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# Basics of Construction Inspection Concrete



Thanks Holli and welcome everyone. Thanks for taking the time out of your schedule to view today's webinar on the basics of construction inspection – concrete.

Several of the past webinars we've done have focused on NRCS project work using our NEH Part 642 specifications.

A lot of attendees are not working with these comprehensive specifications. We decided to do a short webinar on concrete inspection and focus on more general information and what can you do on your project that will have the biggest impact on getting a quality concrete product. What really needs to be looked at. Obviously we can't cover everything but we will try to hit the most important topics quickly today. We like to think of it as what is the least you need to know to give you the best chance of having a quality concrete structure.



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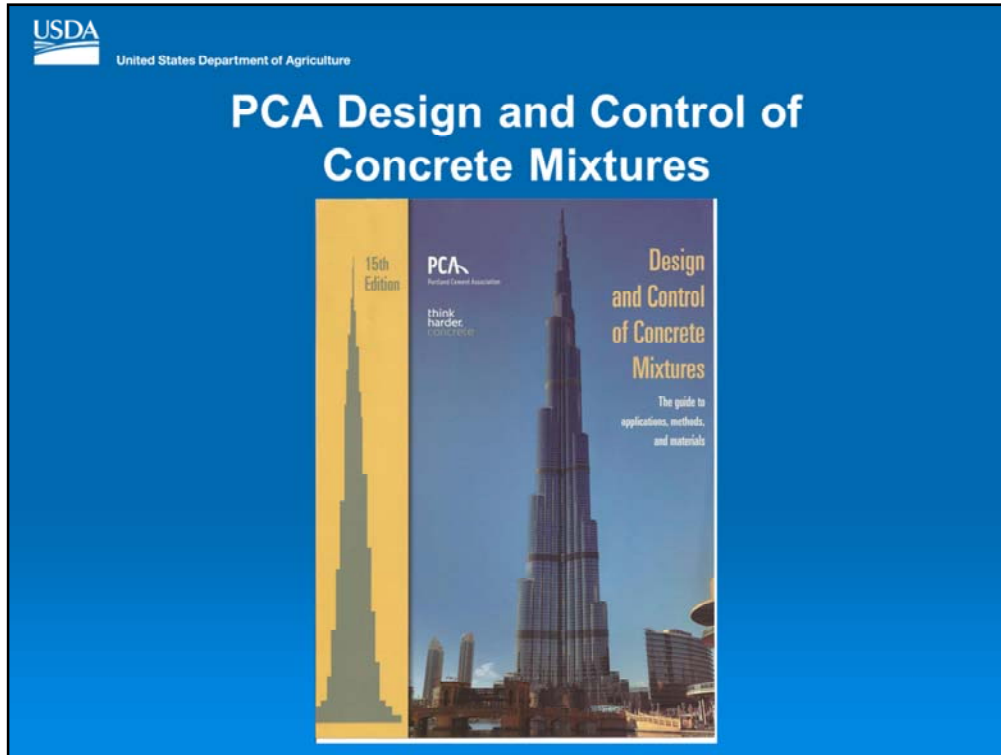
## Part 645 Construction Inspection National Engineering Handbook

### Chapter 12 Concrete

### NEH 645 CL 12.1 Concrete Checklist

2. Forms				
2.1	Forms appear to be of good quality.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2	Forms are mortar-tight.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3	Form surfaces (sheathing) are smooth and free of irregularities.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

A lot of the information for this presentation was taken from NRCS Part 645 Chapter 12 – Concrete and the associated checklist in Appendix A.



Another great resource for anyone doing concrete work is PCA's Design and Control of Concrete Mixtures. If you are an NRCS employee, contact your State Conservation Engineer as we have several copies of this publication available for employees at this time.



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## Topics

1. The Concrete Mix
2. Forms
3. Steel Reinforcement
4. Transporting Concrete
5. Placing Concrete
6. Form Removal
7. Finishing Unformed Surfaces
8. Finishing Formed Surfaces
9. Curing

Don't Panic! We are going to touch on these 9 topics in this webinar but just briefly on each. These range from the design mixture that you will be using to final curing of the structure.



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## Basics of Construction Inspection Concrete



NRCS employees serve as quality assurance inspectors. That means we are there to verify and document specification compliance. We can't direct the contractor's work, but we should be proactive whenever we suspect the contractor will install something that is unacceptable and that will be expensive to remove and replace.



