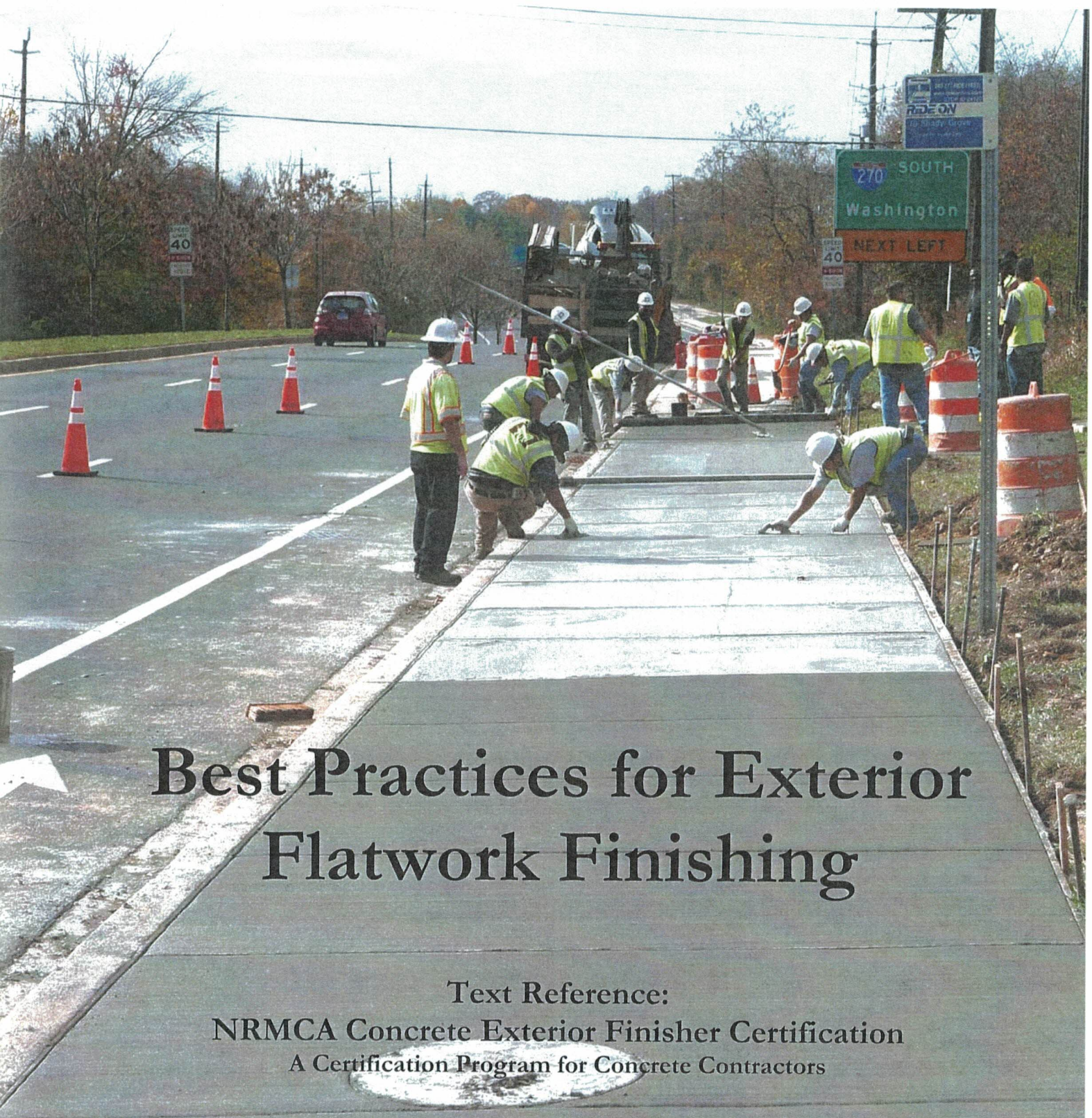


Best Practices for Exterior Flatwork Finishing

Text Reference:
NRMCA Concrete Exterior Finisher Certification
A Certification Program for Concrete Contractors

NRMCA

www.nrmca.org

Henry B. Prenger, P.E.

