Proper Use of Supplementary Cementitious Materials

Michigan Concrete Association
2020 Fall Seminar
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PDF handouts: https://info.miconcrete.org/virtual-learning

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SCM's Why do we need to talk about them Now?

- Use is more common now
- They are blamed for scaling issues (seen in first year or two)
- It adds another material into the mix
- Fly Ash supply issues – Big Coal is being restricted
- There may be Slag Cement Supply issues at times
- Slower set time – we need fast open to traffic strength
- We have been using old standard practices to place a new product

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Why do we use SCM's

- Durability – The deicing policies have changed
- Workability – Makes it easier to place
- Finishability – Finish with much less blessing
- Sustainability – Use of recycled materials & saves money
- To Make Better Concrete – When used properly!

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Calcium Hydroxide (CH) Depletion

- MDOT research 1997 – Robert Muethel (Rocky)
- CH Depletion - Cause by Carbonation & Leaching
- Start of key investigation into the problem
- Fly Ash was utilized on projects constructed between April 1st and October 15th
- Several research projects were inspired because of this study

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Snow is coming – sometime?

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On a Sunny Day

- Calcium Chloride – attracts water
  - Stays wet
  - Great for dust control
- Sodium Chloride (Rock Salt or Safe Salt)– does not attract water
  - Turns to dust

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Hydration Reaction

- Reaction of hydraulic cementitious materials with water results in production of **calcium silicate hydrates (C-S-H)** and calcium hydroxide (CH), also ettringite and other hydrated aluminate phases (C-A-H)
- **Hydraulic Reaction:**

Hydraulic Cement + Water → C-S-H + C-A-H + CH

- C-S-H provides strength – desirable product
- CH provides little strength and is soluble, also is a reactant in many MRD mechanisms – undesirable product

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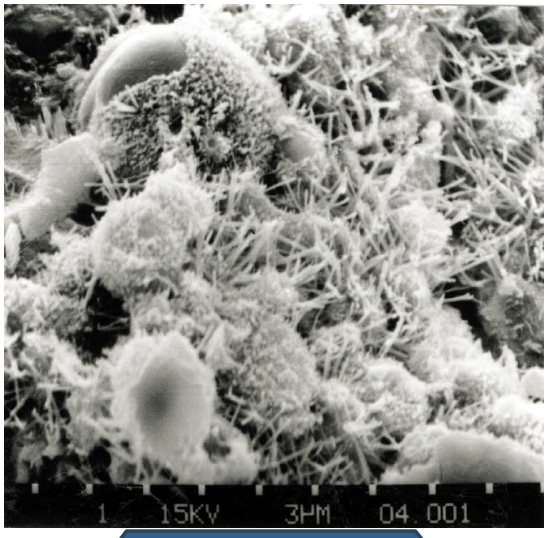
Cement Hydration



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Oxychloride – the key issue in Michigan

- Salt brine and CH react chemically and produce expansive Oxychloride Material
- We use air entrainment to protect the concrete from water expansion during its phase change – it can expand by a factor of 9 times.
- Oxychloride's expansion potential is 30 times.
- The temperature required for this reaction can be well above 32 degrees.

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Reduce Permeability – Key to Durability

- Keep the water out and reduce the salt brine ingress
  - Lower *w/cm* (0.40 or less) – Can be difficult to place
  - Penetrating sealers
  - Use SCMs

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A word on sealers…

- **Paint it** – Surface coat: Epoxies, polyurethanes, methacrylate's, waxes, acrylics and chip seals.
- **Pore Blocker** – Reacts with CH forming a gel that blocks pores - Blocks moisture movement in and out of concrete: Lithium, linseed oil
- Chemically Reactive – **Water repellent** – Reacts with Silica or moisture to form a permanent attachment to the water-repellent molecule – allows moisture to leave the concrete: Silanes, Siloxanes

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Silane or Siloxane?

- **Silanes:**
  - Extremely small molecular size – deeper penetration
  - Chemically bond with silica to form a permanent attachment to water-repellent molecule
  - Don't change the skid or slip resistance
  - Performs better on poured in place concrete
- **Siloxanes:**
  - Slightly larger molecular structure
  - They do not chemically bond to the silica – they react with moisture to form hydrophobic resin
  - Ideal for treating concrete block or non-cementitious materials like brick, stucco and stone

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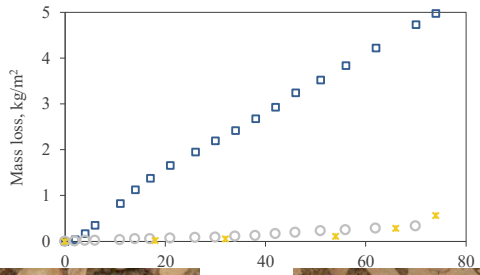
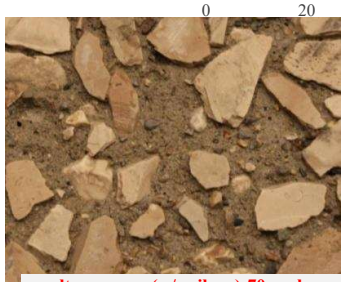
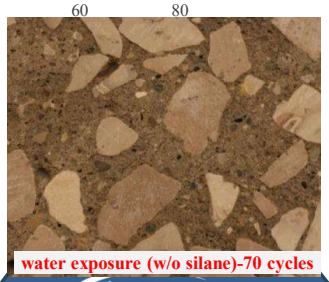
- Hydrophobic surface treatment using silane



salt exposure (w/o silane)
water exposure (w/o silane)
salt exposure (w/ silane)



salt exposure (w/o silane)-70 cycles



water exposure (w/o silane)-70 cycles

salt exposure (w/ silane)-74 cycles

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A word on sealers…

- The best option for existing concrete
- Questions are:
  - How long do they last?
  - F-T durability of the sealer?
  - Cost effectiveness compared to other options?

