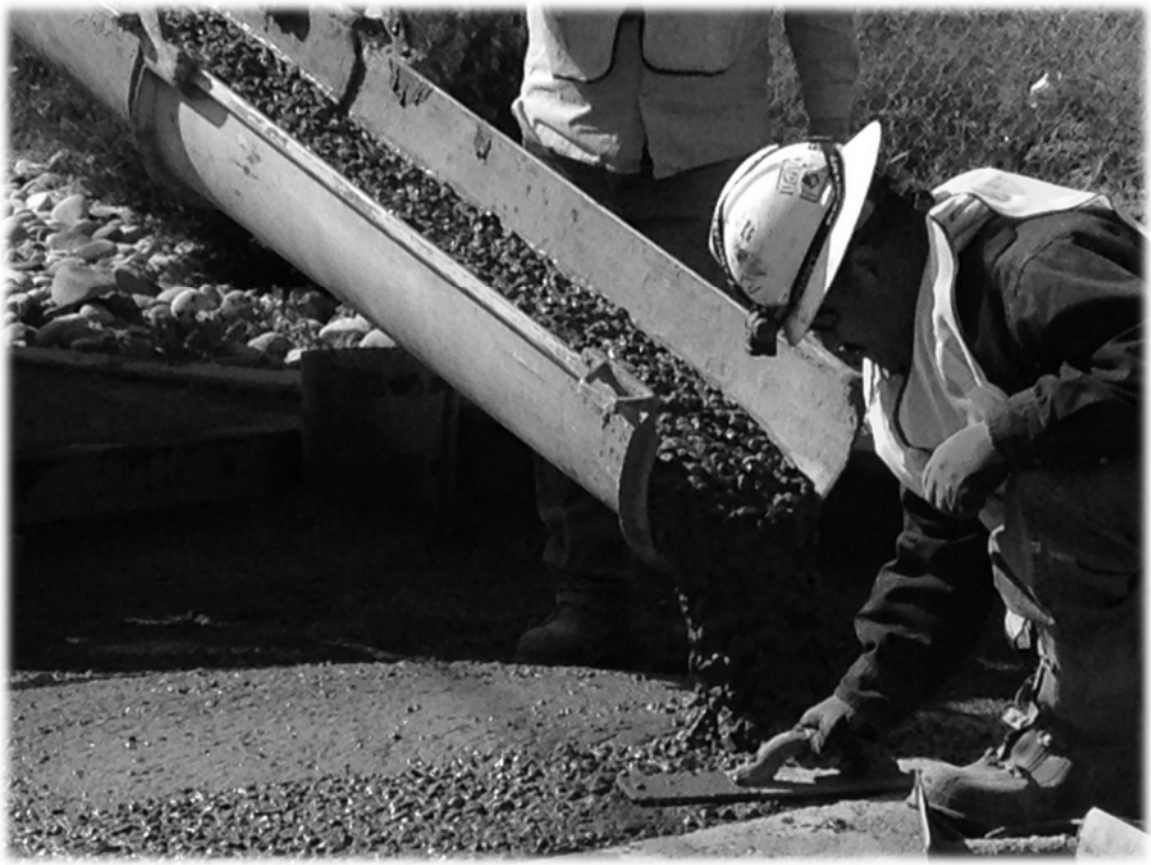
COLORADO READY MIXED CONCRETE ASSOCIATION

EXTERIOR CONCRETE FLATWORK CONSTRUCTION AND MAINTENANCE BEST PRACTICES



Disclaimer

The Colorado Ready Mixed Concrete Association has compiled this guideline for assistance with planning, and the installation of exterior concrete. This guideline simply summarizes some of the most common ACI requirements typical to Colorado residential flatwork at this point in time. This guideline may not address all situations and requirements. The current versions of ACI 301 and ACI 318 should be referenced and followed.

This guideline is not intended to replace any contract project documents.

Forward

By Kevin Kane, CRMCA Technical Committee Member

Concrete is a very economical and durable building material. Its properties allow it to be molded, formed, adapted, fitted, and shaped on the jobsite. No other building material possesses all of the properties of concrete. However, poor-quality cast-in-place concrete construction is neither durable nor aesthetically pleasing. Poor-quality cast-in-place concrete requires costly removal and replacement, which adds little, if anything, to the equity of the home. So it's better for all stakeholders, including the homebuilder, the ready mix concrete supplier, the concrete contractor, and most importantly, the Homeowner, to get it right the first time. And to get it right the first time, it is necessary to make sure that all stakeholders have the same fundamental expectations and understanding of concrete and how to attain durable and aesthetically pleasing cast-in-place concrete.