NATIONAL READY MIXED CONCRETE ASSOCIATION

Best Practices for Exterior Flatwork Finishing

TEXT REFERENCE FOR

NRMCA Concrete Exterior Flatwork Finisher Certification

This text has been developed to cover the basics of installation and care of exterior concrete flatwork that will be exposed to freezing temperatures and application of deicing chemicals. The purpose is inform concrete contractor personnel of accepted industry practice and to minimize the occurrence of scaling and other durability-related problems.

This text is used as the content for the above-mentioned certification exam.

Text and Images by
Henry B. Prenger, P.E.

NRMCA

National Ready Mixed Concrete Association
900 Spring Street, Silver Spring, MD 20910
Phone 301.587.1400 • Fax 301.585.4219
www.nrmca.org

Slump

Slump is an important measurement of the ability to place and finish concrete (image shows low, medium, and high slump).

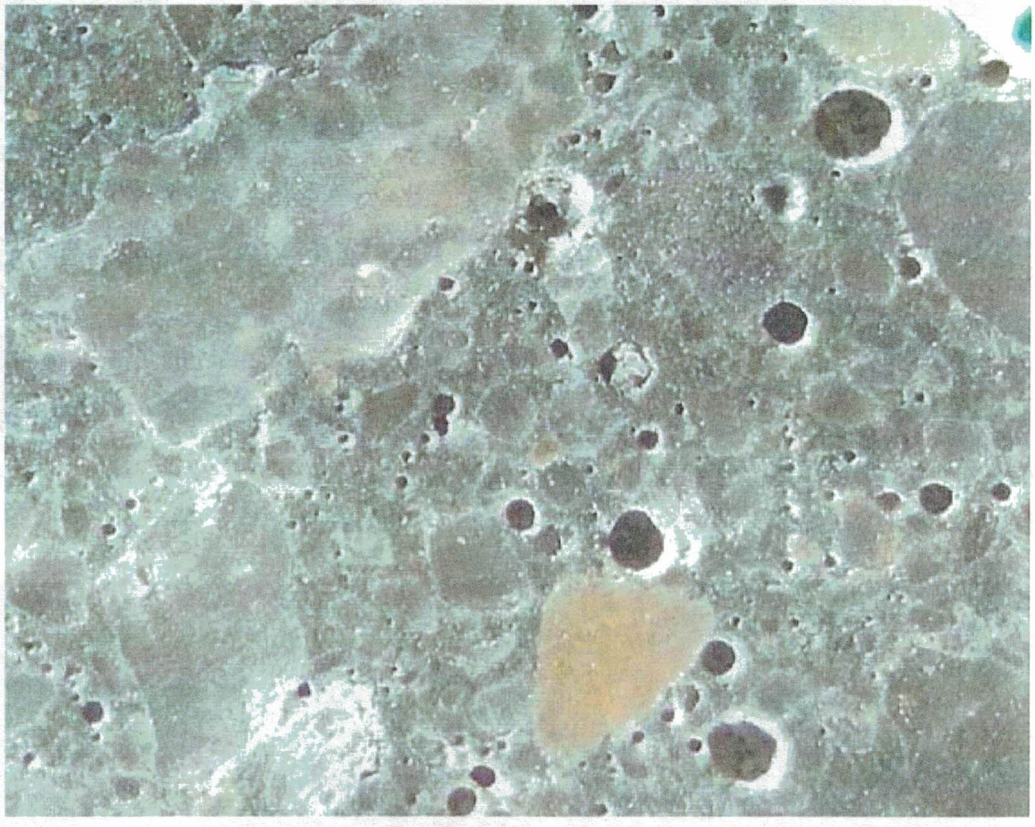
Concrete with very low slump is hard to finish and it can be difficult to close the surface of the concrete.