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## Concrete Mix



- Is it the specified/approved mix?
- Does it look good?
- If applicable, does it have entrained air?
- Is it too hot?
- Is the w/c below the maximum allowed?

As NRCS employees we don't turn down a concrete mix. We are there to verify that the owner is getting the desired product. These are some of the items we look for when the mix arrives on the job. If your not getting quality concrete delivered to the job, it might be prudent to talk to your local concrete supplier(s). If they are aware of your concerns, they can probably address those concerns.

# Concrete Mix

- Is it the specific/approved mix?
  - Same mix number?
  - Proportioned the same?
  - Contains additives?

TRUCK	USER LOGIN	DISP TICKET NUM	TICKET NUM	TICKET ID	TIME	DATE
402	DEA	219531	219517	43201	09:18	11/09/2011
LOAD SIZE	HTY CODE					
16.50 YD	01440					
MATERIAL	DESIGN QTY	REQUIRED	BATCHED	VAR	% VAR	MOISTURE ACTUAL WGT
AGG LG 1	1232 lb	13566 lb	13540	-26	-1.9%	
AG LG 3/8	284 lb	2902 lb	3000	10	0.60%	
SAND -3/16	1437 lb	15718 lb	15640	-78	-0.50%	4.18 A 75.10 g/l
ST MARMS 1	360 lb	3780 lb	3785	5	0.13%	
FLY DIR C	85 lb	892 lb	920	28	3.14%	
CEMENT SA	115 lb	1208 lb	1295	87	7.20%	
WATER	73.00 g/l	0.00 g/l	0.00	0.00	0.00%	
WATER 2	100.00 %	4255.19 g/l	267.00	1.51	0.57%	667.00 g/l
OXIN A260	0.50 %	35.20 oz	35.00	-20	-0.79%	
OXIN 900R	0.50 %	29.40 oz	30.00	0.60	2.04%	
OXIN 8FLUX	4.00 %	4235.20 oz	232.00	-3.20	-1.36%	
CALCIUM	0.75 %	41411.2 oz	1408.0	-3.20	-0.23%	
HOT	0.00 g/l	0.00 g/l	0.00	0.00	0.00%	
NON-STABILIZED	NUM BATCHES: 1					
DESIGN WATER:	346.5 g/l	ACTUAL WATER:	342.1 g/l			

The batch ticket should include what is commonly referred to as the mix design number. This mix design number must align with the approved mix if a mix design was submitted and approved. Otherwise, look for something that identifies the mix as one that meets the specified strength and contains the specified amount of air.

## Concrete Mix

- Does it look good?
  - Slump within specified range?
  - Uniform without segregation?
  - Dark gray color?



Slump is an indication of mix consistency and workability. If a slump range was specified, the contractor should check it before the concrete is placed. Concrete with a high slump, such as the one in the bottom right corner, indicates a high water content, a superplasticizing admixture was used, or both. Slump that is too low like the one in the top right corner indicates a mix that may be difficult to place, consolidate, and finish.

The concrete in the bottom left corner is flowable concrete that gets its flowable consistency from special mix proportioning and a superplasticizer. I included this photo to show how high slump concrete can be placed with minimal segregation.

The concrete is white in the photo that shows broken pieces of concrete. This concrete had to have a white ashy look when it was discharged from the concrete truck. The white ashy color is a sign that most of the cement hydration occurred while mixing. This concrete did spend too much time mixing which resulted in poor strength and an almost certain poor durability. In contrast, a good mix will have a dark gray color like in the two slump photos on the right side of the page.

## Concrete Mix

### ➤ If applicable, does it have entrained air?

- Chace meter
- Other tests
  - [ASTM C231/C231M-17 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method](#)
  - [ASTM C173/C173M-16 Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method](#)



Air entrainment is common in colder climates because it helps guard against freeze/thaw damage. It also improves workability and reduces permeability, so it is also used in warmer climates. It doesn't increase the compressive strength, it actually decreases it but it is used because of the other beneficial qualities. The air entraining additive is added at the batch plant and dissipates over time, especially in hot weather. In hot weather the mix may leave the plant with 5% entrained air and 30 minutes later only have 2% air.

Someone at the jobsite should test to determine the air content before the concrete is discharged from the truck. Additional air entraining additive can be added at the jobsite if the air content is not within the specified range. The inexpensive glass vial and stopper device shown here is called a Chace meter and is used for measuring air content. It is not an ASTM test, but is a good indicator of air content. It only takes a small amount of cement paste and a little isopropyl alcohol to get a pretty good read on the air content of the mix.