According to the American Concrete Institute's Guide to Durable Concrete, "durability of hydraulic-cement concrete is determined by its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. Durable concrete will retain its original form, quality, and serviceability when exposed to its environment. Properly designed, proportioned, placed, finished, tested, inspected, and cured concrete is capable of providing decades of service with little or no maintenance". In Colorado, the environmental factors that are most destructive to poor-quality cast-in-place concrete is twofold, as follows:

1. Cycles of freezing and thawing while in a saturated condition
2. Applications of deicing chemicals

This Flatwork Installation Guide is designed for homebuilders, ready mix concrete suppliers, concrete contractors, and Homeowners. It is intended to supplement other resources and guidance documents on how to attain durable and aesthetically pleasing cast-in-place exterior concrete flatwork.

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Safety

The purpose of the best practices discussed in this document is to assist in the understanding of placement and finishing of exterior flatwork. The document does not address safety, in whole or in part, and is not meant to supersede safety regulations, guidelines, or concerns. Safety is the responsibility of the reader to determine the appropriate safety standards prior to use. Proper safety guidelines and equipment should always be used when handling concrete.

Key Points and Best Practices

1. Communication between all parties is critical to a successful placement.
2. Proper mix design selection
    - Minimum 4500 psi, Maximum 0.45 water/cementitious (w/cm) ratio, air content of 6.0% +/- 1.5% (7.5%+/- 1.5 for 3/8" agg) or as otherwise specified
3. Proper placement conditions
    - Be prepared for adverse weather conditions, excessive wind, low humidity, hot/cold weather.
4. Proper site preparation
    - Subgrade uniformity, compaction and moisture.
5. Proper finishing
    - Do not use steel trowels on exterior concrete
    - Proper depth and layout of control joints
    - Do not finish water into the surface (bleed water and/or applied water)
6. Proper Curing
    - Cure and seal concrete.
7. Maintenance
    - Damage to the concrete can happen when proper maintenance is not followed
    - Clean and reseal the concrete surface, periodically, as recommended by product manufacturer.
    - Remove snow and ice promptly.
    - Repair cracks prior to sealing of concrete.

Mix Design Selection

Your ready mix concrete producer has a concrete mix design that will meet the performance requirements of compressive strength, surface wear resistance, and durability for exterior concrete exposed to the extremes of Colorado weather and environmental conditions.

The American Concrete Institute (ACI) and other industry experts recommend the following materials and properties for best performance for exterior concrete flatwork in areas that have freeze thaw cycles like those experienced in the Colorado area:

1. Coarse and fine aggregate meeting ASTM C33 requirements

2. Portland cement meeting ASTM C150, C595 or C1157 as recommended by the ready mix concrete producer.
3. Fly ash or other appropriate supplementary cementitious materials.
4. Compressive strength of at least 4500 psi (ACI 318)
5. Water/cementitious ratio of 0.45 maximum (ACI 318)
6. Air entrainment of 6.0% +/- 1.5%
7. Slump range as specified by the ready mix concrete producer's mix design**. If you exceed the mix design slump range with water added at the job site, you should expect reduced compressive strength, increased potential for more cracking and surface scaling**. If you need higher slump than your current exterior mix design is providing, consult with your ready mix concrete producer to adjust your mix design and provide increased slump with a chemical admixture.

Use these additional admixtures to help you in adverse weather or site conditions:

Fiber reinforcement: Use fibers to reduce plastic shrinkage cracking, associated with windy, low humidity and high evaporation conditions; which are quite prevalent in Colorado. Your ready mix concrete producer will add these at the concrete plant before the concrete is delivered to your jobsite.

Hydration stabilizer: This chemical admixture when added to the concrete will delay the hardening process of the concrete and extend the amount of time for concrete finishers to place and finish the concrete. Your ready mix concrete producer has a dosage rate for hydration stabilizer that they can adjust for hot temperatures, extended travel or other delays. Plan ahead for these conditions.