Properly proportioned concrete with a slump around 3 to 5 inches is relatively easy to place and finish. The mixture holds together well.

Slump that exceeds 5 inches may be easier to place but should never be used for slabs unless the slump is achieved using a high range water reducer. High slump concrete without high range water reducers can have excessive and prolonged bleeding, a tendency to segregate (separation of paste and stone), lower strengths, longer set times, and a higher likelihood for scaling.

Air Entrainment

When water freezes, the ice takes up more volume than the original water. We've all experienced this by leaving a bottle of water in the freezer and having the bottle burst as the water expands as it freezes.



Water in concrete also expands as it freezes. Small air bubbles are entrained in concrete to provide space for the freezing water to expand into. It is extremely important for the freeze-thaw durability and for the scaling resistance of the concrete that there is the right amount of air throughout the concrete. When finishing and curing concrete, care needs to be taken to ensure that the entrained air is not removed from the surface where it is most needed to minimize scaling.

Acceptance of Concrete at the Jobsite

When the concrete truck mixer arrives on the jobsite, the inspector should check to make sure that:

1. It is the correct mix for the project
2. The water to cementitious ratio has not been exceeded. (Do not add water in excess of what the producer holds back at the plant)
3. The truck is still within the maximum allowable time period from the time it was loaded. Generally, this time period is 90 minutes unless special precautions are taken to extend the time. This time limit can be waived if the slump is adequate without needing excess water.

Unless otherwise specified, tests should be performed on the first truck and every 50 yd^3 (or every 5 loads) after that to ensure the concrete meets the requirements for temperature, air content and slump.

Concrete strength specimens can be made from samples from some trucks – generally one every 150 yd^3. These samples should also be tested for air content and slump. Care needs to be taken to make sure cylinders are maintained at the proper temperature and do not dry out during the initial curing period at the jobsite before they are transported to the lab. A good way to initially store cylinders, especially in remote locations where it is difficult to cure cylinders properly, is to place them in a 5-gallon bucket of water and to use curing boxes that can maintain the required temperature.

Placing and Finishing Concrete

Preparation

Before the pour, check the weather forecast for the possibility of wind, rain, snow, freezing or high temperatures, or other adverse conditions. Make sure to have measures to protect against precipitation, wind, or if freezing temperatures are expected. **Do not place concrete in freezing temperatures.**

Excavate the area for the placement and set forms such that the concrete slab will be of uniform thickness. For ramps and slopes, excavate so that the slab thickness will not vary. Before placing concrete, make sure of the following:

- the base or subgrade has been adequately and uniformly compacted,
- any unsuitable material has been removed from the subgrade and replaced with compactable material,
- grades have been established,
- forms are secure, straight and level,
- joint locations have been marked,

- expansion joint material is placed or is ready to be inserted,
- any required reinforcement has been placed,
- there are enough proper finishing tools, and
- there is curing compound and a working means of applying it.

Avoid placing concrete on vapor barriers (or retarders). Moisten the subgrade if it is dry without leaving any standing water. **Never place concrete on a frozen subgrade.**

Placing and Screeding

Place concrete in the forms as close to the final location as possible to avoid moving it too much after placement. If pumping, ensure the diameter of the hose is adequate and do not allow concrete to free-fall a long distance. Use flat-headed rakes and shovels to move the concrete. Move screed over top of forms in sawing action. Use screeds that are flat and free of bows or twists to bring concrete level to the surface of the forms.

Vibratory Screeds and Internal Vibration

Care should be taken when using vibratory screeds. The screed needs to be kept moving continuously to avoid over-vibrating any section. **Vibratory screeds should not be used with concrete that has slump over 3 inches (as in the example above)**. Over vibrating concrete will cause segregation of the aggregate and paste, will bring too much paste to the surface, can disrupt the air void system, and can result in durability problems.

If internal vibrators are used, they should be inserted and removed vertically. Vibrators should never be dragged across or through the concrete. Care should be taken not to over vibrate the concrete.

After initial screeding or strike-off, the concrete surface is usually open with exposed coarse aggregate particles.

