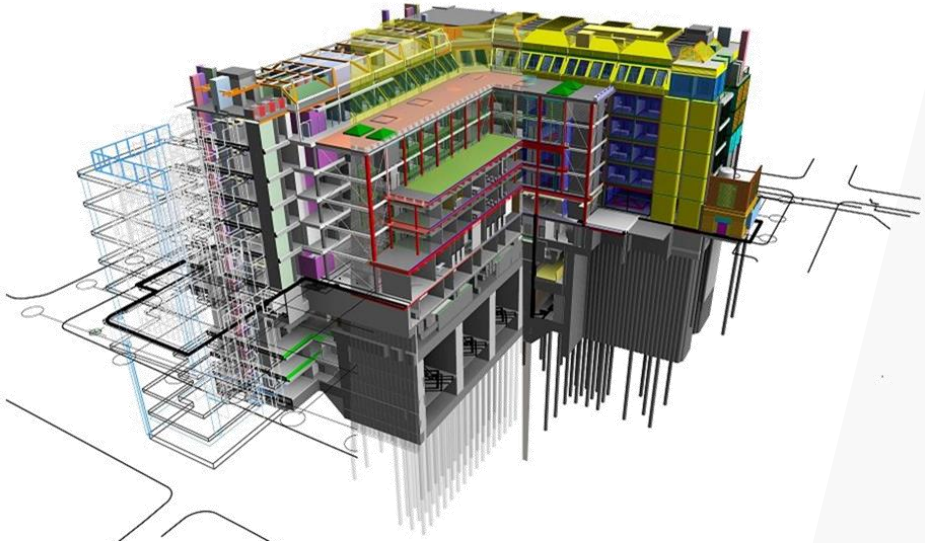
Building Information Modeling (BIM)

Building Information Modeling has been around for decades, but the technology is continuing to advance. 3D modeling design software allows professionals to see their project's design, plan, and construction. BIM can help communicate project details to all parties and to improve supply chain metrics while reducing waste, delays, and mistakes.



Additional benefits:

- earlier identification of error and fault
- fewer change orders
- improved communication, collaboration, and productivity throughout the product
- more transparency of information that can be used during the bidding and procurement process
- more reliable design process

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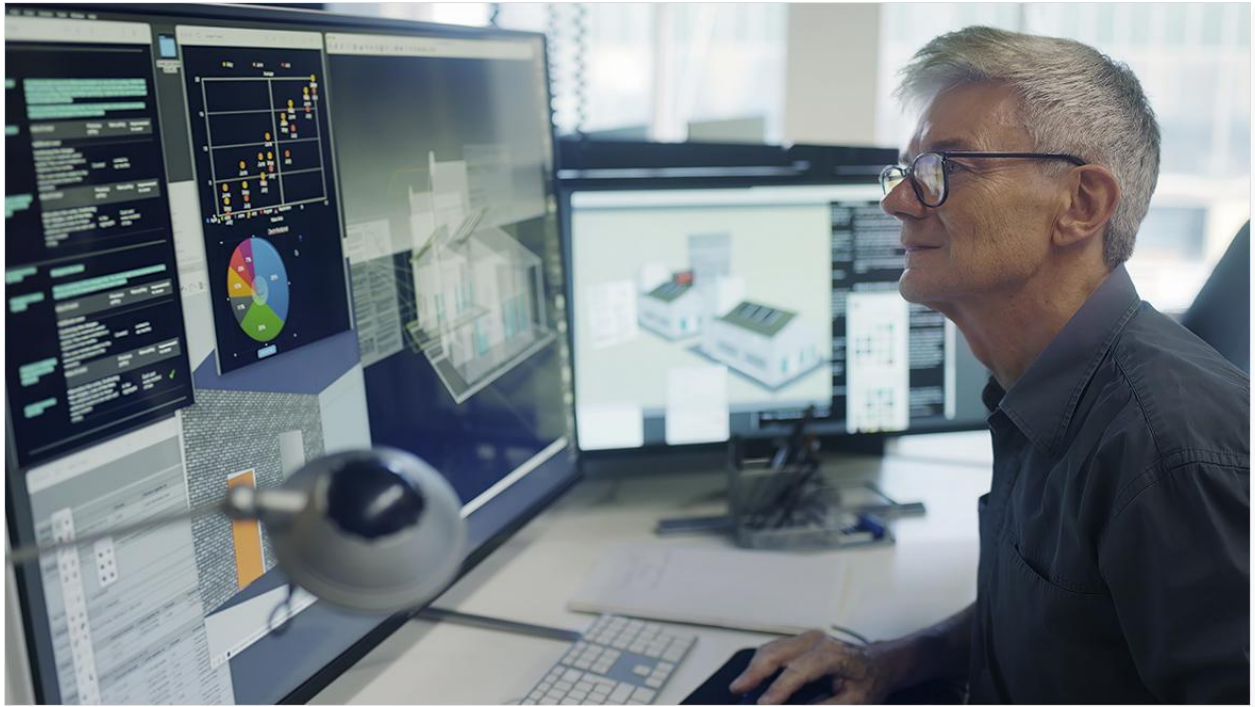
Historical Specs & Plan Development

