



A Day at the Concrete Jobsite

Presented by CRMCA's Western Market Committee

Clarion Inn

755 Horizon Drive

Grand Junction, CO 81506

Agenda – Thursday, January 28, 2016

11:00 – 11:15	Registration and Lunch
11:15 – 11:20	Welcome and Introduction – Marty Cooper & Dana Jenick, CRMCA Western Market Committee Chairs
11:20 – 11:30	Preparation Before Mixer Truck Arrives - Mike Adcock, Adcock Concrete & Robbie Lewis, Elam Ready Mix
11:30 – 12:15	Testing - Bud Werner, CTL Thompson
12:15 – 12:20	Break
12:20 – 1:00	Placing & Finishing - Mike Adcock, Adcock Concrete & Robbie Lewis, Elam Ready Mix
1:00 – 1:45	Curing/Sealing - Tom Pelo, BASF
1:45 – 2:00	Summary with Q & A Marty Cooper & Dana Jenick, CRMCA Western Market Committee Chairs Mike Adcock, Adcock Concrete Robbie Lewis, Elam Ready Mix Bud Werner, CTL Thompson Tom Pelo, BASF

Thank you for our sponsors!





Colorado Ready Mixed Concrete Association


PREPARATION BEFORE THE MIXER TRUCK ARRIVES

PRESENTED BY: MIKE ADCOCK, ADCOCK CONCRETE & ROBBIE LEWIS, ELAM READY MIX



BIOGRAPHY OF PRESENTER

- Mike Adcock
- Owner
- Adcock Concrete
- Concrete industry for 28 years
 - Concrete labor / Finisher
 - Estimator
 - Stamp Concrete & Architectural Concrete finishes
 - Foreman TIC for 6 years
 - Contractor Owner 22 years
 - Certifications held:
 - ACI Flatwork finisher
 - ACI Tilt Up Technician
 - ACI Industrial Flatwork Finisher Technician
 - ACPA Member



BIOGRAPHY OF PRESENTER

- Robbie Lewis
- Operations Manager
- Elam Ready Mix
- Concrete industry for 17 years
 - Concrete labor / Finisher
 - Estimator
 - Pre-Cast Concrete 6 years
 - Ready Mix Sales & Dispatch 8 years
 - Ready Mix Operations 3 years
 - Certifications held:
 - ACI Flatwork finisher
 - ACI Field Level I
 - NRMCA Concrete technologist Level 2 & 3



PRE-POUR MEETING

- Who should attend:
 - Owners, Structural Engineer, Architect, Construction Manager, General Contractor, Concrete Contractor, Concrete supplier, testing Agency
- Discuss what mix design to use
 - Review submitted mix design & discuss placement method, point of testing, desired plastic properties for placement, reinforcement for placement & contingency plan for issues that may arise.
- Quality Control / Assurance
 - Who the testing lab is and what technicians will be on the project.
 - Lab qualifications
 - What are project requirements for concrete plastic properties, floor flatness (FL) and levelness (FL) and do the fit the placement plans.
- Truck access
- Washout area
 - Who is the responsible parties for setup and maintenance



SUBGRADE PREPARATION

- Assessment of subgrade to accommodate placement
 - Subgrade should provide uniform support throughout
 - There should not be any hard or soft spots. The slab will only be supported by the hard spots and be bridged over the soft spots creating an environment for cracking to occur.
 - If subgrade is not uniform or there is organic and foreign material present, this material needs to be removed and a sub base of sand, gravel or other granular material should be uniformly placed.
 - All subbases or subgrade material should be compacted to uniform bearing capacity.
 - Do changes in subgrade elevation align with the jointing plan



FORMING

- Establishing grades
 - Forms should match the given elevations by the engineer and prints for the slab.
 - If no slab elevations are given, the foreman should establish the grade and slope sufficient enough to allow the desired slope to ensure proper drainage
 - Grade stakes and lasers are often used throughout a slab pour to act as control points and guides during placement
 - Slab forms must be set accurately to achieve close surface tolerances.
 - Wall forms should be secured and checked for clearance from reinforcement as well as vertical and horizontal alignment



SITE ACCESS

- Tracking pads should be implemented at each entrance and exit to prevent unwanted contamination onto service roads.
- Access should be clear of obstructions to allow easy access for mixer trucks to maneuver to the placement and allow an area for staging following trucks.
- Are there any unidentified hazards or required traffic patterns?
- Are there any weight limitations or risks



WASHOUT & CLEAN UP

- Washout areas need to be designated & well marked.
- The area needs to be large enough to ensure that all mixers for the placement will be able to sufficiently wash down and not allow overflow and or contamination to the surrounding area.
- The washout should also be conveniently placed as near to the concrete placement as practical. Washout areas when placed further down a project site or requires the mixers to use a street to access can lead to unwanted spills and property damage.
- Washout areas need to be maintained on a regular basis to maintain volume and limit spilling, what is the contingency plan?





Colorado Ready Mixed Concrete Association


A DAY AT THE CONCRETE JOBSITE - TESTING

O.R. WERNER, PRINCIPAL, CTL THOMPSON
JANUARY 28, 2016



BIOGRAPHY OF PRESENTER

- Orville R. Werner II
- President, CTL Thompson Materials Engineers
- Registered Professional Engineer (Colorado, Idaho, Wyoming)
- Fellow, American Concrete Institute (F-ACI)
- 44 year career in concrete technology with USBR (11 years) and CTL (33 years)
- Active in ACI, ICRI (International Concrete Repair Institute), and CRMCA (Colorado Ready Mixed Concrete Assn.)
- Have been an aggregate producer laborer, construction inspector, lab technician, concrete spec writer, trial mix engineer, concrete industry consultant, and expert witness in my career.



WHY ARE WE TESTING

- Our testing gives the public reasonable assurance of safety.
- Our testing can help the contractor and the supplier resolve little issues before they become big issues.
- Our testing can help an owner achieve the quality of construction that results in a durable and strong structure or pavement as their engineer designed.
- Good testing can help the manufacturer optimize concrete mixes.
- We are part of the team, but not on anybody's side.



A BAD DAY OF TESTING!

- CTL got the request for testing at new job just before quitting time the day before.
 - The person making the request does not know the specified strength, slump, air content, or approved mix design.
 - He doesn't know if there is a place on site to store cylinders.
 - It is not clear how many tests are to be taken on site, so a guess is made.
 - It turns out the client is someone we have never talked to before. (i.e. the owner, who typically prefers to minimize money spent on testing, but has to meet the code requirements.)



A BAD DAY OF TESTING!

- It's a busy day in the concrete industry.
 - All of our techs are fully scheduled for the day. The tech ultimately assigned to this job has five other tests at 3 other locations.
 - He arrives at the site and waits for the pump to arrive. The concrete arrives 40 minutes after the pump is set up. The tech is already late for his next job where the contractor is on schedule.
 - Nobody knows where to sample the concrete.
 - Once the test is completed, there is no clear person in charge to deal with the failing tests.
 - Lacking a proper curing environment on site, the tech finds the best alternative, knowing the RM supplier won't be happy with it unless it meets specs.



A BAD DAY OF TESTING

- The day after isn't much better.
 - The tech is busy at other jobs on the far side of town and can't get back to pick up the cylinders.
 - When he does get back he finds out the facility is locked and nobody is around to let him/her in.
 - When he does get in, the tech finds that the power to the curing facility was turned off overnight (or over the weekend), and the curing facility was moved by the contractor, causing the cylinders to fall over in the curing box. Occasionally cylinders disappear! Curing boxes frequently disappear.