Floating the concrete with a bull float pushes coarse aggregate below the surface and fills in low spots or depressions. Use magnesium floats. Keep floats as flat as possible when passing it over the concrete to avoid pressure that may seal and close the surface.

After floating, the voids in the concrete should be filled in and the surface should be relatively smooth.

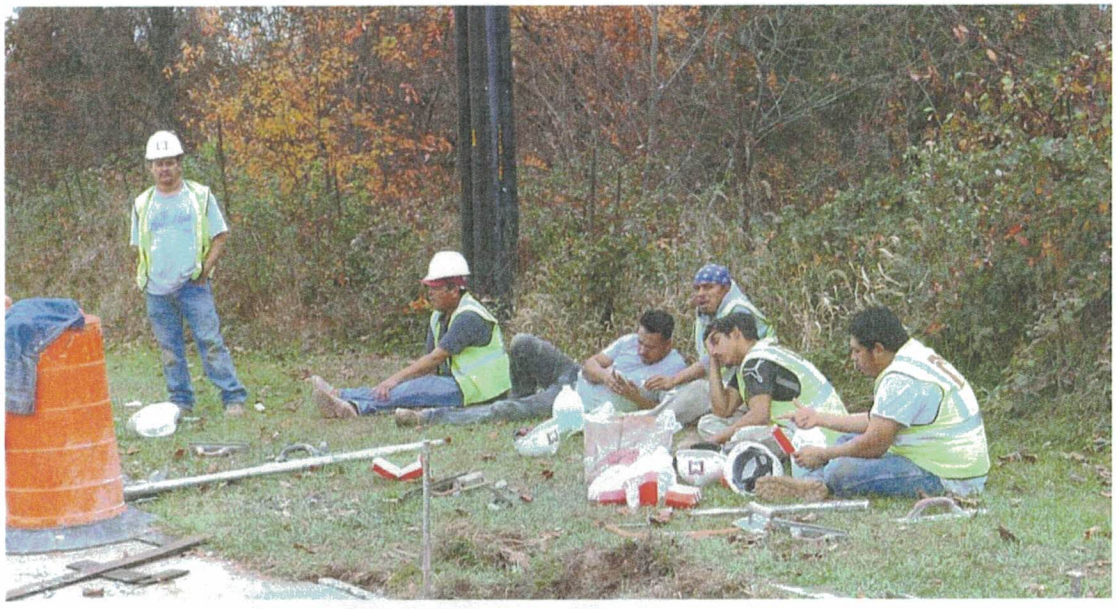
Do not use water (blessing the concrete) as an aid to floating the concrete!!!

Any water added to the surface of the concrete will dramatically affect the strength of the top surface of the concrete and could decrease the air content at the surface of the slab. **It will increase the possibility that the concrete surface will scale!!!**

*Some of the tools you **should not** use – a brush for blessing concrete, a rake for moving concrete, and a steel trowel.*

Use square edged shovels or come-alongs to move concrete in the forms.

Consolidate concrete along the form edges to avoid honeycombing.



After floating the concrete, take a rest and don't touch the concrete until the bleed water stops coming to the top and the concrete has begun to set.

The basic chemical reaction that causes concrete to harden and gain strength occurs between cement and water in the concrete. Only a small amount of water is needed for this reaction to occur. When concrete is produced, extra water is used to make the concrete flowable and placeable. After concrete is placed in the forms, the heavy particles in the concrete move toward the bottom and the extra water is forced to the top. This water is called bleed water. Never finish bleed water into the surface of the concrete. It will dramatically affect the strength of the top surface of the concrete and will decrease the air content in the surface of the concrete. **It will make the concrete more likely to scale!!!**

After floating the concrete, take a rest and don't touch the concrete until the bleed water stops coming to the top and the concrete has begun to set.

