Ensuring Durable Concrete Surfaces

Steven M. Waalkes, PE – Executive Director/CEO
Michigan Concrete Association

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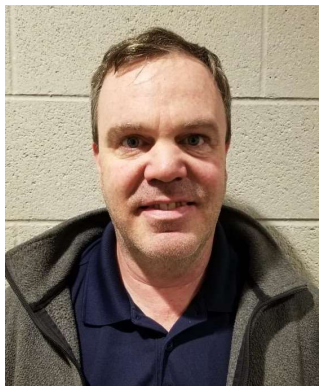
UM Dearborn, Fairlane Center North

Who does the MCA represent?

The Michigan Concrete Association was established in 2009 as a merger between the Michigan Concrete Paving Association (1968) and the Michigan Concrete Association (1952). We currently have over 170 member companies!

Our Team






MCA Technical Staff:

- Steve Waalkes
- Heather Smith
- Dave Cook
- Chris Nelson
- Mark Meddaugh
- Katie Izzi

Other TEAM Members

- Ready Mix Producers
- Concrete Paving Contractors, large, medium and small (predominantly DOT and public work)
- Commercial Contractors (predominantly private work)
- Allied Suppliers and Service Providers
- Associate Members (Concrete Product Manufacturers, Engineering, Design & Testing Consultants

Overview – How to Ensure Durable Concrete Surfaces

- Design – incl. mix design, slopes, etc.
- Specifications – MDOT, ASTM
- Construction & Inspection
- Maintenance – surface sealers, deicers
- Potential Issues
  - ASR
  - Popouts
  - Scaling and mortar flaking
- Type IL Cement

Durable Mix Designs for Exterior Concrete

- Minimum cementitious content = 564 lb /cyd (source: PCA)
- Slag cement replacement = 25-30%
- Air content = 5.0 to 8.0%
- Limestone coarse aggregate
- Slump = 3 to 6 inches

Proper Slopes for Exterior Concrete

Slope (%)	Slope (in/ft)	Concerns / Notes
0.5%	1/16” per ft	Absolute minimum for exterior surfaces; will still have birdbaths
1%	1/8” per ft	Typical target min.; good construction should have minimal birdbaths
2%	1/4” per ft	Typical target max.; usually no birdbaths; but ADA max. is 2.1%
5%	5/8” per ft	Max. pedestrian running slope to not have level landings
8.3%	1” per ft	Max. ramp slope; need level landings every 30” of rise

Specifications

- MDOT mixtures typically very durable
  - Prequalified aggregate sources
  - Minimum cementitious contents
  - Use of SCM's encouraged or required in high performance mixtures
  - One-time water addition allowed before placement begins
- MDOT construction specs require curing compound application
  - 200 sq ft per gallon or 25 syds per gallon
- Non-MDOT (commercial, industrial, residential) can follow ASTM
  - In many cases will still use MDOT quality materials

Examples of Modifications to Specifications

- For **Placement** add language stipulating that all concrete road pavement up to 31 feet wide, from 6 inches thick or greater installed in public right of way shall be placed with a self-propelled slipform paver or machine running on steel full height forms. Other paving means shall be approved by the **Engineer**.
- Minimum cementitious content of **517 lbs/cyd**
- For **Late Season Placement** - Concrete placed after September 30, a penetrating silane or siloxane sealant shall be applied to the concrete within 30 to 40 days after placement, in accordance with manufacturers recommendation for application.

Proper Construction for Durable Concrete

Construction practices that can affect durability:

- Addition of (and mixing in) water to the ready-mix truck on site
  - Must not exceed maximum w/cm ratio – extra water lowers strength
  - Can sometimes affect air bubble spacing (air void coagulation)
- Under or over vibration of the concrete (if at all)
  - Under can result in honeycombing; over can result in loss of entrained air
- Use of water during finishing makes the surface weaker
- Over finishing can result in loss of entrained air at the surface
- Lack of or improper curing results in unhydrated cement at the surface, resulting in a weak paste layer

Durable Concrete Requires Inspection!

- Concrete inspection is how we ensure the **quality, safety, and longevity** of concrete pavements.
- Not trying to play "Gotcha!" with contractors or suppliers, but instead **partnering** to ensure quality.
- Through inspection, we **identify and address defects** during construction to minimize repairs after the project is complete.
- Critical in Michigan due to **freeze-thaw cycles and high-traffic conditions**.
- It's **required** in almost all specifications!