A GOOD DAY OF TESTING!

- Starts with communication.
 - Preconstruction Meeting for Concrete (Require us and the contractor and the supplier and the pumper to attend and allow us to charge for our time?)
 - Mixes to be used, required strengths, specified slump.
 - Person to report to on site.
 - Curing facility.
 - After hours power and access.
 - Sampling location and frequency.
 - Number of cylinders and ages to be tested.
 - Special testing?
 - Is this a full time or part time testing/inspection?
 - Who gets test reports?
 - Most of this plus more is covered in CRMCA's pre-con meeting checkoff list.



A GOOD DAY OF TESTING!

- Starts with communication.
 - Scheduling (We have to schedule just like the RM concrete producer has to schedule.)
 - 24 hours to 5 days in advance. Can adjust if scheduled in advance. Need to know window of time.
 - Number of tests to be made, and mix ID.
 - Project Name and address.
 - On site contact info., and after hours access.
 - Other testing that might be done with the same trip? (Masonry, steel, rebar, etc.)
 - Is this a full time or part time testing/inspection?
 - Special needs, such as site-cured cylinders for post-tensioning or traffic opening.
 - Are there options if the schedule doesn't fit?



A GOOD DAY OF TESTING!

- Ends with communication.
 - Feedback from others (only negative feedback needed)
 - Was the scheduler professional and polite?
 - Were we on time?
 - Are there unexplained cylinders on site?
 - Was our technician cooperative and professional?
 - Did somebody on site get notified of failing results?
 - Did you get the reports in a timely manner?
 - CRMCA evaluation from concrete industry QC personnel.
 - Feedback to others
 - Unavoidable deviations from test procedures and results.



THINGS WE DO ON-SITE

- Tests
 - Slump
 - Air content
 - Density
 - Temperature of concrete
 - Cast Cylinders
 - Cast Beams
- Other
 - Install temperature sensors (Maturity)
 - Return to pick up cylinders, monitor maturity



THINGS WE DO ON-SITE

- Record/Distribute data
 - Date and time of test sampling
 - Temperature, concrete and ambient
 - Slump and Air and Density
 - Mix ID and Batch ID as shown on delivery ticket, including batch time.
 - Water added on site, if known.
 - Present the above information, especially if out of spec, to the designated representative on site (probably not the pumper!)



TEST FOLLOW-UP IN THE OFFICE

- Prepare reports, and send out to all interested parties after 7 and 28 day strength test results.
- Assure that failing results are brought to the attention of a person with authority.
- Follow-up to assure cylinders are returned to the lab.



TECHNICIAN QUALIFICATIONS AND ASSIGNMENT

- The lab tech should be certified per ASTM C94/1077 (CRMCA/ACI) method C39
- All field techs should be certified per ASTM C94/1077 (CRMCA/ACI) methods pertaining to their numerous tests.
 - May or may not be qualified for other construction tests.
 - Times assigned on first request basis.
 - May not be the same technician on repeated trips to a given project.
 - Probably doesn't have time to do additional testing beyond original request, but its worth asking.
- Certification does not assure that the testing will be conducted properly.



SAMPLING

- ASTM C172
 - 2 or more portions for revolving truck mixer.
 - Middle of batch
 - Sample within 15 minutes and composite within 20 minutes.
 - Need at least 1 cubic foot for cylinders.
 - Our instructions to techs are, that if they hear the drum speed up for mixing after the sampling is complete they should discard the sample and get a new one immediately.



SLUMP TEST

- ASTM C143
 - Plate on flat/level surface
 - Equipment damp and clean when testing
 - Start test within five minutes after sampling and compositing, complete test in 2-1/2 minutes
 - Equal *volume* layers
 - 25 rods per layer (don't hit plate, 1" penetration on subsequent layers)
 - Pull steady 3 to 7 seconds
 - Measure to nearest ¼ inch.
 - Atypical cone failures?
 - Don't mess with the tech. By staying within but varying the above parameters, a good tech can change the slump results as much as an inch.



SLUMP FLOW TEST

- ASTM C1611
 - Applicable to SCC
 - Minimum 36 inch diameter plate, nonabsorbent, smooth, rigid, level
 - Slump cone (inverted or per C143)
 - Fill cone, don't rod.
 - Lift to 9 inches in 3 seconds
 - After the concrete quits moving measure largest diameter, then diameter at 90 degrees to the largest diameter to the nearest ½ inch. When a halo appears it is included in the measurement.
 - Average the two to the nearest ½ inch.
 - A visual stability index can be assessed based on the size of the halo, but this is not a quantifiable concrete property.



J-RING TEST, FOR SCC

- ASTM C1621
 - Exactly the same as C1611 except:
 - Place a ring of 16 evenly spaced 0.625-inch vertical rods in a 12-inch diameter in the middle of the plate.
 - Also run the C1611 test
 - Compare those results (C1611 and C1621) If the measured diameter of the concrete using C1621 is within 1 inch of that measured by C1611 that constitutes “no visible blocking” (good SCC)



AIR CONTENT TEST

- ASTM C173 Volumetric, Rollometer (when?)
 - Equipment damp and clean when testing
 - Start test immediately after slump test (one tech) so that you can cast cylinders no later than 15 minutes after the sample is composited. Complete test may take 10 to 15 minutes but the final reading can be delayed when cylinders are cast.
 - Equal volume/height layers
 - 25 rods per layer (don't hit bottom, 1" penetration on subsequent layers), use rubber mallet after each layer
 - Screed off, attach lid, add some water, add alcohol, fill with water to indicated level. (How much alcohol?)
 - Agitate/roll sample. (Takes at least two minutes.)
 - Don't add alcohol after agitation. Correct per standard when more than 2 liters of alcohol are used.
 - Open top, allow level to stabilize. (< 6 minutes, 2% foam)
Read to nearest 0.25%



AIR CONTENT TESTS

- ASTM C231 Pressure Method (Type B)
 - Equipment must be calibrated (not more than 3 months.) Equipment damp and clean when testing.
 - Start test immediately after slump test (one tech) so that you can cast cylinders no later than 15 minutes after the sample is composited. Complete test may take 5 minutes
 - Equal volume/height layers
 - 25 rods per layer (don't hit bottom, 1" penetration on subsequent layers), use rubber mallet after each layer. (vibrate if slump is less than 1")
 - Screed off with plate, attach lid, fill with water, pump up pressure to initial, check water level, close petcocks, release pressure, tap smartly with mallet, tap gage with hand, read.
 - Apply aggregate correction factor.
 - Always run an air test, even if not air entrained.



AIR CONTENT ISSUES

- Air content changes as the concrete is handled. Pumping changes the air content. We just can't predict how big the change will be.
- Do you want a certain percent of air as-delivered or as-placed in the form. Does it really matter?
- Hardened air content is not expected to be the same as fresh air content. Most specifications do not specify hardened air content.
- Too much air unnecessarily reduces compressive strength. It may also reduce durability.
- Air is slump-dependent. Water addition can change it.



DENSITY

- ASTM C138
 - In field, almost always in conjunction with the pressure meter air test.
 - Calibrate volume of pot on air meter to the nearest 0.0001 cu. ft. (If the volume is between 0.249 and 0.251 cubic feet the error is small (about the accuracy of the scale used) if you assume a volume of $\frac{1}{4}$ cubic foot which makes calculation easy.)
 - Scale accurate to nearest 0.1lb. Either tare container or have calibrated weight of container.
 - Slump less than 1", should use vibrator.
 - If no spec, why measure?