The ASTM tests for air must be made on concrete from near the middle of the load; by the time you make these tests a good portion of the concrete will have already been placed. So the Chace meter is a good tool that we can use to see if the concrete contains entrained air. If not, notify the contractor to take whatever action he/she deems necessary to ensure the concrete complies with the specification for

air content. The contractor may want to test the concrete to confirm the lack of air before asking the supplier to add air-entrainment or before rejecting the load. These actions are the sole responsibility of the contractor.

## Concrete Mix

### ➤ Is it too hot?



It is easy to check the concrete temperature. This should be done before the concrete is discharged from the truck. Specifications require the concrete mix be within a specified temperature range. Too cool and the concrete will not set up, too hot and it will be of poor quality.

## Concrete Mix

➤ Is the w/c below the maximum allowed?

$$\frac{w}{c} = \frac{\text{water (lb)}}{\text{cement (lb)}}$$

- *water (lb) = add water (lb) + aggregate free water (lb)*
- *cement (lb) = portland cement (lb) + SCM (lb)*
- *SCM – supplementary cementitious material such as fly ash or silica fume*

This is a critical inspection item. Quality concrete cannot be made if it has a high w/c. The w/c is generally specified to be no higher than 0.5, but may be specified to be even less for projects that require high quality durable concrete.

The weight of water in the numerator is the water added at the plant plus the aggregate free water. If water is added on site, it must be included. The weight of cement in the denominator includes the weight of portland cement plus the weight of any SCM in the mix such as fly ash or silica fume. The inspector needs to understand the mix proportioning information on the batch ticket in order to compute the w/c. We must verify that the w/c does not exceed the maximum allowed by the specification.

## Forms

- Are they of good quality?
- Are they appropriately braced?
- Are they in the correct location and the correct size?



Why look at the forms? For most of our work, we're looking at the finished product so what do we care about the forms we use?

Let's think about an example. The contractor is building a concrete retaining wall that will be visible (something like what you see in this picture). The contractor doesn't install enough braces and the forms bulge in a couple of areas. Are we going to get the contractor to completely replace the wall? Probably not without a big fight. The contractor is going to argue that it still meets the needs, it's just a little thicker in that area.

We've seen this many times in construction. We could probably fight to have something replaced but that's going to hold up everything so we agree to let it stay. We wind up accepting a substandard product.

A little extra attention to the forms might help with this? But what can you do in a situation like this? Maybe just a statement like "I don't think you have enough bracing to hold the forms in place. If they don't hold true then I am not going to accept this and you're going to replace it completely. I'm going to document this conversation."

This same thing can be said of a lot of the topics today. We may not have the iron clad specification to back up all that we all of the things that we're going to talk about today but there are ways to put pressure on the contractor to do what's right even without that.

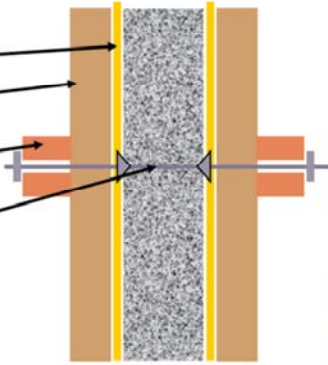
\* Are they of good quality? Is the contractor using new material or scabbed together pieces with a lot of seams and holes. If so, it's going to take a lot of finish work after the forms are pulled to make the surface presentable.

\* Are they properly braced? Are they going to hold when the concrete is placed and vibrated? Discussed above – look at the picture – this one looks pretty good doesn't it?

- Are they in the correct location and the correct size? Have a tape measure ready to take your own measurements. Even the best contractor can make mistakes by not reading the plans right. Walls not the correct size or not in the correct location, slabs not the appropriate thickness..... It's easier to fix this if you're checking the forms than the completed concrete.

## Components of Vertical Forms

- *Sheathing*
- *Studs*
- *Wales*
- *Tie rods or bolts.*



There are construction terms for horizontal and vertical forms. Knowing these will help give you some credibility with the contractor. I'm only going to show the vertical forms because little of our work involves horizontal forms because we build on the ground.

The sheathing is the first layer which is in contact with the concrete. We usually see plywood used as sheathing.