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SCMs - Oxychloride Expansion is our biggest Issue

- Oxychloride requires calcium hydroxide (CH) to form
- Reduce the CH – reduce oxychloride formation

Portland Cement Reaction

Cement + Water -> C-S-H + CH

Pozzolanic Reaction (example: Class F Fly Ash)

CH + Pozzolan + Water -> C-S-H

- Forming C-S-H reduces permeability
- Consuming CH reduces oxychloride formation potential

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Slag Cement - Hydration

- Slag cement is hydraulic and produces calcium silicate hydrate (C-S-H) as a hydration product
- Slag cement reacts slower than portland cement
  - Hydration of portland cement produces C-S-H and CH
  - CH reacts with the slag cement, breaking down the glass phases and causing the material to react with water and form C-S-H
- Slag cement is not pozzolanic
  - It does consume CH by binding alkalis in its hydration products
  - Provides the benefits of a pozzolan

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Slag Cement

- Because slag cement is slower to react, setting time can be increased significantly compared to straight Portland cement concrete
- **Curing is always essential** for achieving a quality product; **it is even more critical with slag-cement-based concrete**
- The slower reaction rate, especially at lower temperatures, is often overlooked, and this can lead to durability issues such as scaling when not properly cured

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Proper Placement Practice

- Well graded mixes with SCM's do not need extra water
- They do need vibration
- Water should be added at plant and not on the grade when possible
- Producers should not hold back water just so the contractor can add some on site

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Properties of SCM Concrete

- Lower heat from hydration (less cement) – typically lower mix temperature
- Slight delay in initial set time
- Gradual initial strength gain in first 7 days
- Higher ultimate strength 28 to 90 days
- In cooler weather utilize hot water in mix to maintain 65 to 70-degree mix temperature

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Proper Placement Process

- Placement – place as soon as it is delivered – schedule time between trucks
- Vibration – Always vibrate to consolidate – Hand Vibrator, vibrating screed or float
- Strike-off to grade immediately
- Float – fill in any voids – **minimize any finish water addition** – keep W/C low
- Texture – burlap or turf drag, broom
- **CURE** – seal moisture in for secondary reaction – minimal bleed water to surface
- Jointing – saw times may very
- Protect until open to traffic

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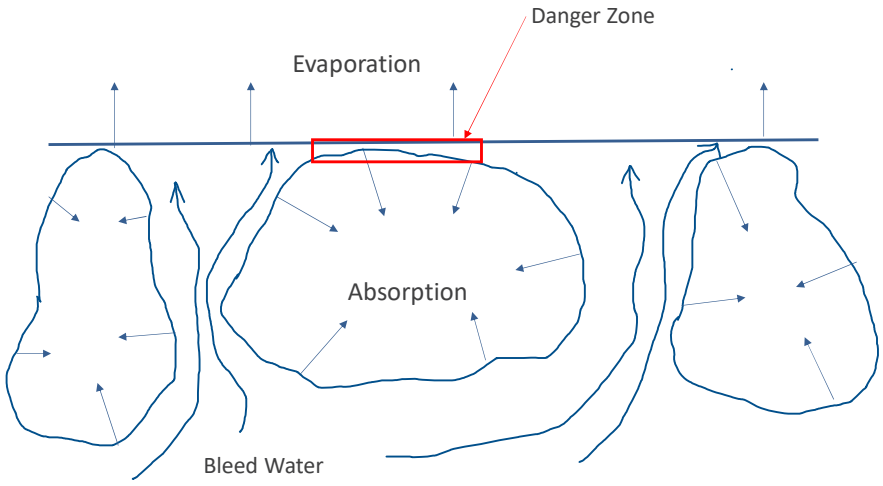
Moisture Movement – Mortar Flaking



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Caution on Saw times

- Summer –Ground is warm, concrete surface is warm & the Concrete sets from the surface down – ideal conditions for sawing joints
- Fall – Ground is warm while air and the concrete surface may be cool – concrete may set from the ground up creating a critical saw window. Heating the concrete mix will help
- Spring – Ground is cold, concrete materials are cold, set will likely be delayed. Heating the concrete mix will help kick start the setting process

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Curing

Start early – as soon as sheen disappears

Complete coverage – not blotchy

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What about ASR?

- ASR was the Canary in a Coal Mine for us; what is good for ASR mitigation also works well for salt attack mitigation
- We do have some aggregate sources with high ASR potential
- ASR activity requires the presence of water, reactive silica & Alkali
- SCM's densify the concrete making it hard for water to get in
- SCM's ties up the excessive CH product so it is not available for reaction with reactive silica

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New Driveways

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Take Aways – Actions

- Consider applying a Silane treatment to all new driveways prior to the first winter (Ideally, apply after about 28 days)
- Use of SCMs reduces susceptibility of concrete for chemical attack (as long as it is properly placed and cured)
- Materials selection is very important
  - Low *w/c*, Low paste content, Use SCMs
- Curing is essential
  - Keep the mixture water in and allow the materials time to form dense, impermeable, hydration products

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Special Thank You

- Larry Sutter – Michigan Tech
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- CP Tech Center
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Bottom line

- It is possible to make durable concrete…
- In a salt world
- We need to update our construction process

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Questions

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