Accelerators: Accelerators can be added to the concrete to speed up the hardening process in cold weather conditions. This product can be helpful on cold days when you need to get the initial set of the concrete quicker for finishing operations and blanketing. Ask your ready-mix producer for the proper dosage of accelerator for your concrete. The use of concrete accelerator containing calcium chloride should not be used with reinforced concrete and may cause discoloration or color mottling of the concrete surface. If a more uniform surface appearance is desired a non-chloride accelerator (NCA) can be substituted. Accelerators are not considered anti-freeze for concrete.

Ordering Concrete

The following are items to keep in mind when ordering concrete, in addition to consulting ASTM C94.

1. GENERAL AREA/REGION FOR DELIVERY
2. CUSTOMER NAME
3. DELIVERY INFORMATION
    - Job Site Address and/or current project information.
    - Nearest Intersection
    - Zip Code
4. CONTACT INFORMATION
    - Name

    - Company placing the order
    - Phone Number(s); including contact person on site
5. MIX DESIGN
    - Be familiar with your project's requirements. If your concrete supplier has submitted project specific mix designs; be familiar with those to ensure proper mix and application are matched to your current order.
6. QUANTITY
    - Make sure to double check your figures and always order extra concrete to compensate for settling, an uneven sub-base, and spillage. Then round your order up to the nearest cubic yard.
7. SLUMP/CONSISTENCY
    - Ensure you are following your project requirements.
    - Method of placement.
8. DATE AND TIME
    - Delivery schedules can fill up fast. It works best to place your order several days in advance.
9. TRUCK INTERVALS/SPACING
    - If your project needs more than one truck load, you will need to estimate - how long it will take you to unload each truck. Be realistic. It is easier to slow down the delivery rate than it is to speed up the delivery rate.
10. PROJECT DESCRIPTION
    - Method of Placement (Pump, Tailgate, Wheelbarrow, etc.)
    - Type of Placement (Slab, footing, commercial/civil type of structure or element.)
11. ADDITIONAL PRODUCTS
    - Color, Fibers, Admixtures, etc. Do not miss project specific requirements.

Checklist of Tools, Materials and Manpower

- Have the proper manpower and equipment for the size of the placement and the conditions of the site.
- Prepare safe and adequate entry and exit to and from the site considering size and weight of concrete trucks. A truck carrying 10 cubic yards of concrete can typically weigh over 75,000 pounds.
- If required, contact a testing lab to schedule concrete quality control testing, a minimum of 24 to 36 hours before the placement and communicate the testing that is to be done.
- Provide a proper wash out area with safe access for the concrete truck and pump.
- Be prepared for unforeseen changes in project conditions (weather, drastic drop in temperature, or power loss.)
- When ordering concrete, evaluate the expected weather conditions to select the best possible day for a successful placement. Reschedule your placement if adverse weather conditions will be coming.

Subgrade Preparation

Soils in Colorado may be unstable and require special construction. Unstable soils often shrink or swell and the stress applied by these soil changes can cause cracks in the concrete to form. It is

important to obtain and review geotechnical reports to understand the unique jobsite soil conditions. Contact your geotechnical engineer for assistance.

Establishing Grade of Concrete Surface

- Positive drainage should always be provided for exterior slabs to prevent ponding of water on concrete., and slope away from structures
- If the project does not have specific elevations, establish proper grades.
- Before placing concrete, workers should check the elevation of the subgrade.
- High spots should be removed and low spots filled with properly compacted material.
- Limit variations in concrete thickness, but never use less than the designed concrete thickness in a slab.

Reinforcement for crack control

Non-structural reinforcement intended to resist stresses produced by shrinkage and temperature effects can consist of deformed bars, welded-wire reinforcement, and synthetic or steel fibers.

- Many slabs-on-grade contain some deformed reinforcing steel. These slabs are considered unreinforced because the only purpose of the reinforcement is to minimize crack width.
- Deformed reinforcing steel should be supported and tied together sufficiently to minimize movement during concrete placing and finishing operations. Chairs or precast-concrete bar supports are generally considered to be the most effective method of providing the required support for reinforcement.
- Avoid walking on the reinforcement after it has been placed on the supports.
- Install reinforcement in accordance with ACI 332 and manufacturer's recommendation.
- Do not hook or lift welded wire reinforcement from the subgrade as the concrete is being placed. Welded-wire reinforcement should not be placed on the ground and pulled up after placement of the concrete, nor should the mats be "walked in" (wet setting) after placing the concrete.
- Keep the wire mesh or steel clean of debris.
- For placing purposes, a welded-wire fabric in sheet form is preferred to welded-wire fabric in rolls because the sheet form is safer and easier to use and hold in position.
- Synthetic (plastic) macro fibers are an alternative to rebar and/or welded wire mesh for many exterior slabs. With prior approval and within manufacturer's recommendations, macro fibers can provide improved drying shrinkage crack control, improved residual flexural strength (long term crack control after the concrete has cracked) and reduce plastic shrinkage cracking (cracking before the concrete has hardened).