The basic chemical reaction that causes concrete to harden and gain strength occurs between cement and water in the concrete. Only a small amount of water is needed for this reaction to occur. When concrete is produced, extra water is used to make the concrete flowable and placeable. After concrete is placed in the forms, the heavy particles in the concrete move toward the bottom and the extra water is forced to the top. This water is called bleed water. Never finish bleed water into the surface of the concrete. It will dramatically affect the strength of the top surface of the concrete and will decrease the air content in the surface of the concrete. **It will make the concrete more likely to scale!!!**

Sometimes, it is very easy to see the bleed water on the surface of the concrete. On some types of concrete, however, the rate of bleeding is slower and bleed water may not be visible on the surface.

On dry and/or windy days, the bleed water evaporates very fast and it can be difficult to determine when the concrete has stopped bleeding. On dry days, evaporation retarders should be sprayed on top of the concrete to protect it from drying until it starts to set. Evaporation retarders should not be finished into the surface of the concrete.

When you are unsure about whether the concrete has stopped bleeding and is ready for final finishing operations, you can test the concrete by checking the pressure that it takes to press your thumb into the surface. If your thumb easily penetrates the concrete and if wet mortar adheres to your thumb when you pull it out, the concrete has not set sufficiently to begin finishing operations.

Still plastic and bleeding.

Ready for final finishing operations – thumb makes an easy impression in the concrete about a half an inch.

If concrete is beginning to set and there is still bleed water on the surface, use a hose drag or squeegee to remove water from the surface before starting final finishing operations.

Too late – concrete has set where final finishing will be extremely difficult

Once concrete has started to set, there is a very short window to perform final finishing operations before the concrete has set up to a degree that it can no longer be manipulated.

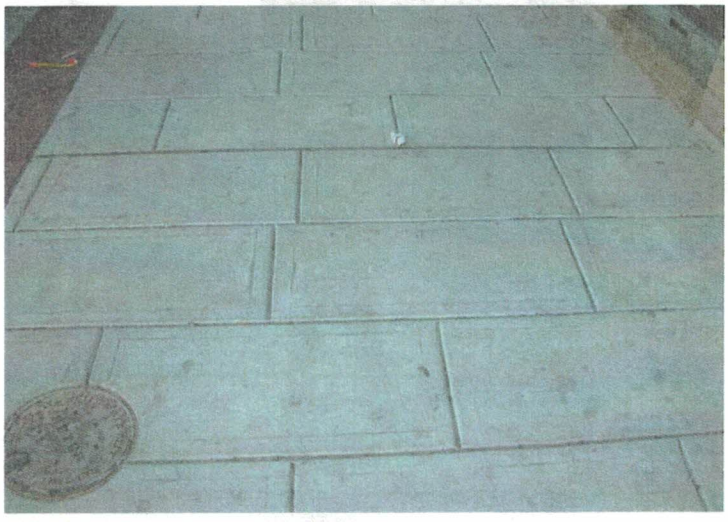
Do not add water to the concrete during final finishing operations (blessing the concrete). It will dramatically affect the strength of the top surface of the concrete and could decrease the air in the surface of the concrete. **It will make the concrete more likely to scale!!!**

Check to make sure the surface of the concrete is flat. Fill in any low spots and cut any high spots.

Carefully lay out the where the joints will go in the concrete.

Tool joints into the concrete before it has set. (Alternatively, saw cut joints after concrete has hardened.) At this point, also perform edging operations to separate the slab from the forms and produce rounded corners that will not break off.

Use magnesium floats. Avoid using a steel trowel if possible. Excessive use of steel trowels will work the air out of the surface of the concrete and make it more susceptible to scaling. It can also trap bleed water under the concrete surface skin causing delaminations. It is not necessary to get an extremely smooth surface on exterior slabs.



Avoid if possible any intricate finishing operation that requires an excessive amount of hand finishing. **Excessive hand finishing works the air out of the surface of the concrete and will make the concrete more likely to scale!**

Make sure there are enough workers on site to finish in a timely fashion. Concrete set times vary depending on a number of factors, including:

1. Brand of cement
2. Whether fly ash or slag cement is being used (both increase set times)
3. The ambient and concrete temperatures (Higher temperatures make the concrete set faster)
4. What types of admixtures were used (retarders, accelerators, etc.)