CASTING CYLINDERS AND BEAMS

- ASTM C31
 - Vibrator (1-inch max diameter for 4-inch cylinders) must be used for slumps under 1". Two layers for cylinders, one layer for beams.
 - Vibrator can now be used with concrete of any slump for strength specimens.
 - Rodding process, depends on size of sample. Three layers in 6x12's, 2 layers in 4x8's (different size rods), two layers in 6" beam molds, 25 rods per layer for cylinders, 1 rod per 2 sq. in. for beams/prisms.
 - Mark specimens when they are cast!!
 - Make specimens at their initial curing location. Don't carry them long distances or transport them in a vehicle.



CURING CYLINDERS AND BEAMS

- ASTM C31
 - Initial Curing – in molds, no moisture loss or vibration, 60F to 80F, Level surface, up to 48 hours but at least until strong enough to strip.
 - (High strength concrete (over 6000 psi) between 68F and 78F.)
 - Final Curing – cylinders in water or 100% humidity room at 23C+/-2C. Beams have to be in water at 23C+/-2C. Water has to be saturated with calcium hydroxide.
 - Transporting – 8 hours or more after final set. Protect from damage from jarring and freezing. Limit transport time to 4 hours. Keep them wet during transport.



MATURITY MONITORING

- (If time allows in the presentation.)
 - Very useful tool. Much better than field cylinders.
 - Can be done (in a pinch) without a formal maturity study.
 - Cylinders can be monitored for maturity on the first test.
 - Maturity probes accurately read the time-temperature function.
 - Maturity probes can be spread throughout the placement to determine the variability of strength gain.
 - High early mixes should probably be monitored for maturity in lab cylinders during the mix design study.
 - Frankly, with today's maturity meters, one can calculate the Maturity v strength function without a meter if cylinders are tested at pertinent ages.



WHAT TO DO WITH FAILING RESULTS

- How significant is the failure? (No concrete mix is designed for 100 percent compliance time after time.) If it isn't a structural or durability problem in this instance and the source of the failure is fixed, is it a problem?
- Don't blame the lab for low strengths unless you can make a strong case that the low strengths are the result of the lab error.
 - For example Low initial cure temperature.
 - For example Over 48 hours in the field.
 - For example Durometer rating of the pad caps needs to match required strength to show conformance.
 - If the cylinders froze, there is a really big problem.
 - If the cylinders got hot, there is a really big problem.



WHAT TO DO WITH FAILING RESULTS

- If strength fails the specified criteria, the response varies with specifier, but we expect an occasional failure. ACI states that the concrete has not "failed" unless a test result shows a 500 psi deficit, or unless the average of three successive tests fails to meet the specified limit. CDOT and FAA have much more complex limits and consequences for flexural failures.
- As a test lab we prefer to extract and test cores from locations with questionable strength, and we welcome supervision from all interested parties during coring and testing.



REFERENCES

- Annual Book of ASTM Standards, Section Four, Volume 04.02
 - This has all the standards used in testing concrete.
 - All technicians must have access to the newest standards
- ACI 301/318
 - I suggest having a copy of a recent set of the "ACI Manual of Concrete Practice"



Thank you for listening!!

??Questions??





Colorado Ready Mixed Concrete Association


PLACING & FINISHING

PRESENTED BY: MIKE ADCOCK, ADCOCK CONCRETE & ROBBIE LEWIS, ELAM READY MIX



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PREPARATION

- Placing Equipment and Labor
 - Make sure all necessary equipment is on site and in good working condition.
 - Straight edge, screeds, hand floats, trowels, bull float, Fresno, jointers, edger's, mucking rakes, shovels, concrete vibrators & power trowels if applicable.
 - Equipment for placing the concrete:
 - Chute Discharge, Pump truck, Georgia buggy's, wheel barrows, laser screeds & transfer belts.
 - Equipment for curing & cutting
 - Saws, evaporation retarders, blankets (Protection from weather)
 - Proper size crew for the placement:
 - Make sure to plan for issues, have enough hands available to control unforeseen issues.



PLACEMENT OF CONCRETE

- Consolidation & Vibration
 - Internal Vibrators
 - High frequency and low amplitude, used to consolidate concrete in slabs on grade and walls especially when rebar / steel is present in the placement.
 - Consolidation can help eliminate entrapped air which if left unaddressed may cause honeycombs and porous voids.
 - Screeding or Striking off
 - The use of a straight edge generally made from aluminum or magnesium to strike off the concrete to the proper elevation required for the slab.
 - Bull Floating
 - Types of bull floats: Wood & Magnesium & Fiber, size generally 4" to 8" wide & 4' to 20' long. (general size is 4' to 5' long).



HAND SCREEDING



LASER SCREED



VIBRATORY POWER SCREED



TRUSS SCREED



BULL FLOATING

- Bull floating should be done immediately after screeding and completed before bleed water appears on the surface.
- The bull float smooths the surface reducing high and low spots created from the screeding operation. Reducing high and low spots with a bull float requires care & practice.
- Bull floating is done between 45 & 90 degree angles to the direction of travel of the straight edge.
- Need to beware of sealing the surface with the bull float. Wooden bull floats are less likely to seal the surface of the slab.
- Darbies are also used at this time period typically on edges. They are generally made of wood, composite material, aluminum or magnesium.
 - Generally 3" to 4" wide & 2 ½' to 6' in length



BULL FLOAT



HIGHWAY STRAIGHTEDGE



WAITING FOR INITIAL SET

- Initial Set is when the cement & aggregates settle and tighten as the bleed water comes to the surface.
 - Depending on the type of placement, weather conditions & mix design, sometimes excessive bleed water can develop on top of the slab.
 - Excessive bleed water can be removed with a rubber hose or a squeegee, being careful not to remove paste from the surface of the placement.
 - Initial set of the slab has been achieved when a finisher can get onto the slab with knee boards or skates and leave an impression of $\frac{1}{4}$ " or less.



EDGING

- Edging
 - Edger's come in various sizes & shapes. All edger's are used to make neat rounded edges next to the forms.
 - Primarily used on exterior concrete such as sidewalks, driveways, curb & gutters, etc...
 - The rounded edges are less vulnerable to chipping and spawling.