Jointing

- Isolation joints, sometimes called expansion joints, provide freedom of movement between the concrete slab and adjacent building elements.
- All isolation (expansion) joints should be in place before concrete placing begins, and should equal slab thickness.
- Material for isolation joint should be made from asphalt impregnated sheets or other suitable joint material that is compressible and prevents bonding to ridged structure.

- Contraction joints, sometimes called control joints, accommodate movements that are caused by temperature changes, drying shrinkage, and creep.
- Contraction joints may be formed by tooling, sawing or using plastic divider strips. The location of these joints should be marked ahead of time on the edge of forms or other permanent items.
- The joint is sawed, formed, or tooled part way through the thickness of the concrete to form a weakened plane that encourages cracks to occur at a predetermined line and not at random locations. Contraction joints are recommended to be spaced apart 24 to 36 times the thickness of the slab in inches. The joints should be cut between 1/4 and 1/3 of slab thickness. Seek a balance between too few joints which cause more random cracking and too many joints which increase the cost of maintenance.
- Jointing of irregular shaped slabs should be pre-planned.
- Early-entry dry-cut joints are generally run 1 to 4 hours after completion of finishing, depending on the concrete's setting characteristics. These joints are typically not as deep as those obtained by the conventional saw cut process, but should be a minimum of 1" in depth.
- Drying shrinkage may cause unwanted cracks to develop before sawing. Therefore, sawing should begin as soon as the concrete can support the saw, usually within 4 to 12 hours after the concrete has been finished.
- Rapid temperature decreases can cause thermal contraction and cracking.
- Construction joints are full depth separations in slabs introduced for the convenience of construction. They are usually located where one placement ends and the next begins. They may be required if the concrete placement is interrupted. Dowel bars or key-ways may be required at construction joints.
- Be aware of areas that are common for cracking such as outside corners, re-entrant corners, thin sections, stair risers, irregular geometric shapes, slab penetrations, etc. and should be considered in joint planning.

Concrete Placement and Finishing

Concrete must be discharged and placed in a timely manner upon arriving to the job site. Skill, knowledge, and experience are required to deal with a variety of concrete mixtures and field conditions. Making sure there is adequate manpower, equipment, and time is critical for this operation. At a minimum, at least one member of the placement and finishing crew should be an ACI Certified Flatwork Finisher and Technician to ensure proper quality construction practices. This person can verify that all proper ACI finishing guidelines have been followed.

Concrete shall be placed as near as possible to its final location, either directly from the truck chute or with wheelbarrows, buggies, or pumps (Fig. 1). **AVOID ADDING AN EXCESSIVE AMOUNT OF WATER TO INCREASE SLUMP BEYOND THE MIX DESIGN LIMITS. THIS WILL REDUCE THE QUALITY AND INTERGRITY OF THE CONCRETE (Fig. 2).** The ready-mix concrete producer should be contacted if higher slump concrete is desired.

Figure 1: Reasonable slump concrete being placed near its final location.

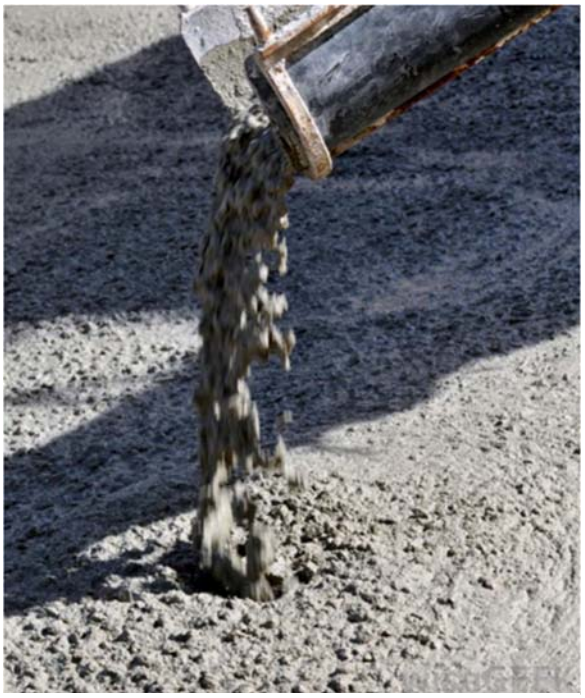

Figure 2: Concrete with excessive water creating high slump

Figure 3: Square-ended shovel

Figure 4: Concrete rake

Spreading of concrete can be achieved by use of a short-handled, square-ended shovel (Fig. 3), come-alongs, or concrete rakes (Fig. 4). Never use a garden rake or shaft vibrator to spread concrete horizontally. (These methods of movement cause segregation)