After final finishing operations, a broom finish can be applied.

Ideally, when applying the broom finish, very little mortar will adhere to the broom. If mortar does build up on the broom, you can clean it with water but excess water needs to be scraped off or shaken off the broom before any further brooming of the surface.

Do not use the broom to work more water into the concrete. It will dramatically affect the strength of the top surface of the concrete and could decrease the air in the surface of the concrete. **It will make the concrete more likely to scale!!!**

If the broom digs too deep into the mortar, brooming has begun too early. Wait for a period to allow concrete to set. The broom should leave a lighter texture on the concrete.

Joints

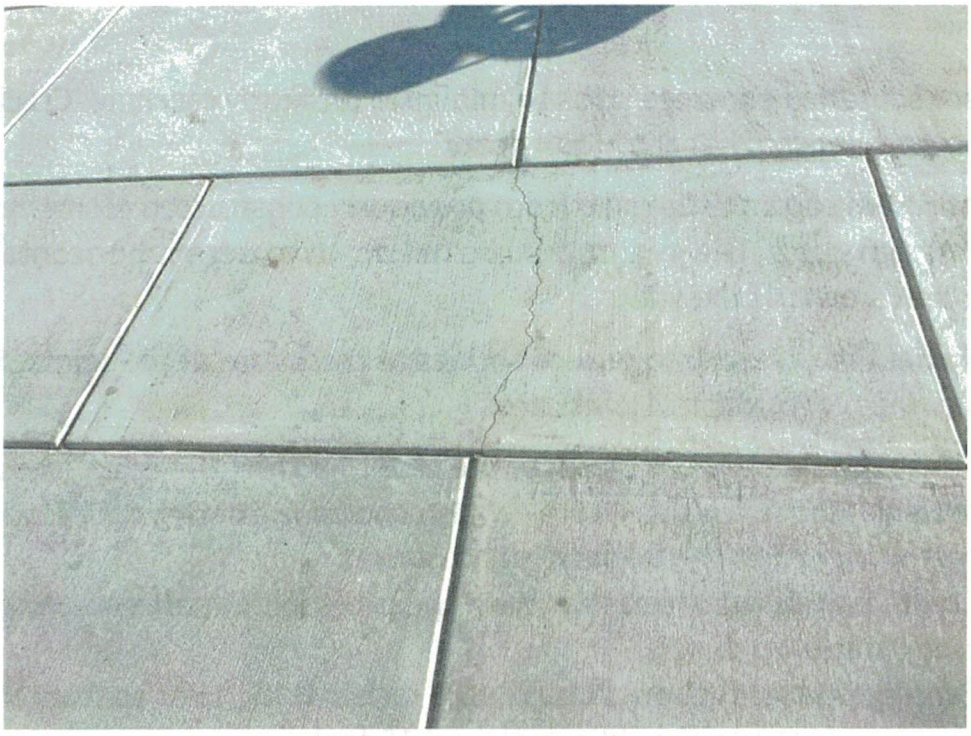
Joints are scored in concrete slabs to minimize unsightly cracking. Cracks should occur at the joints so that they look neat.

Isolation joints separate the slab from previously constructed elements such as curbs and sign posts. The joint should be full depth to permit horizontal and vertical movement of the slab.