JOINTING

- Jointing
 - Joints are made to limit random cracking
 - Types of joints
 - **Isolation Joints** – separates the slab from fixed objects like walls & columns
 - **Contractions Joints** – Weakened plan to allow the concrete a straight and controlled place to crack.
 - **Construction Joints** – A stopping point for a days placement



HAND JOINTER



EMBEDDED PLASTIC STRIPS



TORPEDO GROOVER



WALKING JOINTER



JOINTING SAW

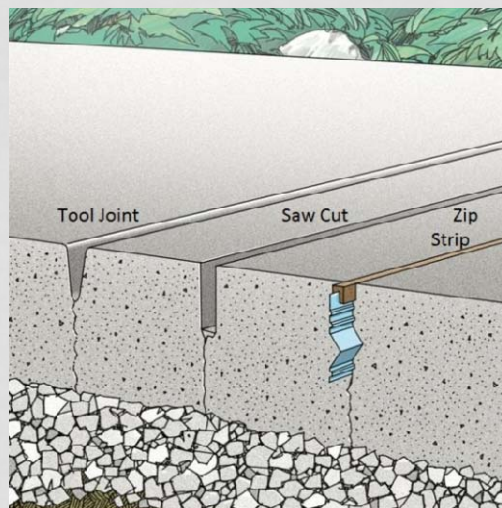


JOINTING

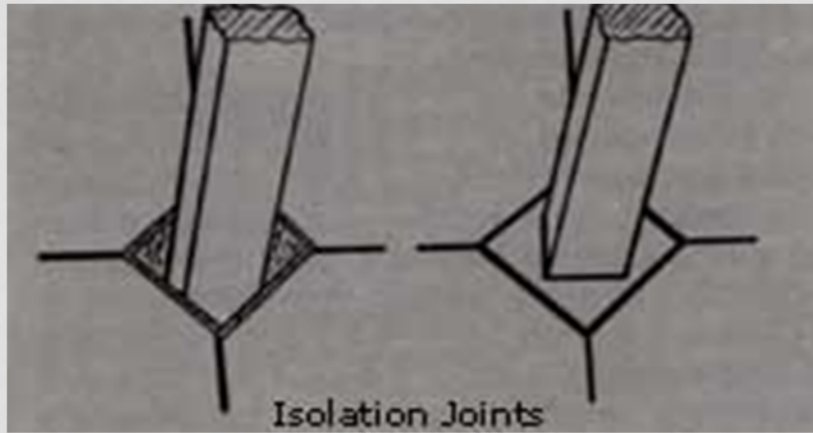
- Isolation joints
 - Isolation joints in slab on grade placements permit horizontal and vertical movement between the slab and any walls, columns, or footing that the slab abuts.
 - Isolation joint materials are made of preformed asphalt impregnated fiber sheeting or similar materials. It is important that the expansion joint extend the full depth of the joint and not above it.
- Contraction Joints
 - Contraction or control joints are cut to give the slab a weakened straight place to crack as the slab settles and shrinks. This eliminates random cracking from happening across the slab.
 - Control joints should be $\frac{1}{4}$ to $\frac{1}{3}$ of slab depth per 1" thickness of the slab. Ex. (4" slab would require 1" joint)
 - Panels formed by control joints should be as square as possible, avoiding narrow panels.
 - Rule frequently stated " Joint spacing in feet should be 2 to 3 times the slab thickness in inches". It is usually best to stick to the 10' to 12' rule.
- Construction Joints
 - Construction joints are joints created by construction limits and pour sequences. Construction joints should be doweled or keyed as appropriate to the structure and slab thickness. Construction joints should be planned prior to placement.



CONTRACTION JOINT



ISOLATION JOINTS



CONSTRUCTION JOINT WITH KEYWAY



FLOATING & FINISHING

- After the waiting period floating is done for 3 purposes:
 - Embed the large aggregates beneath the surface mortar layer.
 - Remove slight humps, low spots & other imperfections to produce a plane, level surface.
 - Prepare the surface for other finishing / final product.
 - If the placement is an exterior pour such as a driveway, curb & gutter, paving or sidewalk once the floating is completed the desired finish should be applied, brooming, tining, swirl and stamp finishing.
 - On interior applications troweling takes place after floating of the slab.
 - Depending on the type of finish requested or desired use of the placement steel and hard troweling may require 3 to 4 passes, especially if a FF & FL are given.



HAND TOOLS FOR FLOATING



BROOM FINISH



HARD TROWEL FINISH



RIDING TROWEL



HOT WEATHER CONCRETE

- Issues that we encounter while placing concrete in hot weather:
 - Rapid evaporation of the top surface causing plastic shrinkage / spongy feel while finishing.
 - Uneven set of the slab
 - Difficulty finishing and sealing the placement
 - Premature development of structural cracking
 - Addition of water to the mixer truck to regain slump causing higher water/cement ratio (weakening of mix design)
 - Solar Radiation, direct sun on the placement will cause rapid set of the surface and cracking in the placement.



WHAT WE DO TO PREVENT HOT WEATHER ISSUES

- Pour earlier in the morning or later in the evening when temperatures are cooler.
- Include hydration stabilizer to the mix design. This will help with causing a delay in hydration of the mix as well as helping maintain internal temps.
- Pre-moisten the forms and subgrade to help cool the ground prior to placement, (make sure not to leave puddles of excess water.) This will also help prevent the water in the mix to be absorbed into the subgrade.
- If the pour is an exterior placement, install wind breaks around the placement. Lite breezes(as little as 5mph) to gusty conditions can cause rapid evaporation.
- Set up canopy shade over the top of the placement to prevent direct sunlight (solar radiation).
- Fogging the placement, this cools the air and raises the relative humidity above the flatwork to lessen rapid evaporation of the surface.
- Ponding or wet burlap on the slab after the placement has cured enough to walk on without causing imprint or damage to the surface.
- Spray placement with a liquid membrane sealer



FOGGING



COLD WEATHER CONCRETE

- Definition:
- When air temperature has fallen to, or is expected to fall below, 40°F (4°C) during the protection period
- Protection period is defined as the time required to prevent concrete from being affected by exposure to cold weather



WHAT WE CAN DO TO HELP AGAINST COLD WEATHER

- Prior to placement remove any frozen subgrade and replace with good material.
- Cover the subgrade / elevated deck with insulating Blankets to capture heat in the placement area.
- If ambient temperatures are too low, heated blankets or heaters may be necessary to achieve proper subgrade temperatures for placement.
- Ground heaters can be utilized for subgrade preparation as well as structure/slab protection.
- Concrete must be protected from freezing until reaching a minimum 500 psi, which generally occurs within the first 24 hours. However curing should be maintained as long as possible to prevent rapid moisture loss. Structures should be protected from freezing during the curing period.



SUMMARY

- Have all equipment on site, including equipment necessary to handle adverse environmental conditions.
- Plan enough workers to accommodate the days placement.
- After mix is discharged on grade begin screed operation.
- Bull float immediately after screeding at a 45 to 90 degree angle.
- Cut control joints deep enough to promote cracking at designated areas. Postpone cutting operations to limit raveling.
- Finishing should be held to a minimum, just enough to meet desired service of placement.
- Cure placement as needed for the environmental conditions.



REFERENCES

- ACI 301
- Kevin Kane, Holcim – CRMCA Hot weather & Cold weather Concrete Presentation
- ACI – Craftsman Workbook, Concrete Flatwork technician & Flatwork Finisher Publication CP-10
- PCA Design and Control of Concrete Mixtures
 - Hot & Cold weather concreting