Freshly placed concrete will contain voids. If allowed to harden in this condition the concrete may become honeycombed and porous, therefore should be well consolidated before finishing. For small flatwork jobs, consolidation can be achieved by rodding the concrete. For large flatwork jobs, consolidation is usually accomplished by use of a vibrating screed (Fig. 5), internal vibrator (Fig. 6), surface vibrating float (Fig. 7), laser-guided screeds (Fig. 8), or vibratory roller screed (Fig. 9).

Figure 5: Vibrating screed

Figure 6: Internal vibrator

Figure 7: Vibrating Float

Figure 9: Roller screed

Figure 8: Laser screed

Screeding or strikeoff is usually done manually with a straightedge consisting of a rigid, straight piece of wood or metal. (Fig. 10) These screeds should be used in a slight sawing motion as it moves across the concrete, maintaining a surcharge of concrete in front of the screed to fill in low spots. A jitterbug should only be used with low slump concrete. Vibrating screeds (Figs. 5 through 8) should move rapidly to ensure consolidation but avoid working up an excessive layer of mortar on the surface.

Immediately after screeding and before bleed water appears, the concrete must be further leveled using a bull float (Fig. 11), darby (Fig. 12), or highway straightedge. The bull float or darby embeds large aggregate, smooths the surface, and takes out high and low spots. Use an edger (Fig. 13) to round and compact the concrete eliminating square edges that are prone to chipping.

Figure 10: Metal straightedge

Figure 11: Bull float

Figure 12: Darby

Figure 13: Edger

***Use care when bull floating to prevent sealing of the surface. If the surface becomes sealed, bleed water will collect just beneath the surface instead of on top of it, and create a weak plane. If this happens, the surface may blister during finishing or delaminate after the concrete hardens**.

1. Bull floating is required for these purposes:
    - Embed the large aggregate beneath the surface mortar layer
    - Remove slight humps or other imperfections and produce a plane, level surface
    - Compact and further consolidate the surface in preparation for other finishing.
2. After bull floating, no finishing practices should occur until bleed water has completely evaporated. Concrete will be glossy when bleed water is present and will dull when it evaporates
3. Concrete is ready for texturing when the bleed water sheen is gone and a finisher can walk on the slab leaving only about a 1/4 in. (6 mm) indentation. Machine floating can be done only if the machine will neither dig in nor disrupt the level of the surface.
4. Joint the concrete as required, using the rule of thumb of 24 to 36 times slab thickness in inches.

Example: Using the equation below, a 4-inch thick residential slab will require between 8 and 12-foot spacing.

$$\frac{T\ x\ M}{12}, where\ \begin{matrix} T = Slab\ Thickness \\ M = Rule\ of\ Thumb\ Multiplier \end{matrix}$$

5. Use a straight edge as a guide. To create a weakened plane, the jointer groove must be 1/4 to 1/3 of the slab thickness, i.e.:
    - Minimum of 1 in. (25 mm) deep for a 4 in. (100 mm) thick slab
    - Minimum of 1-1/2 in. (40 mm) deep for a 6 in. (150 mm) thick slab
    - Minimum of 2 in. (50 mm) deep for an 8 in. (200 mm) thick slab

NEVER FINISH EXTERIOR CONCRETE WITH A STEEL TROWEL!

Figure 14: Steel trowel

Figure 15: Magnesium float

While finishing concrete, "blessing" with water or sprinkling dry cement on the concrete should **NEVER** occur. This can cause dusting and/or scaling. A broom or brush texture is recommended for exterior applications (Fig 16).

Figure 16: Brush texture on concrete

Evaporation reducers, as discussed in the Initial Curing section, shall not be finished into the concrete surface and are not considered part of the finishing process. Evaporation reducers are available for assisting in initial curing of the concrete.

