CONCRETE & MOISTURE VAPOR TRANSMISSION
SIKA CORPORATION / TARGET MARKET FLOORING
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- 25 years in the coatings industry
- 2 companies
  - Valspar Federal Flooring Division
  - Sika Corporation
- Many positions
  - Director of Business Development – today
  - Customer Service Rep – 1993
  - In between
    - Purchasing Manager, Operations Manager, Technical Sales Representative, Marketing & Inventory Manager, Laboratory Manager, R&D Manager & Assistant General Manager
Agenda

• Concrete Mix Design
• Forensics of Moisture Vapor
• Solutions for Moisture Vapor Issues
Concrete is the second most consumed product in the world next to Water.
Most moisture problems start right here
Concrete is basically a mixture of Portland cement, aggregate & water.
Mix designs vary based on desired properties of the finished slab.
Concrete Components

- Portland Cement
- Water
- Aggregate
- Admixtures
  - Mineral
  - Chemical
Portland Cement

- Basic component of concrete.

- Most versatile and widely utilized construction material.

- Different types for different end uses & project timelines
  - Referred to by number Type I - V
Cement is a binder used to hold things together. It is only one component used to produce concrete.

Cement ≠ Concrete
Mix Water

- Almost any natural water that is drinkable with no pronounced taste or odor can be used for making concrete.
- Some waters that are not fit for drinking may be suitable for concrete if tested by a laboratory.
Hydration = Concrete Cure

• Cement + water = hydration reaction
• Concrete paste becomes a gel and then a solid.
• Constituents hydrate & crystallize; the interlocking of the crystals provides strength.
• Exothermic chemical reaction
  – Reaction releases heat
  – Heat release accelerates cure
  – Warmer conditions = faster cure
• High moisture content in cement during curing increases both the speed of curing, and its final strength.
Cure time

- Depends on mixture and environmental conditions
- Initial hardening can occur in as little as twenty minutes
- Concrete typically cures to the extent that it can be put into service within 24 hours to a week
  - Full cure takes significantly longer
  - Typical rule on slab dry time is 1” per month
    - Standard mix design
    - Optimal drying conditions
Aggregate

- Plays roll in the plastic and hardened properties of concrete
  - Dimensional stability
  - Define thermal and elastic properties of the slab
  - Typical mix design will have a mix of fine & course aggregate

- Fine
  - <3/8”
  - Natural sands, manufactured sands or crushed stone.

- Coarse
  - 3/8 to 1 ½ inches
  - Natural gravel, crushed limestone, quarry rock, crushed boulders or cobbles.
Well graded aggregate...

utilizes cement paste more efficiently provides higher slump without additional water improves workability decreases shrinkage minimizes porosity of the slab
Aggregate

- Need to ensure silica based or contaminated aggregate is not used in the mix to minimize or eliminate the occurrence of alkali silica reaction
  - Responsibility of the slab designer
  - ACI 302R
What Is An Admixture?

- What people say...
  - Snake oil
  - Bug juice
  - Colored water
  - It’s specified on a project, so it must be used

- What they really do...
  - Control plastic properties of concrete
  - Improve performance, quality & cost
Admixture Types

• Typical
  – Accelerators
  – Retarders
  – Air Entrainment
  – Water-Reducers
  – Viscosity Modifiers
  – Efflorescence Control

• Others
  – Corrosion Inhibitors
  – Anti Wash-out
  – ASR Controlling
  – Shrinkage Reducers
  – Water Repellent Admixtures

• A couple that are interesting to us...
All concrete has air...

The question is how is the air dispersed throughout the slab?