crmca
COLORADO READY MIXED
CONCRETE ASSOCIATION

**A DAY AT THE CONCRETE JOBSITE:
CONCRETE CURING AND SEALING**

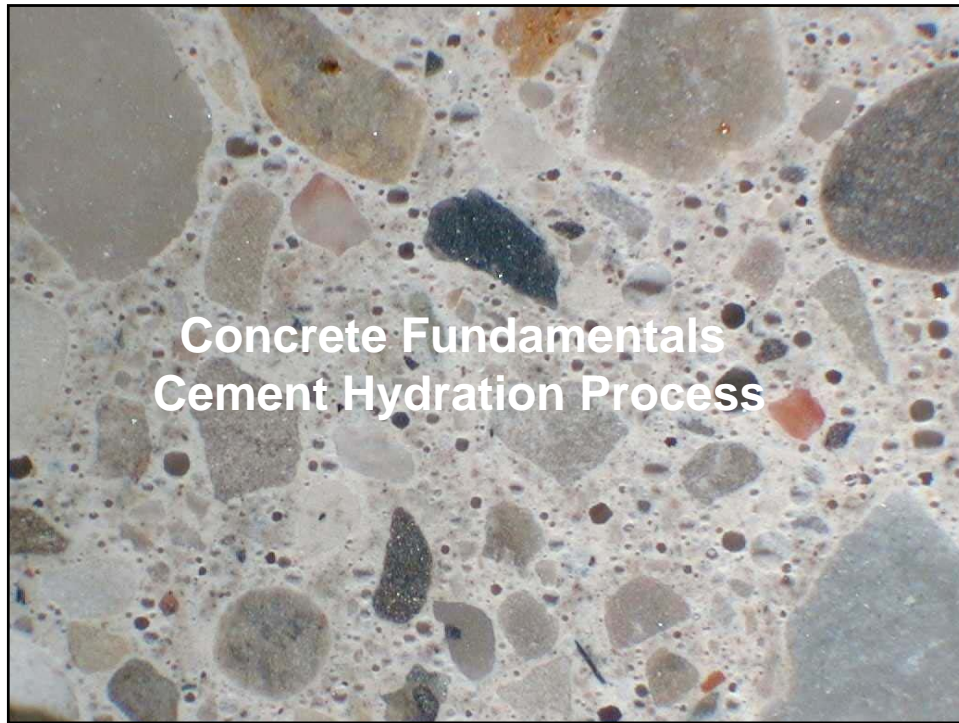
JANUARY 28, 2016, GRAND JUNCTION, CO



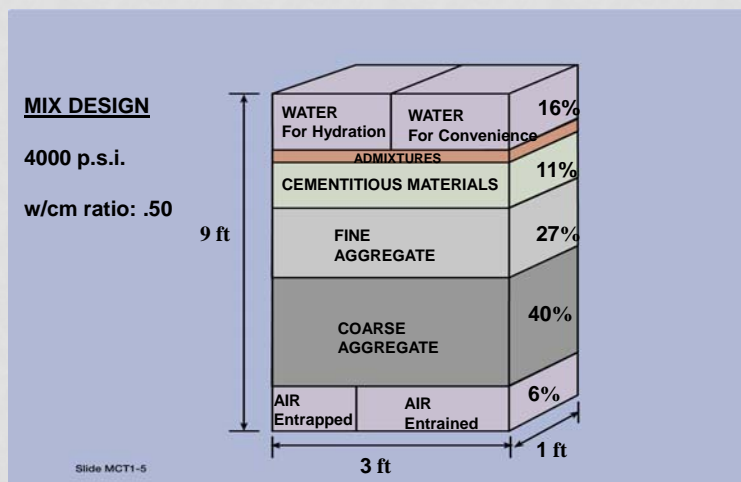
TODAY'S DISCUSSION POINTS

- Concrete Fundamentals
- Concrete Curing
 - *Definition, Benefits, Problems with improper or no curing*
- Curing Methods
- Cure vs Cure and Seal
- Trouble Shooting





Concrete Constituents



CONCRETE CURING DEFINITION PER ACI 308

- Curing is the maintaining of a satisfactory moisture content and temperature in concrete during its early stages so that the desired (read designed) properties may develop.



ACI 302.1R-96 (SECTION 9.1)

Purpose of Curing:

“ After concrete placement and finishing of suitable concrete, **curing is the single most important factor in achieving a high quality slab.** The primary purpose of curing is to slow the loss of moisture from the slab. A longer period of moisture retention permits more complete hydration of the cement, resulting in greater strengths.”

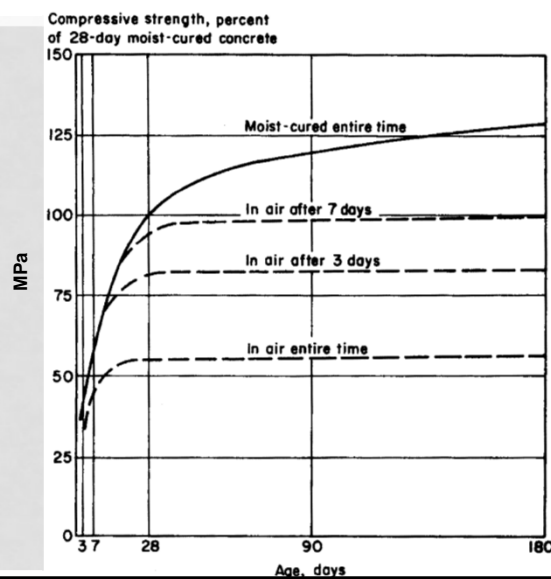


BENEFITS OF CURING

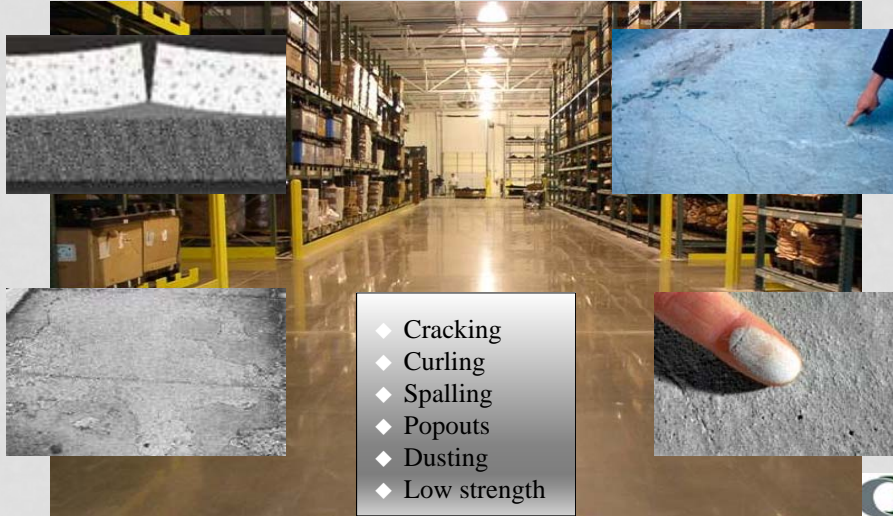
- Achieve Design Strengths
- Improves Durability
- Reduced Shrinkage and Curling
- Enhances Freeze/thaw Resistance
- Better Resistance to Scaling
- Increases Wear Resistance
- Reduces Dusting



ACI 308 EFFECT OF CURE ON STRENGTH



IMPROPERLY CURED CONCRETE



CONCRETE CURING

- **Initial** - procedures implemented anytime between placing and final finishing of concrete to reduce moisture loss from the surface.
 - **Final** - procedures implemented after final finishing and after final set to reduce moisture loss from surface.
-

INITIAL CURING

- Early curing measures are taken during finishing after bleed water has dissipated, and when high evaporation conditions are present.
- Evaporation Reducers: Liquid applied to concrete surface to reduce rate of evaporation during finishing and is to a curing compound. Has no effect on subsequent treatments.
- Fogging: Spray water mist over area to maintain 100% humidity over concrete during finishing process.