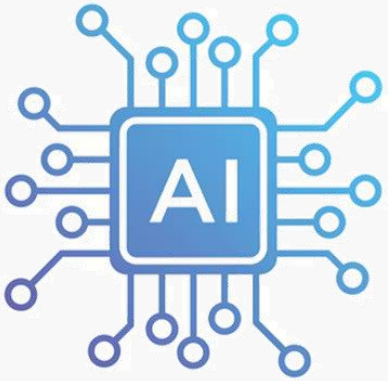
Evolving Technology



- Drafting rooms
- Paper plans
- Libraries

- Computing power
- Cloud-based
- AI

Artificial Intelligence



Smart Concrete?

GPS trackers and IoT sensors on equipment for concrete construction allows for predictive maintenance and can improve production cycles. Intelligent equipment can use human knowledge through computer processes.

Strain gages, temperature sensors and other monitoring devices can assist in scheduling and to provide real-time decision-making needs. Curing and hardening of concrete are crucial to designed performance. IoT applications can automatically regulate temperatures and humidity to ensure the adequacy of concrete properties in the chemical reactions.

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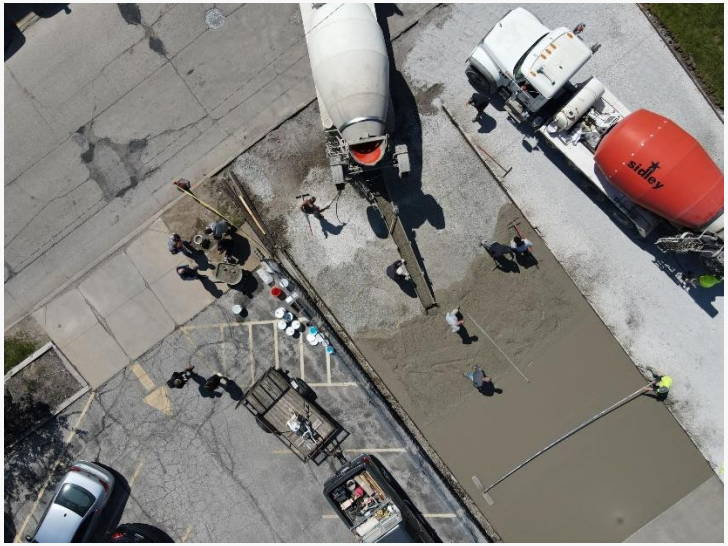
The Use of Drones

An eye in the sky

Construction drones (UAV's) are seeing more widespread use on construction sites. Real-time data can be collected and analyzed remotely to verify material quantities, monitor site progress, identify potential repair needs, deter theft and measure stockpiles. Speed and accuracy are also greatly improved over traditional measurement and recoding methods.

- Detailed aerial imagery
- Application of films or other chemicals
- Mapping and site measurements pre-construction
- Inspection of thermal and visual deficiencies
- Tracking assets on job-sites
- Monitoring for safety and other issues



The more things change……..

Best practices are still as important today as they were then

Some concrete rules will never change..

- Surface Preparation
- Deterioration Prevention
- Use of Bonding Materials
- Curing
- Compatibility
- Respect Environmental Conditions
- Technical before Marketing