Air Entraining Admixtures produce a *better* air void system by modifying the natural air structure into an organized air void system.
Air Entraining Admixtures

• Reduce permeability
• Improve freeze-thaw durability
• Improve plasticity & workability
• Reduce issues with moisture vapor transmission
Capillaries in Concrete

Water exits creating voids and capillary networks. Entrained air adds to or subtracts from these networks. Better air void system leads to less linked capillaries = less MVT
Water / Cement Ratio

- Water (lbs) / Cement (lbs)
  - Water → Total water including “free” moisture from the aggregate
  - Cement → Total cementitious including fly ash, slag, and silica fume

- Need approximately 25 lbs of water to hydrate 100 lbs of cement... .25 w/c ratio

- Higher the w/c ratio the weaker the concrete.
- Higher the w/c ratio the more chance you have MVT issue

- Typical industry standard w/c ratio is .40
  - Allows sufficient water presence for full hydration and successful finishing of the slab with residual water of convenience present but not enough to cause a problem with coating
Water Reducing Admixtures

Reduce the quantity of mix water required to produce concrete of a certain slump

- Reduce water/cement ratio
- Increase workability & flowability
- Increase strength
- Reduce slab dry time for coating
- Reduce issues with MVT
What is the Most “Expensive” Ingredient in Concrete?

Water
Optimize water content

• Use enough for desired properties and workability BUT not so much that you suffer

• Lower water content:
  – Difficulty in mixing/blend
  – Poor flow
  – Low workability

• Higher water content:
  – Weaker concrete overall
  – More shrinkage
  – Cracking
  – Higher residual moisture
  – Longer cure (dry) time
  – Higher porosity
    • Water in voids that does not react – microscopic pores
    • Capillary alignment
LET’S TALK ABOUT MOISTURE...
#1 INDUSTRY PROBLEM = MVT OR MVE

Sheet Flooring

Wood Flooring

Resin Flooring
MOISTURE MOVEMENT IN CONCRETE

Warm Temperature / Low Humidity

Cooler Temperature / High Humidity

Vapor Barrier = No Problem
Capillaries in Concrete

Water exits creating voids and capillary networks
Capillaries in Concrete

Regardless of composition, concrete is a hygroscopic material which will draw moisture from a more humid source into a dry source.
Capillaries in Concrete

Capillary pathways offer a path of least resistance until properly sealed off.
ACI 302.2 REVISION 6

Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials

Reported by ACI Committee 302

- 40% water/cement ratio
- Inclusion of a 10 mil vapor barrier on top of fill
- Enclose building envelope
  - Walls up
  - Roof in place
- Ensure no additional moisture, rain, snow, etc.
- Climatize the building – HVAC
4 SITE ISSUES CAUSE MOISTURE VAPOR PROBLEMS
- Improper mix design
  - High residual moisture levels
  - Can be on grade or elevated pan
- Hydrostatic pressure/ground water
  - Only slabs on grade
  - Only an issue when water is in direct contact with the concrete surface
- Plumbing issues
  - Sprinkler breaks, busted pipes
- Inadequate installation
  - Vapor retarder – insufficient perms, torn or punctured, insufficient overlap or taping, under sand or gravel layer, none
  - Poor site evaluation or geotech to identify water sources
    - Artesian spring...
  - Over troweling, prematurely sealed slab surface
  - Non permeable surface membrane applied too early
TEST CONCRETE SURFACES

Plastic Sheet ASTM D 4263

Calcium Chloride ASTM F 1869

Tramex ASTM E 1907

RH Probe ASTM F 2170
Polyethylene sheet & duct tape
ASTM - 72 hours and test with hygrometer
Real life – a few hours, maybe a lamp and a visual read
Qualitative – look for darkening of the slab or condensation
Test at use conditions
Bargain price but time consuming
Failure means more tests
All of the above assumes the slab has been designed per ACI 302.2 Rev6
RH PROBE – ASTM F2170

- In situ measurement of moisture content at use conditions
- Drill and read after 72 hours for equilibrium
- Quantitative
- Less than 75% RH (RH Probe Method)
- Gives overview of moisture level in the slab but does not directly address MVT
- Costly and time consuming
- Multiple days of testing
- Snapshot of current conditions
- All of the above assumes the slab has been designed per ACI 302.2 Rev6
CALCIUM CHLORIDE – ASTM F1869

- 3 tests for 1\textsuperscript{st} 1000SF, 1 for each additional
- Change in weight of calcium hydroxide over 72 hours
- #s per 1000SF over 24 hour period
- Water Vapor Transmission (CaCl Test)
  - 3 lbs or less for Liquid Rich Systems
  - 5 lbs or less for Mortars (Dry)
- Costly - Number of tests add up quickly
- Time consuming
- Great margin for error
- Snapshot in time of top \(\frac{1}{4}\)” of slab
- Assumes slab designed per ACI 302.2 R6
TRAMEX – ASTM E1907