ACI 305 Nomograph

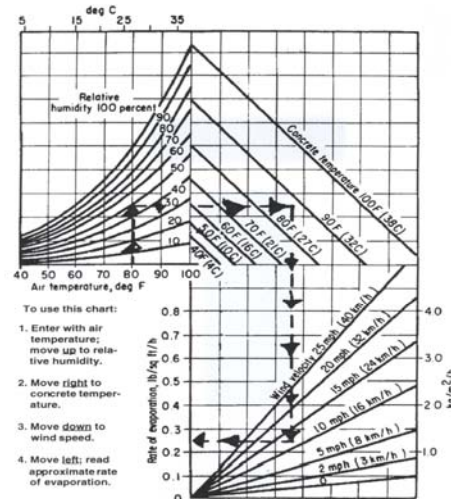


Fig. 2.1.5—Effect of concrete and air temperatures, relative humidity, and wind speed on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use this chart, follow the four steps outlined above. If the rate of evaporation approaches 0.2 lbf/ft²-h (1 kg/m²-h), precautions against plastic-shrinkage cracking are necessary (Leach 1957). Wind speed is the average horizontal air or wind speed in mph (km/h) and should be measured at a level approximately 20 in. (510 mm) higher than the evaporating surface. Air temperature and relative humidity should be measured at a level approximately 4 to 6 ft (1.2 to 1.8 m) higher than the evaporating surface on its windward side shielded from the sun's rays (PCA Journal 1957).



SPECIFICATION TEXT

- Evaporation Reducer: Apply evaporation reducer to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.1 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions one or more times after placing.

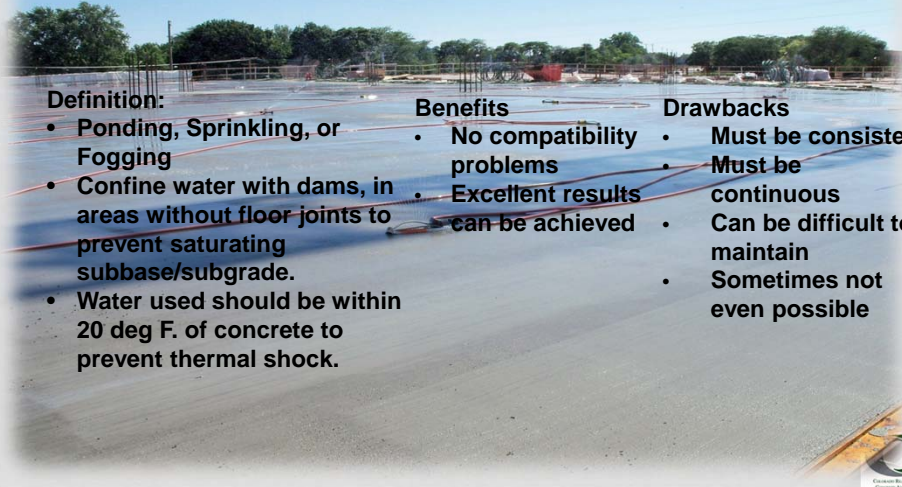


FINAL CURING

- Concrete curing measures taken immediately following final finishing, when curing action will not mar or damage surface.
 - Water Curing
 - Wet Covering
 - Moisture Retaining Coverings
 - Polyethylene Film
 - Waterproof Paper
 - **Liquid Membrane Forming Curing Compounds**



CURING METHODS: WATER CURING



Definition:

- Ponding, Sprinkling, or Fogging
- Confine water with dams, in areas without floor joints to prevent saturating subbase/subgrade.
- Water used should be within 20 deg F. of concrete to prevent thermal shock.

Benefits

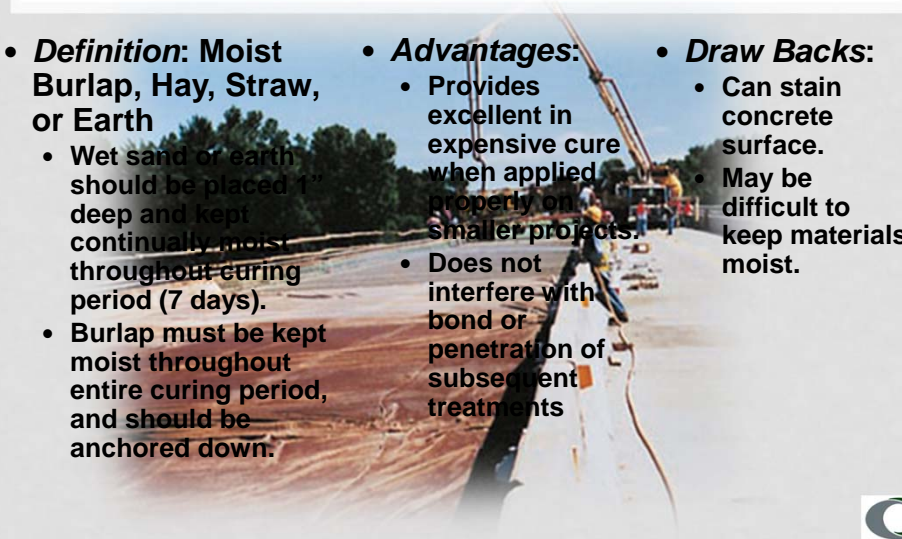
- No compatibility problems
- Excellent results can be achieved

Drawbacks

- Must be consistent
- Must be continuous
- Can be difficult to maintain
- Sometimes not even possible



WATER CURE WITH ABSORBENT COVERING



Definition: Moist Burlap, Hay, Straw, or Earth

- Wet sand or earth should be placed 1" deep and kept continually moist throughout curing period (7 days).
- Burlap must be kept moist throughout entire curing period, and should be anchored down.

Advantages:

- Provides excellent in expensive cure when applied properly on smaller projects.
- Does not interfere with bond or penetration of subsequent treatments

Draw Backs:

- Can stain concrete surface.
- May be difficult to keep materials moist.



Polyethylene Sheeting-

Spread out evenly with minimal wrinkles and secure edges.



MOISTURE RETAINING COVERS ASTM C 171

- **Advantages:**
 - Does not interfere with bond or penetration of subsequent floor treatments.
- **Disadvantages:**
 - Labor intensive and costly.
 - Tripping hazard for trades.
 - Exposed slabs should be cleaned upon removal.



MOISTURE RETAINING COVERS ASTM C 171



Spread out evenly with minimal overlap and secure to area

MOISTURE RETAINING COVERS ASTM C 171



MOISTURE RETAINING FABRIC

- *Advantages:*

- Does not interfere with bond or penetration of subsequent floor treatments.
- Less prone to shadows and discoloration.



- *Disadvantages:*

- Labor intensive and costly.
- Tripping hazard for trades.
- Exposed slabs should be cleaned upon removal.



LIQUID MEMBRANE FORMING CURING COMPOUNDS

- **Advantages:**

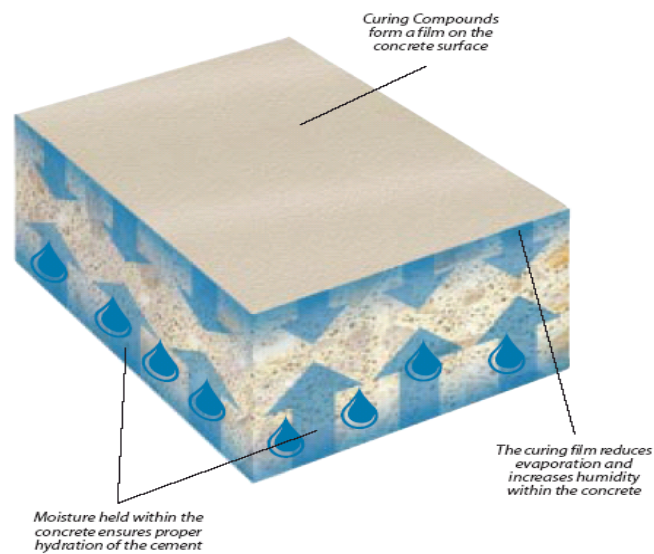
- Cost effective
- Easy to apply
- Friendly to trades
- Protects concrete through construction period.