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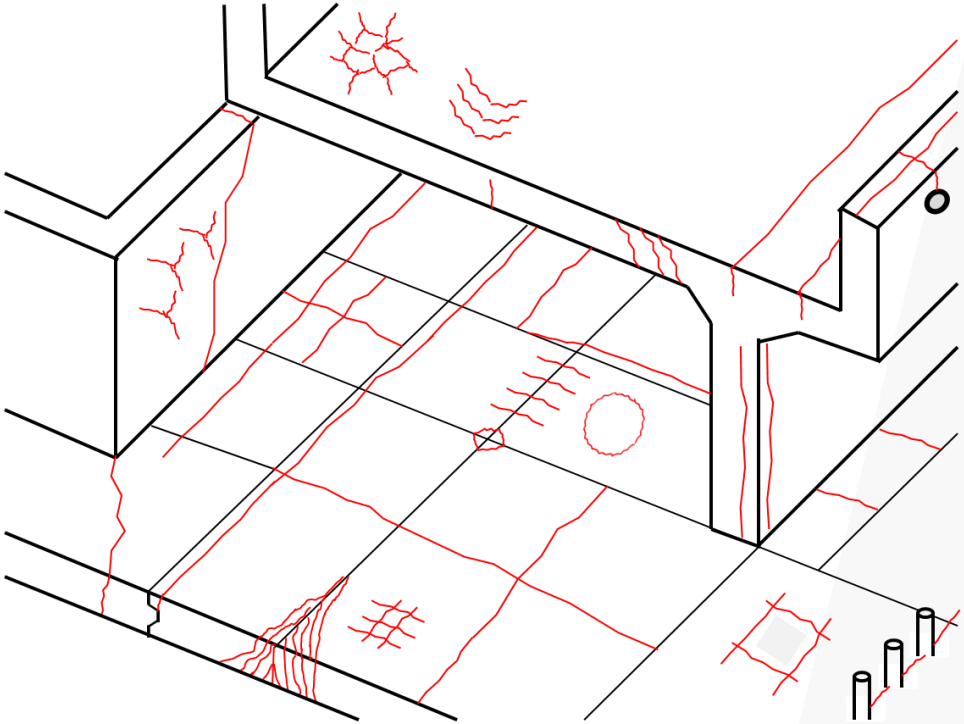
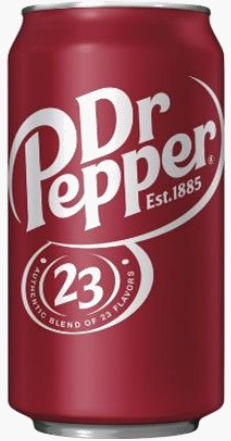
Despite your best Intentions

Concrete will still crack





- Crazing, map, alligator
- Plastic cracking
- ASR
- D cracking
- Negative Moment
- Shear
- Settlement
- From poor compaction
- Improper sawcutting (depth, width)
- T cuts
- Re-entrant
- Drying Shrinkage
- Structural

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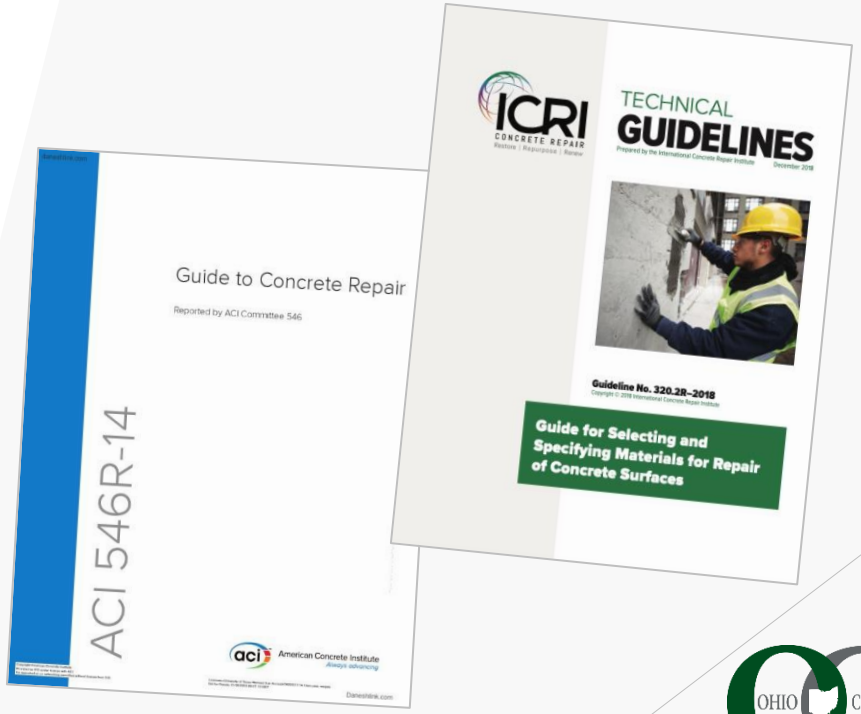
Prevention

Prevent Concrete Deterioration through use of Best Industry Practices

Specify methods and practices

1. High quality concrete and practices.
2. Increased cover.
3. Surface sealers.
4. Chemical resistant coatings
5. Waterproof membranes.
6. Specialty concretes.
7. Corrosion inhibiting admixtures.
8. Improved construction products.