Maintenance Practices to help with Durability

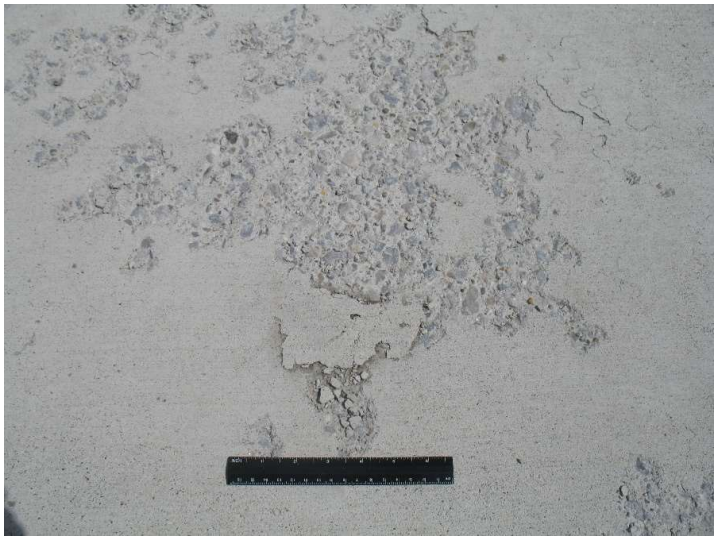
- Sodium chloride (NaCl), commonly termed rock salt, when used as directed, has proven to be the safest deicer for melting ice and not adversely affecting the durability of the concrete
- Once the NaCl has turned the ice to slush, it is recommended that it be shoveled up and disposed
- All forms of de-icing salts and chemicals should be avoided during the flatworks first year of service, and other means of snow and ice removal should be considered
- Other deicers such as magnesium chloride, calcium chloride, potassium acetate, or products which combine these chemicals have been found to be detrimental to the surface durability of concrete

Potential Durability Issues

and how to prevent them

Scaling

- Is the loss of the concrete's surface mortar surrounding the aggregate particles
- The aggregate is exposed and hardened mortar peels away from the surface of the concrete
- It is primarily a physical action caused by hydraulic pressures from water cyclically freezing and thawing within the concrete
- When the pressures exceed the internal tensile strength of the concrete, scaling will result



Scaling

- The extremely strong and expansive forces caused by the formation of ice within the concrete are often exacerbated by **deicing salts and chemicals, which increase both the saturation of the concrete and the number of freeze thaw cycles the concrete endures**
- Especially problematic with concrete with inadequate:
  - Strength
  - Air entrainment
  - Curing

Scaling

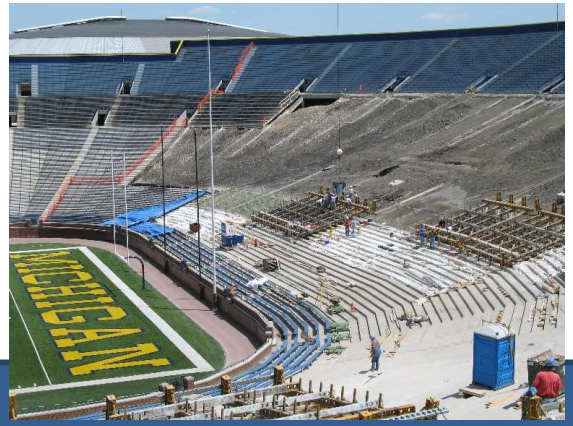
Prevention:

- Proper finishing techniques
  - Do not finish in the presence of bleed water
  - Do not bless the surface
  - Do not use steel trowels on exterior flatwork

Scaling

Prevention:

- PROPERLY CURE THE CONCRETE
  - Maintaining a satisfactory ***temperature*** is an important factor when curing because temperature affects the hydration process
  - Maintaining a satisfactory ***moisture content*** may often be accomplished by applying liquid membrane-forming curing compounds
    - Wax or resin based products that form a surface film and minimize evaporation of moisture during the curing period (ASTM C309 or C1315)



Scaling

Prevention:

- PROPERLY CURE THE CONCRETE
- 21-day air cure or drying period is required to develop the strength and durability characteristics of the concrete
  - Exposure to freezing and thawing cycles and deicing salts within this time period is not recommended
- A sealer should be applied to all new concrete in a 'Very Severe' environment
  - A sealer helps protect concrete from absorbing moisture and being damaged from cyclic freezing and thawing
    - For example, a penetrating silane solution that penetrates deeply and chemically reacts with the cementitious surface has been shown to offer adequate protection from moisture penetration

Mortar Flaking

- Loss of mortar directly over the coarse aggregate particle
- Caused via hydraulic pressures directly over the coarse aggregate
- Usually related to aggregate moisture contents and curing regimen of the concrete slab

Mortar Flaking

- *Bleed-water* (free water in the mix that is pushed upward to the surface due to the settlement of heavier solid particles such as cement and aggregates), can become blocked just below the coarse aggregate particle

Mortar Flaking

- As bleed-water beneath the aggregate cannot readily migrate to the slab's surface to replenish evaporated water; this combination of:
  - Bleed-water blockage
  - Lack of moisture necessary for cement hydration just above the coarse aggregate particle
- Results in a thin, dry, mortar layer of poor durability, high shrinkage, and poor bond with the underlying aggregate causing the mortar directly over the coarse aggregate particle to become compromised