Initial and Final Curing of Concrete

Curing is a critical step in any concrete project because proper curing maximizes the durability, scaling resistance and strength of the concrete

Initial Curing

– Per ACI 308R-16, "initial curing refers to procedures implemented any time between placement and final finishing of the concrete to reduce moisture loss from the surface." This step in the process is needed if high evaporation conditions exist, which prematurely dries out the concrete surface and may cause plastic shrinkage cracking and/or the surface to crust and tear while the underlying concrete remains soft and plastic. There are two typical accepted methods of initial curing.

Surface Evaporation Reducers: A liquid chemical properly mixed with water per the manufacturer instructions and then spray applied per manufacturer instructions to the concrete surface to reduce the rate of evaporation of bleed water. **Since this chemical is mixed with water, it is not to be worked into the concrete surface prior to the formation of the monomolecular film. It is also not considered a replacement for final curing**.

Fogging: Applying a fine fog mist above the concrete surface area to maintain 100% humidity over the concrete during the finishing process. The fog mist is not to be sprayed directly onto the concrete surface.

Final Curing

– is a process that provides a moist environment on the surface of the concrete that prevents the loss of moisture in newly hardened concrete. Loss of moisture is due to evaporation and hydration of the concrete. The final curing process occurs after final set by applying and maintaining water to keep the surface saturated, or by applying a liquid chemical curing compound on the surface of the finished concrete that forms a membrane to retain moisture within the concrete.

The final curing process should start immediately after final finishing operations are completed, and the surface is strong enough to remain undisturbed by the curing process.

- The following final curing methods are very effective for providing sufficient moisture control:
  - Soaker hoses for constant moisture
  - Ponding with water and covering with plastic to prevent the water from evaporating
  - Saturated covering (wet burlap with plastic sheeting over it, or moisture retaining fabric)
  - Liquid membrane-forming curing compounds – applied with sprayer

- When using a liquid membrane - forming curing compound for exterior concrete; apply per the manufacturer recommendations for proper coverage rate. Curing compounds are meant to be applied forming a continuous and complete covering of the surface. Spotted appearance of a sprayed curing compound is not adequate coverage. ASTM C309 is the performance standard for curing compounds.

- There are liquid chemical cure-and-seal products that perform as both a curing compound and a concrete sealer. These products should meet the performance standards of ASTM C1315
- When using a cure-and-seal type product, follow the manufacturer's instructions for proper coverage rate, application methods and allowed temperature range to apply.
- Concrete temperature and weather conditions (ambient air temperatures, relative humidity, wind speed, direct sunlight, etc.) will play a major part in how and when final curing will take place, so proper planning is important.
- Per ACI 308, final curing should be continued until the desired concrete properties have been achieved. As a rule of thumb, concrete should be cured for a minimum of 7 days.
- In cold and freezing weather, concrete should be covered with insulated blankets to prevent the concrete temperature from falling below freezing, and ideally maintaining a minimum concrete temperature of 55 degrees F for 7 days.
- Curing methods using water should not be used when outside temperatures are expected to drop below 40F.
- When curing colored concrete, extra care and proper preparations should be taken to avoid marking the surface. Create air space between coverings and the concrete surface will help reduce plastic or blanket markings due to efflorescence.
- For detailed information on concrete curing refer to the latest edition of ACI 308 Guide to External Curing of Concrete.

Sealing the Concrete

Sealing of Exterior Concrete **-** Concrete sealers are liquid chemical products that are applied to the concrete surface. These products work by sealing the concrete surface and preventing the penetration of water and harmful substances, including chemical deicers. Sealing concrete helps extend the service life of concrete and preserves the aesthetics of concrete. Generally, there are 2 types of sealers; membrane forming sealers and penetrating type sealers. Membrane forming sealers are formulated for different levels of sheen which can range from a matte finish to high gloss. Penetrating sealers penetrate the surface of the concrete and have no sheen or gloss.