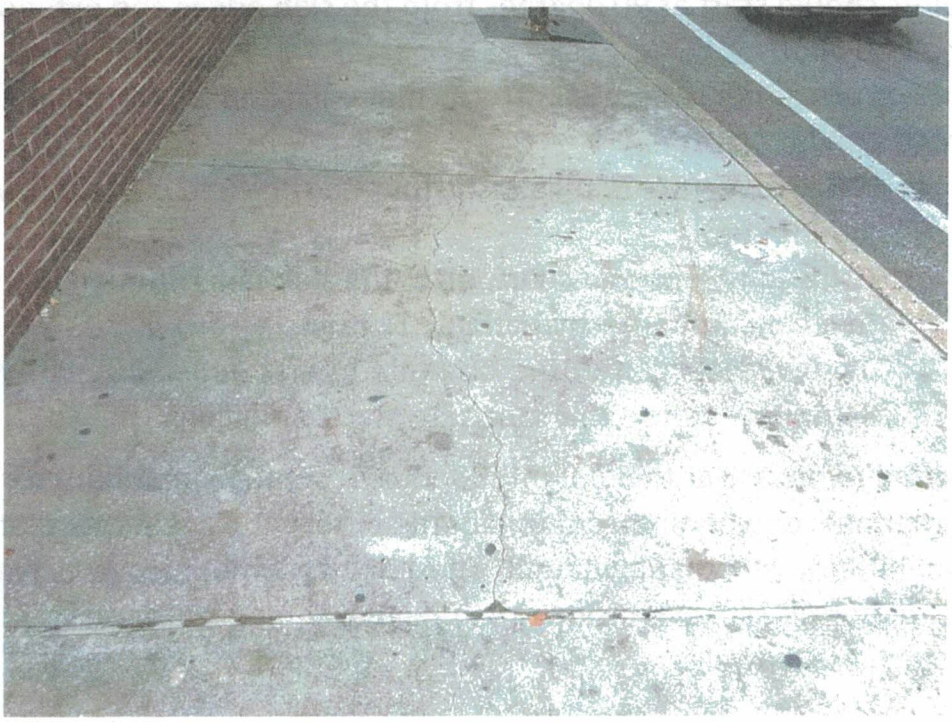
Control joints are created to ensure shrinkage cracks are at the joints. Some of the basic rules of for control joints are:

1) Joints should be ¼ the depth of the slab to attract the crack (most jointing tools do not cut to this depth – when choosing jointing tools, look for those that will provide the deepest cut possible).
2) Create panels that are as square as possible (unjointed slabs will naturally crack in square panels).
3) For larger slabs that are about 4 to 6 inches thick, joint spacing should be about 10 feet and should not exceed 15 feet.
4) For slabs of width less than 10 feet that are 4 to 6 inches thick, joint spacing should be limited to the width of the slab.
5) Joints should start at 90 degrees from the slab edges and extend through the slab width.
6) Do not use joints to create patterns that will result in cracking.
7) Joints can be placed:
    a. While concrete is still plastic (but has finished bleeding) with a jointing tool
    b. Using early entry saw cuts after the slab has stiffened but will not ravel and not later than about 12 hours
    c. By saw cutting after the concrete has hardened but within about 24-36 hours – before the concrete starts shrinking.

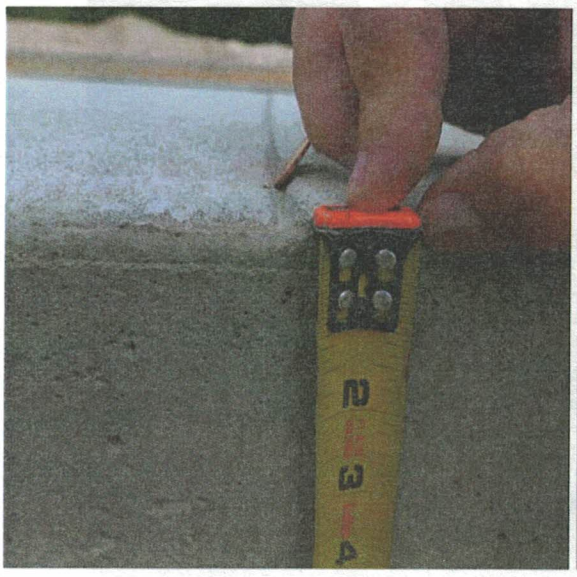
Construction joints are at the end of the pour to create a neat joint for the next pour. Sometimes dowels are used to join the different placements that permit horizontal but not vertical movement. These joints sometimes have expansion materials to permit slab expansion due to higher temperature on long stretches of slabs, such as sidewalks.