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Curing Best Practices

ACI 302.1R-15 is the latest version, but ACI 302.1R-04 said it best:

Purpose of Curing:
"After concrete placement and finishing of suitable concrete, curing is the single most important factor in achieving a high quality slab.

Properly cured concrete will be stronger, more durable, and will look better than poorly cured, or uncured concrete

Unless otherwise specified, use membrane-forming curing compounds that conform to ASTM C309 or ASTM C1315. Silicate-based liquid surface densifiers are prohibited as curing compounds (ACI 563). Curing compounds will require removal to apply sealers

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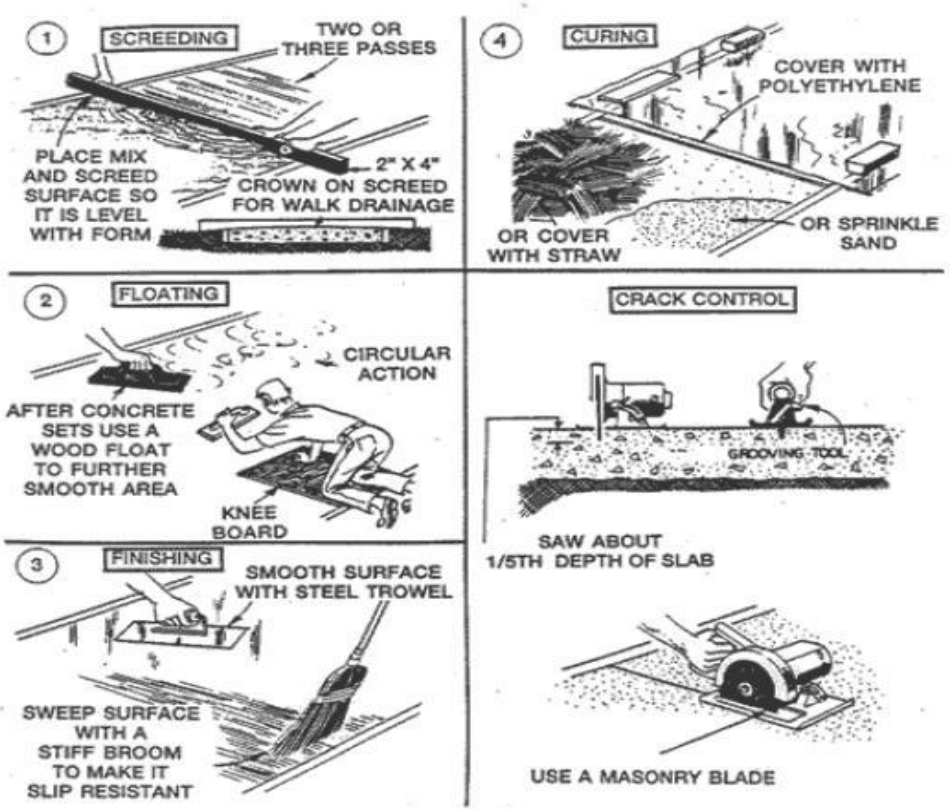
A few reminders about Jointing….

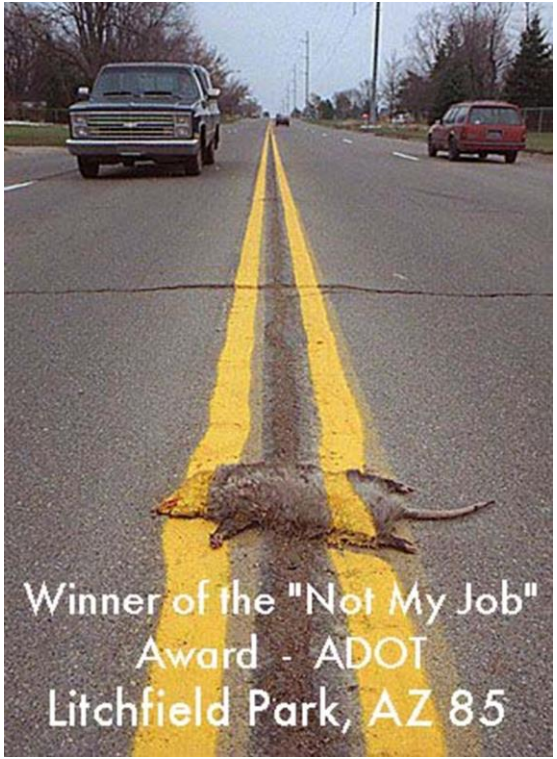


Placing, Finishing & Jointing are all important parts of a successful concrete project:

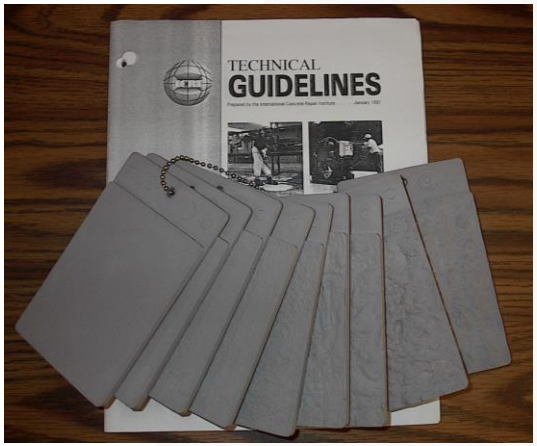
- Always cure concrete
- Different finishing techniques are available
- Create your own crack pattern!

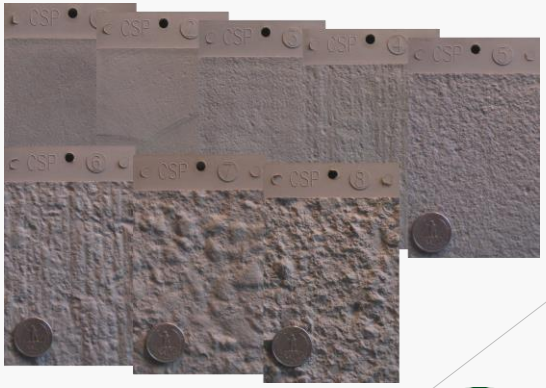
Surface Preparation

A repair is only as good as what it is stuck to….



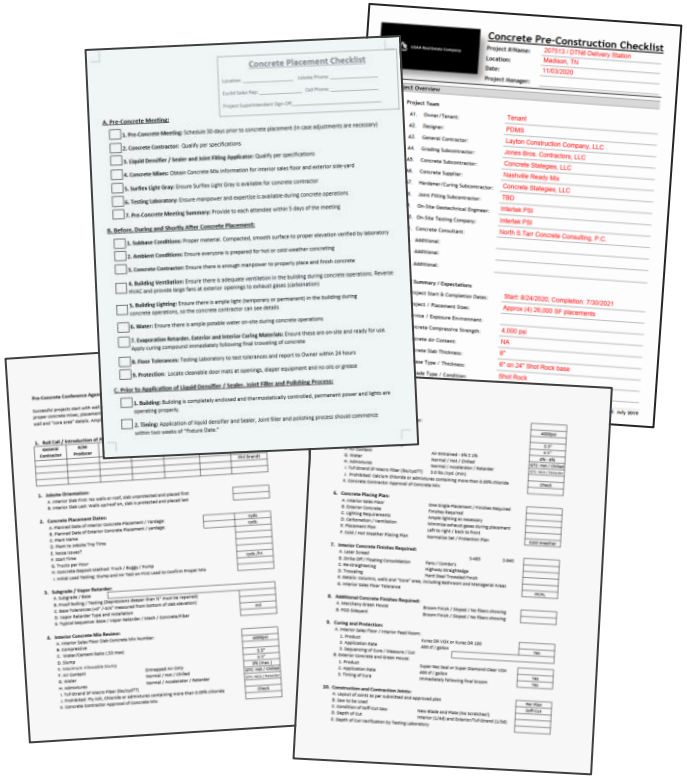
"The repair will be only as good as the surface preparation, regardless of the nature, sophistication, or expense of the repair material."





The Pre-Job Meeting

Document everything



- Upload to secure servers
- Take the lead in ensuring quality
- Review notes and action items
- Propose products, technologies

Conclusions

4 key takeaways

Concrete technology is continuing to evolve with new methods, techniques, materials and tools to help build stronger and faster than ever before

Proper specifications, coordination and implementation of work can yield and exceed original design intent

Sustainability and Durability of concrete can be achieved with economical consideration

Concrete isn’t going anywhere!

It will be here for generations to come.

FRC Pavement
Elyria, OH
UAV Photo courtesy of Ohio Concrete

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Durable. Economical. Sustainable.

Thank you for your time and attention

We look forward to discussing opportunities for your next concrete project

Questions / Discussion?