- Sealers are typically applied after 28 days from the concrete placement day, allowing the concrete to first cure and dry, unless a cure-and-seal type product conforming to ASTM C1315 was applied just after final finishing on the day of placement.
- Understand how the concrete was cured before applying a sealer. Many curing compounds must be removed from the surface using a power washer and allow sufficient time for the concrete to dry before a sealer is applied. Some curing compounds dissipate and break down over time.
- Be sure the surface is clean, dry and free of debris, and apply the sealer per the manufacturer's instructions.
- Do not over apply the sealer. Adhere to the manufacturer's instructions in regard to coverage rates to avoid issues with bubbling, blistering and white or cloudy shading of the concrete surface.
- Allow sealer to dry completely before exposing to pedestrian or vehicular traffic.
- Sealers are available for specialty applications such as colored concrete, or exposed aggregate.
- Follow the sealer manufacturer's recommended re-application schedule. Typically, sealers will need to be re-applied every three to five years. You can spot check portions of the concrete to determine when sealers need to be reapplied; when water no longer beads on the surface of the concrete, it is time to reapply a sealer.

Short Term Care and Maintenance of the Concrete (First 12 months)

- Promptly removing snow and ice accumulation from the concrete will increase its service life.
- Avoid using de-icing chemicals on the concrete. Instead, sand can be used for traction.
- Be advised, de-icing chemicals will be deposited onto surface of concrete by vehicles' undercarriage and tires.
- Avoid contact between concrete surface and lawn fertilizers that contain iron to limit rust spots and staining.

Long Term Care and Maintenance of the Concrete (After 12 months)

- If deicing chemicals must be used, avoid use in the first year of service. Always be sure to check the labels on deicers. Never use products which contain magnesium chloride or potassium acetate. Sodium chloride is the least damaging deicer for use on concrete.
- It is very important to not allow snow and ice to build up on your driveway, patio or other exterior concrete. Concrete that has been in service for years without scaling can scale later due to oversaturation from snow and ice buildup. This can be easily avoided with prompt removal after a snow or ice event.
- Fertilizers contain substances which chemically attack concrete. Promptly sweep or blow off any fertilizer that is inadvertently cast on the concrete when applying fertilizer to grass and plants. Fertilizer left on concrete can also cause "rust staining"
- Follow the sealer manufacturer's recommended re-application schedule. Typically, sealers will need to be re-applied every three to five years. You can spot check portions of the concrete to determine when sealers need to be reapplied; when water no longer beads on the surface of the concrete, it is time to reapply a sealer.
- It is normal for concrete to shrink and expand due to moisture and temperature fluctuations; concrete will typically shrink 1/16" per 10 linear feet. These shrinkage cracks typically occur within the joints and not across the surface of the concrete. Before re-sealing concrete, repair cracks exceeding 1/16" wide. The owner is responsible for crack repair.

Glossary and Standard Reference

Admixtures - a material other than water, aggregates, cementitious materials, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing.

Air entrainment - the incorporation of air in the form of microscopic bubbles (typically smaller than 1 mm [0.04 in.]) during the mixing of either concrete or mortar.

Bull Float –a tool comprising a large, flat, rectangular piece of wood, aluminum, or magnesium usually 8 in. (200 mm) wide and 42 to 60 in. (1 to 1.50 m) long, and a handle 4 to 16 ft (1 to 5 m) in length used to smooth unformed surfaces of freshly placed concrete.

Curing - action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur so that the potential properties of the mixture may develop.

De-icing Chemicals - a chemical, such as sodium or calcium chloride, used to melt ice or snow on slabs and pavements; such melting being due to depression of the freezing point.

Dowel Bars - a steel pin, commonly a plain or coated round steel bar that extends into adjoining portions of a concrete construction, as at an expansion or contraction joint in a pavement slab, so as to transfer shear loads; (2) a deformed reinforcing bar intended to transmit tension, compression, or shear through a construction joint.

Early-entry Dry-cut saw - a tool designed to cut joints in concrete commencing 1 to 4 hours after finishing and without raveling the cut edges.

ACI – American Concrete Institute

- 308: Guide to Curing Concrete
- 318: Building Code Requirements for Structural Concrete and Commentary
- 332: Residential Code Requirements for Structural Concrete and Commentary

ASTM - American Society for Testing and Materials

- C33: Standard Specification for Concrete Aggregates
- C94: Standard Specification for Ready-Mixed Concrete
- C150: Standard Specification for Portland Cement
- C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- C595: Standard Specification for Blended Hydraulic Cements
- C1157: Standard Performance Specification for Hydraulic Cement
- C1315: Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

**All definitions referenced from the Manual of Concrete Practice 2017, Index with ACI Concrete Terminology.*

Exterior Concrete Flatwork Construction
and Maintenance Best Practices
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Colorado Ready Mixed Concrete Association
6880 S. Yosemite Ct., Ste. 100, Centennial, CO 80112
303-290-0303 · crmca.org