Contraction joints should continue uninterrupted across the slab. Once a crack begins to propagate, it will continue even if the joint stops.



Smaller joint spacing helps prevent mid-slab cracking. Always try to make slab panels as square as possible.



Shallow joints will not propagate cracks in the joint

Look for jointing tools that have the deepest depth possible

When possible, joints should be initiated from corners of fixed items embedded in the concrete.

Expansion joint material being placed to separate the slab from the curb.

Curing Concrete

Curing is the essential step of ensuring the newly placed concrete is maintained with adequate moisture and temperature for the concrete to gain strength and durability. Curing can be by retaining water within the concrete – using curing compounds; or by providing additional water – using damp burlap or water sprays.

If curing is not done, all the good work performed with finishing will be lost and the slab will not achieve the strength and durability it was designed to achieve. It is very important that curing is begun as soon as the finishing is completed. For water curing – wet burlap, water sprinkling, covering with plastic – should be started after the concrete has hardened sufficiently so that it is not marred by the curing method. Curing compound can be sprayed immediately after finishing as long as there is no bleed water on the surface.

Immediately after brooming the concrete, apply a white pigmented curing compound. Use a rate of application specified by the manufacturer of the curing compound. Make sure to completely cover the surface of the concrete. It is recommended to spray in two directions to ensure complete and uniform coverage. Do not finish concrete after curing compound has been applied.

Like this – an even coverage.

Not like this.

A breathable sealer is a good recommendation to protect the concrete from the damage that can occur due to the application of deicing salts. The sealer creates a protective barrier to minimize penetration of water that can cause saturation and from the effects of deicing salts. The sealer should be applied after the concrete slab has dried out and preferably before winter. Silane and siloxane-based sealants work well and performance of commercial products will vary. Generally, sealants with solids contents on the order of 25% will give you the quality protection needed. Manufacturer's directions should be followed.

ITEM	PERFORMANCE ITEMS	PASS (P) OR FAIL (F)	
		1st Try	2nd Try
1	Did the examinee have the appropriate tools available for the placement. The following is a suggested list of needed tools • Screeds • Bull Floats • Square nose shovels or come-alongs • Hand floats • String lines • Brooms • Curing Compound or alternate curing products If alternative equipment or products were used, it is the examiner's discretion to ensure that they would be acceptable for a successful placement		
2	Did the examinee have the proper personal protective equipment needed for placing concrete. The following is a suggested list • Hard hat • Safety glasses • Chemical resistant safety gloves • Long pants It is the examiner's discretion to ensure that the examinee was following safe practices for placing concrete		
3	Did examinee verify adequacy of the subgrade before placement of concrete? • Compaction • Free of all foreign matter • Uniformity of subgrade surface • Moistened but with no standing water		
4	Did examinee know to check concrete batch ticket to ensure it was the correct mixture for the project and to determine the amount of water that can be added?		
5	Did examinee know that concrete should be tested for air, slump, and temperature before placing?		
6	Was discharge, spreading, and strike-off completed in a rapid and consistent manner?		
7	Was the operation of the bull float done in a manner that would not compromise the durability of the finished surface?		
8	Did examinee wait until all bleed water had dissipated and concrete had begun to set before starting final finishing operations?		
9	Did finisher use a magnesium float to perform final finishing operations?		
10	Were the joint locations marked on the forms? Were contraction joints spaced properly and where they tooled completely across the slab?		
11	If required, were isolation joints placed in the proper location and to the proper depth?		

ITEM	PERFORMANCE ITEMS	PASS (P) OR FAIL (F)	
		1st Try	2nd Try
12	Did examinee provide a well formed edge to the concrete and did they form it at the proper time?		
13	Did examinee broom the concrete at the proper time?		
14	Did examinee cure the concrete properly, with complete coverage in two passes at 90 degrees to each other?		
15	Did examinee add water to the surface of the concrete at any time in the process?		

OVERALL GRADE ON PERFORMANCE EVALUATION

☐ **PASS** ☐ **FAIL**