- **Disadvantages:**

- May interfere with bond of subsequent treatments
- Must be removed prior to application of subsequent treatments.



CONCRETE- CURING COMPOUNDS





CONCRETE CURING AND SEALING COMPOUNDS

Products which cure and seal offer better protection and repellency at the concrete surface

High solids curing & sealing compounds can offer deeper film thickness for added protection

Better film integrity means more efficient curing and improved moisture retention

CRSI
Concrete Reinforcing Steel Institute

SEALER AND COATING CHEMICALS 101: “SOLIDS CONTENT”

- Liquid Carrier
 - Purpose is to keep solids in suspension, and to provide mechanism by which to get solids to surface and allow uniform application and penetration.
 - Solvent or Water Based
 - Carrier Eventually Evaporates
- Solids or Reactive ingredients:
 - Expressed in %
 - Resinous Solids remain on surface after carrier evaporation to coalesce or cross link and form resinous membrane.
 - Other types of solids (silicates and siliconates) penetrate and react with the substrate to form something new in pores and capillary structure of concrete surface

Solids Floating in Liquid Carrier

CRSI
Concrete Reinforcing Steel Institute

CONCRETE CURING AND SEALING - ASTM STANDARDS

- ◆ **ASTM C-309** standard specification for liquid membrane forming compounds for curing concrete
- ◆ **ASTM C-1315** standard specification for liquid membrane forming compounds having special properties for curing & sealing concrete



ASTM C-309 vs ASTM C-1315

	<u>ASTM C-309</u>	<u>ASTM C-1315</u>
SCOPE	CURE	CURE and SEAL
TYPE	1-CLEAR 1D-FUGITIVE DYE 2- WHITE PIGMENT	1-CLEAR 2-WHITE PIGMENT
SOLIDS	NA	25% MINIMUM
CURING EFFICENCY (maximum water loss)	.55 kg/m ²	.40 kg/m ²
REFLECTANCE	2/60%	2/65%
YELLOWING	NA	TESTED BY CLASS



SUMMARY CURE vs CURE & SEAL

- CURE
 - Maintains Minimal Moisture
 - Clear, Red Fugitive Dye, or White Pig
 - Some Can be Removable
- CURE AND SEAL
 - Maintains Maximum Moisture
 - Clear and White Pigmented
 - Long Lasting – Not designed to be easily removed
 - Protects Concrete
 - Reapplication Compatability
 - Improved Appearance



ARE ANY LIQUID CURES OR CURE & SEALS COMPATIBLE WITH FLOORING TREATMENTS?



Understand that such products by nature form a membrane that must be removed for adhesive bonding considerations before the floor is installed.

Look for products with “Dissipating Resin” which means that the membrane is more easily removed.



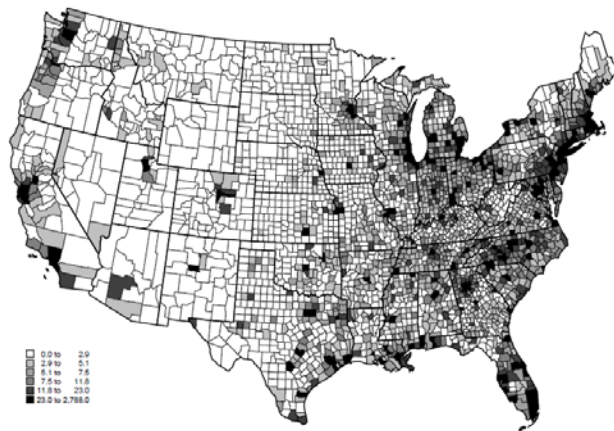
SILICATE “CURING” COMPOUNDS

- **Definition:** Liquid applied chemicals that penetrate into the concrete and react to densify the concrete surface.
- **Advantages:**
 - Cost
 - Compatibility
- **Disadvantages:**
 - Does not form membrane, and imparts little or no curing advantage.
 - Do not meet moisture restriction requirements of ASTM C 309 (0.55 kg/sq. m)
 - When applied to fresh concrete, very little penetration actually takes place due to moisture content in the concrete.



EPA REGULATIONS

County-Level Density Map of Annual VOC Emissions for 2007 Base Case
(tons/square mile)



LADCO (Lake Michigan Air Directors Consortium)

OTC (Ozone Transport Commission), which is made up of 13 northeast and Mid-Atlantic States.



WATER-BASED AND EXEMPT SOLVENTS

Exempt or VOC friendly solvents that can be used in place of petroleum-based solvents in curing compounds and curing and sealing material formulations.

Be aware of the VOC regulations in your market. Utilize the types of products that meet these requirements for your project or customer.

This will give peace of mind to you and your clients.



SUSTAINABILITY



LEED-NC Categories

EQ (Indoor Environmental Quality) points can be achieved when cure and seal have low or no VOC content.

MR (Materials & Resources) points can be achieved when the product is locally produced.



SPECIFICATION TEXT

- Make reference to **ASTM C-309, Type 1, Class A or B** for moisture retention and coverage rate.
- **Maximum allowable VOC content** should be specified if the project is in a state that has VOC regulations.
- **Coverage rates** should be identified to ensure an adequate film is formed on the concrete surface.
- If **compatibility with floor adhesives** will be a concern, be sure to provide text for removing the curing compound prior to applying the floor adhesive.




SPECIFICATION TEXT

- For high efficiency curing and sealing compound, reference should be made to:
 - ASTM C-1315 for moisture retention, non-yellowing (Type I when clear is specified and Type II when white pigment is specified).
 - Class A non-yellowing for exterior use.
 - Class B moderate yellowing for interior areas non-aesthetic
 - Class C not tested for yellowing to be used in areas where appearance is of no concern.
 - Similar to specification text for curing compounds, reference should be made for coverage rate, moisture loss 0.40 kg/sq. m, and VOC content.




Do I really need to cure concrete?



It's cool out. I don't need to cure....



YES!





CYLINDER CURING

ASTM C 31 during initial curing (48 hours), the cylinders must be kept at a temperature between 60° and 80° F and in a moist environment. Capped Mold

Final cure- cylinders stripped and submerged in water tank or placed in 100% humidity fog room at 73 ± 3 F

Do not store in sun or in cold ambient temperature!
Could loose at least 15% strength.

Improper Curing Hazards Trouble Shooting



PLASTIC SHRINKAGE CRACKS

- Cause:
 - High evaporation conditions during placing and finishing.
- Prevention:
 - Initial Cure: Evaporation Reducers or Fogging



DUSTING

- **Causes:**
 - High w/c ratio at surface.
 - Timing of finishing
 - Adding water to surface.
 - Environmental Damage
 - Early Freezing
 - Rain Damage
 - Carbonation.
- **Prevention**
 - Do not finish when bleed water is present
 - Utilize evaporation reducers.
 - Protect from environment
- **Repair:**
 - Liquid Densifiers



SCALING/DELAMINATION

- **Causes:**
 - Weak surface damaged by freeze thaw stresses.
 - Improper Air Content
- **Prevention:**
 - Proper cure
 - Protect surface with cure and seal or penetrating silane or siloxane water repellent
 - Proper air content
- **Repair:**
 - Re-Surface
 - Tear Out



CRAZE CRACKING

- Causes:
 - Insufficient Cure

- Repair:
 - Live with it.
 - Re-Surface
 - Tear Out



Crazing is a network of fine superficial surface cracks due to minor surface shrinkage caused by moisture loss.