- Sensors test the dielectric constant of the concrete
- Prep the test area to remove laitance & contamination
- Instant reading
- Reasonably priced meter
- Tests top inch
- Moisture content less than 4%
- Moisture content less than 5%
- Moisture content less than 6%
- Assumes the slab has been designed per ACI 302.2 Rev6
YOU KNOW YOU HAVE AN ISSUE – NOW WHAT?

- Topside moisture control systems
  - 100% solids epoxy
  - Cementitious
100% SOLIDS EPOXY

- 100% solids epoxy system
- Thin film topdown protection
- Tramex reading below 6
- Prep well to CSP 3-5
- Apply one or two coats
- Build any system on top
- Must be pinhole free
SLAB OUTGASSING

bubble

pinhole
URETHANE CONCRETE

- Urethane concrete system
- Heavy duty topdown protection
- Tenacious adhesion
- Reading does not matter
- Prep well to CSP 4-6
- Can be 1/8” – 3/8”, slurry or mortar
- Finish as you like
  - Decorative, industrial, ESD, etc.
- Must be pinhole free
CEMENTITIOUS UNDERLAYMENT

- Urethane concrete system
- Heavy duty topdown protection
- Tenacious adhesion
- Reading does not matter
- Prep well to CSP 4-6
- Can be 1/8” – 3/8”, slurry or mortar
- Finish as you like
  - Decorative, industrial, ESD, etc.
- Must be pinhole free
LOW SOLIDS PERMEABILITY REDUCERS

- Urethane concrete system
- Heavy duty topdown protection
- Tenacious adhesion
- Reading does not matter
- Prep well to CSP 4-6
- Can be 1/8” – 3/8”, slurry or mortar
- Finish as you like
  - Decorative, industrial, ESD, etc.
- Must be pinhole free
BARRIER SYSTEMS

- Urethane concrete system
- Heavy duty topdown protection
- Tenacious adhesion
- Reading does not matter
- Prep well to CSP 4-6
- Can be 1/8” – 3/8”, slurry or mortar
- Finish as you like
  - Decorative, industrial, ESD, etc.
- Must be pinhole free
## CONCRETE SURFACE PROFILE (ICRI)

<table>
<thead>
<tr>
<th>Application</th>
<th>CSP #</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sealers</strong> (0-3 mils)</td>
<td>CSP 1-3</td>
<td>Scrubbing, Low Pressure Water, Acid Etching, Sand Blasting, Shot Blasting</td>
</tr>
<tr>
<td><strong>Thin-Film</strong> (4-10 mils)</td>
<td>CSP 1-3</td>
<td>Scrubbing, Low Pressure Water, Acid Etching, Sand Blasting, Shot Blasting</td>
</tr>
<tr>
<td><strong>High Build</strong> (10-40 mils)</td>
<td>CSP 3-5</td>
<td>Grinding, Sand Blasting, Steel Shot Blasting, Scarifying, Needle Scaling</td>
</tr>
<tr>
<td><strong>Self-Leveling</strong> (50 mils- 1/8”)</td>
<td>CSP 4-6</td>
<td>Sand Blasting, Steel Shot Blasting, Scarifying, Needle Scaling, High/Ultra High Pressure Water Jetting</td>
</tr>
<tr>
<td><strong>Polymer Overlay</strong> (1/8” –1/4”)</td>
<td>CSP 5-9</td>
<td>Sand Blasting, Steel Shot Blasting, Scarifying, Needle Scaling, High/Ultra High Pressure Water Jetting, Scabbling, Flame Blasting, Milling</td>
</tr>
</tbody>
</table>
SURFACE PREPARATION

I.C.R.I Guideline # 03732

CSP 3-6  Light Shotblast to Medium Scarification
BEST WAY TO MINIMIZE THE CHANCES OF A MOISTURE RELATED ADHESION FAILURE...
Questions?