MCA Issued a Technical Bulletin in July 2024

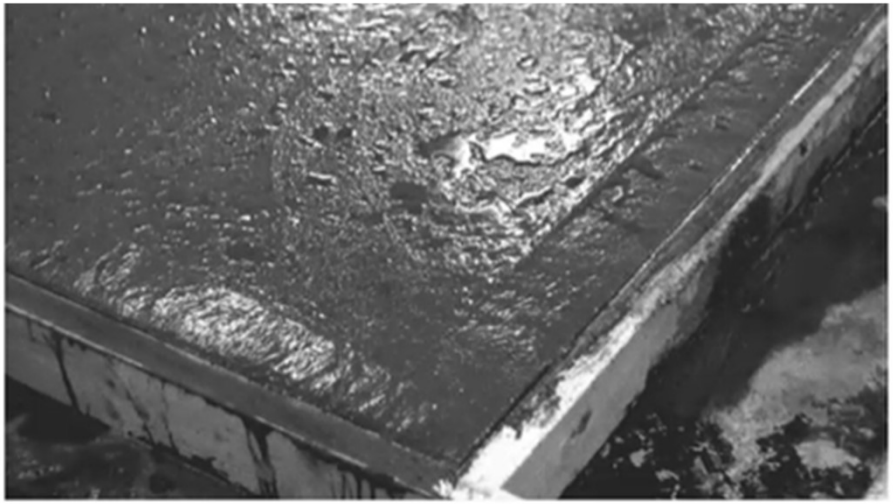
1. Proper finishing and curing are essential
2. As with any new/changed material, mixes need to be tested and verified to confirm effects on fresh and hardened properties such as:
    a. Air content
    b. Slump or slump flow
    c. Bleed potential
    d. Setting time; and
    e. Compressive strength
3. Adjust mix as needed: proportions of cementitious materials, slag, aggregates, admixture dosages, etc.

www.miconcrete.org/concrete-scaling

Best Practices for Type 1L or PLC

Good concrete practices – cement fineness, bleeding/rate, setting time

1. Blaine (surface area) values are typically higher for PLC
2. Higher % material retained (sometimes Passing) on +325 (45 µm) sieve



Understand the effects on bleeding characteristics of the concrete and on timing of finishing operations

Information obtained from ICRI webinar presentation, Tips on a Successful Transition to Working with Portland-Limestone Cement Mixes, dated April 16, 2024.

Further Densification

- In cold climates we are finding that applying a clear/colorless silane containing sealant prior to the first winter season will allow for further densification of concrete containing Type 1L cement
- Relatively Inexpensive, Good Insurance to Reduce Scaling

"The only constant in life is change" – Greek Quote

Blended Cement Nomenclature

- Binary blended cements (clinker =+1 ingredient)
  a. Type 1L - contains limestone (5% to 15%), commonly called PLC
  b. Type 1P – contains a pozzolan (up to 40% allowed)
  c. Type 1S – contains slag (<70% for structural or <95% for non-structural uses)
- Ternary blended cement (clinker +2 additional ingredients)
  a. Type 1T – can contain
     i. Pozzolan + limestone (also a PLC)
     ii. Slag + limestone (also a PLC)
     iii. Two different pozzolans
     iv. Slag + pozzolan

Information obtained from ICRI webinar presentation, Tips on a Successful Transition to Working with Portland-Limestone Cement Mixes, dated April 16, 2024.

Summary

- Concrete surfaces are durable, long-lasting, cost effective and aesthetically pleasing if:
  - They are designed & specified properly
  - They are constructed properly
  - They are inspected to ensure compliance with the project specifications
  - They are maintained and taken care of properly

MICHIGAN CONCRETE ASSOCIATION

Resources

There are numerous organizations within the concrete industry that provide resources and guidance for the design, placement, and practice of concrete overlays.

1. The **National Concrete Pavement Technology Center**, typically referred to as the **CP Tech Center**, based at the Iowa State University Institute for Transportation in Ames, Iowa. (www.cptechcenter.org).
2. **American Concrete Pavement Association (ACPA)**. Over 50 years old, ACPA is the largest trade association in the world dedicated to concrete pavements, and as such, maintains direct links to the U.S. Congress, the Federal Highway Administration, the Federal Aviation Authority, and scores of both state and local government transportation agencies. (www.acpa.org).
3. **Southeast Michigan Council for Governments (SEMCOG).** Grants to assist Local Agency Funding. (www.semcog.org)

Resources

4. The **American Concrete Institute (ACI)** is a 100+ year old association which is both national and international in scope that entails all things concrete. Based in Farmington Hills, MI, (www.concrete.org).
5. The **National Ready Mixed Concrete Association (NRMCA)** is another valuable resource for owners, specifiers, producers, and contractors involved in the use of ready- mix supplied concrete materials. (www.nrmca.org)
6. **MCA** is your Number 1 Resource for Concrete, if we don't know the answer we will direct you to someone who does. (www.miconcrete.org)

LTU CTM Program

MICHIGAN CONCRETE ASSOCIATION

QUESTIONS?

Steve Waalkes, P.E.
Executive Director/CEO
steve@miconcrete.org