Cure and Sealer Trouble Shooting



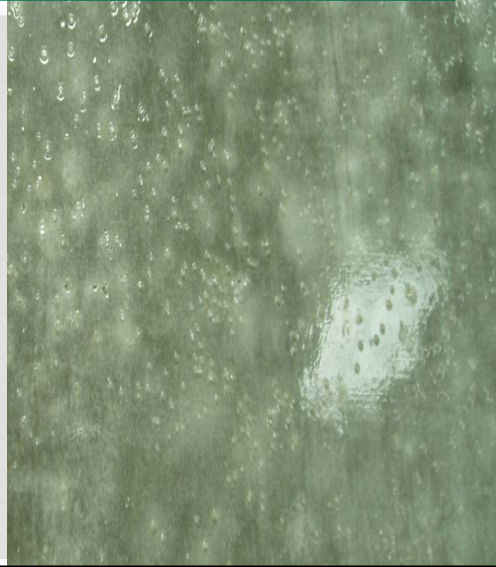
PROBLEM: COMPOUND HAS BUBBLED

Problem: Curing and sealing compound has bubbled.

Cause: Product was applied too heavily, or in hot weather/direct sun

Prevention: Carefully follow manufacturer's recommended coverage rate and apply during the coolest part of the day when concrete is not in direct sun. Two thin coats should be applied rather than one heavy coat.

Solution: Perform a solvent wash and allow to dry. Re-application is not recommended.



PROBLEM: SOLVENT-BASED COMPOUND TURNED WHITE

Problem: Solvent-based compound turned white.

Cause: Product was applied too heavily or there are too many coats of sealer on the concrete, and moisture trapped underneath the sealer has caused it to lose adhesion from the concrete.

Prevention: Follow manufacturer's recommended coverage rate; do not re-seal concrete until previous coat(s) have worn away or have been stripped off.

Solution: Solvent wash and allow to dry. Re-application is not recommended.



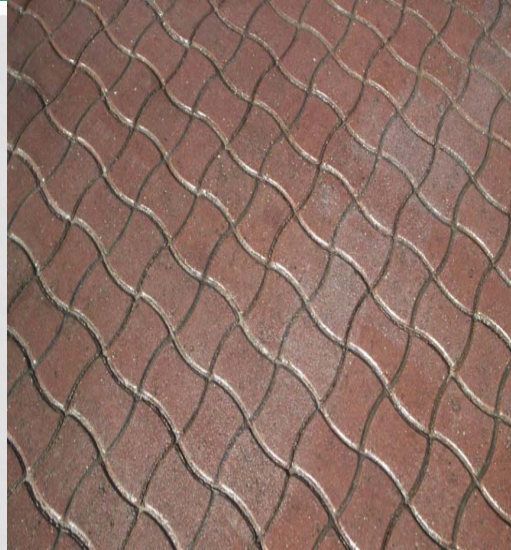
PROBLEM: MILKY WHITE OR POWDERY

Problem: Water-based Curing and Sealing Compound is Milky White or Powdery

Cause: Product was applied in low temperature or high humidity conditions or where airflow is low OR product was applied too heavily.

Prevention: Follow manufacturer's recommended coverage rate and application conditions.

Solution: Cure and seal may need to be completely removed with a chemical stripper or mechanical means. Reapply in proper conditions.



PROBLEM: STREAKS, ROLLER MARKS, OR DRIPS



Problem: Concrete shows streaks, roller marks, or drips after curing and sealing compound is applied.

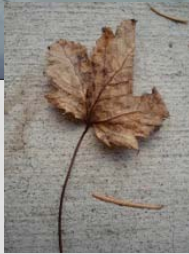
Cause: Careless or sloppy application; product was applied unevenly without keeping a "wet edge"; wrong type of sprayer or spray tip was used.

Prevention: Carefully follow application instructions on product's technical data sheet.

Solution: Perform a solvent wash to redistribute heavy areas of product if a solvent based cure and seal product was used.



PROBLEM: STAINS FROM OIL, TREE DEBRIS, FERTILIZER

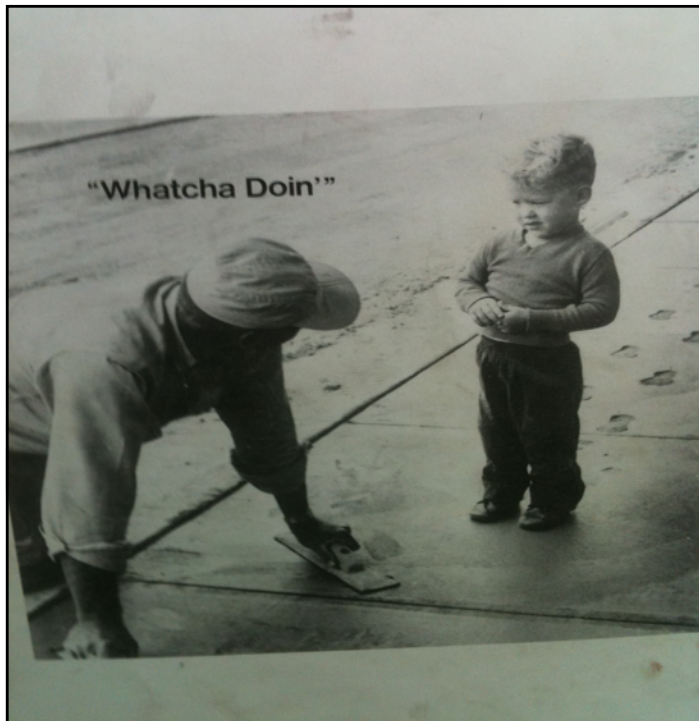


Problem: Curing and sealing compound is stained from oil, tree debris, fertilizer, etc.

Cause: Curing and sealing compounds will not prevent stains.

Prevention: Prevent oil and other chemical drips from cars and equipment. Sweep tree debris and fertilizer granules from concrete as often as possible.

Solution: Use a commercial concrete cleaner or stain remover to clean stained concrete. Sealer product may require reapplication if cleaner or stain removal process removes the sealer as well.



Questions??



REFERENCES

- Standard Specification for curing Concrete, **ACI 308**, American Concrete Institute, Farmington Hills, MI.
- Cold Weather concreting, **ACI 306R**, American Concrete Institute, Farmington Hills, MI.
- Hot Weather concreting, **ACI 305R**, American Concrete Institute, Farmington Hills, MI.
- **ASTM C 171**, Specification for Sheet Materials for Curing Concrete, American Society for Testing Materials, West Conshohocken, PA.
- **ASTM C 309**, Specification for Liquid Membrane Forming Compounds for Curing Concrete, American Society for Testing Materials, West Conshohocken, PA.
- **ASTM C1315**, Specification for Liquid Membrane Forming compounds having special properties for curing & sealing concrete, American Society for Testing Materials, West Conshohocken, PA.
- Concrete in Practice, **CIP 11**, What, Why and How, Curing In-Place Concrete, National Ready Mixed Concrete Association, Silver Spring, MD.
- Portland Cement Association, Design and Control of Concrete Mixtures, 14th Edition. Skokie, IL.



THANK YOU

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