Studs support the sheathing. They are spaced close enough to prevent deformation or bulging of the sheathing. 2x4's are commonly used for studs.

Wales support the studs. They are spaced so that they prevent deformation of the studs. Wales can be of different materials. We see doubled 2x4's commonly used.

Tie Rods hold everything together and have spacers to allow the proper wall thickness. They are held by some type of locking device. Bolts are not commonly seen for this type of work.



What do you think about this wall?

Sheathing is plywood and it looks pretty new.

Studs are single 2x4's. They're spaced a little farther apart than I'd expect but probably OK.

Wales are double 2x4's and look pretty good.

Ties are held in place by the metal wedges you see.

Overall it looks pretty good and I'd have confidence that this contractor probably knows what they're doing.



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## Steel Reinforcement

- Is it of the correct size and grade?
- Is it kept clean of mud and form release agent?
- Is it correctly spaced?
- Is there correct clearance from forms or earth?
- Is it secured to prevent movement during concrete placement?

When checking the forms, you're also going to be looking at the steel reinforcement.

- Is it of the correct size and grade? If it is coming from a fabricator, like bars will be bundled and tagged. You can check the tag for the size and grade. If it is purchased and bent locally, you're going to have to read the markings on the bar.
- Is it kept clean of mud and form release oil? When delivered, the steel should be kept off of the ground but that won't always be the case. It needs to be cleaned before placing in the forms. Form release oil is applied to the sheathing to keep it from adhering to the concrete. It should always be applied in such a manner that it does not coat the reinforcement steel.
- Is it correctly spaced? You need your tape measure again. The exact spacing between bars (12" centers) is not critical, but it should be reasonable.
- Is there correct clearance from the forms or earth? This is critical. The steel needs to be the correct distance from the outside forms or the ground for structure on grade. 1.5" is the absolute minimum for forms, 2" is sometimes seen and 3" is usually seen in slabs on grade.



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## Steel Reinforcement



Here are some examples of steel delivered. You can see the tags and also you can see the bar marking on the bars on the left. Bar marks will show the size, grade and the mill.



This is a great example of terrible work. Note the bar spacing on the lower right. The outside bar is much less than 1.5" from the outside form and the inside bar is right in the middle of the wall where it will do no good. The inside bar on the lower left is almost touching the inside form.



There appears to be some segregation issues in this structure where we have a lot of aggregate and very little paste in this area but what I'm also noticing is that the reinforcement bar is very close to the surface. It's hard to see but there is a horizontal bar that is bent around the vertical bar in the picture.



This is a pretty good looking structure. The steel is evenly spaced and appears to be tied well.



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## Welded Wire Reinforcement



Welded wire is mostly found in thin slabs. If your design calls for welded wire (formerly wire mesh) reinforcement then what you're probably going to see is what's on the left. It's just laying on the ground. The contractor will tell you that his highly skilled concrete crew will use hooks to pull it all up into the correct position when the concrete is placed. Most of it is probably going to stay right where it is, on the bottom. Some may be pulled up to the middle of the slab. Probably the best location is just a little below the center of the slab. The one on the right has it elevated with chairs. They look a little far apart but at least it will be in the right location every 3 or 4 feet.

The good news is that the design engineer isn't counting on very much tensile strength out of the steel reinforcement or they would have designed it with reinforcement bars.

What about Fibers? I don't think they hurt anything, except making it hard to finish the surface. Someone smarter than me said to only use them when you don't need anything.



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## Conveying Concrete

- Does it arrive before it begins setting up?
- Can it be consolidated with an immersion vibrator?
- Has it segregated while being conveyed?



Not a lot we can say and most of it is out of your hand. You are usually just going to get what is delivered. You should be looking at the mix, the temperature and the time it has been in the truck.

- Does it arrive before it begins setting up? If the temperature is above 85 degrees, concrete can begin to set in 45 minutes. It can be up to 90 minutes in cooler weather. Continuing to agitate it after that time will reduce the strength.
- Can it be consolidated with an immersion vibrator? More on this later but if it leaves a hole when you remove the vibrator then it is no longer viable.
- Has it segregated while being conveyed? Usually caused by dropping it too high or agitating too much. If all of the aggregate segregates out of the paste you have a problem.



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## Placing Concrete

- Are bonding surfaces clean and prepared?
- Does the contractor have all of the necessary equipment and personnel to complete the placement and finishing?
- Does the concrete delivered meet the job mix?
- Is the concrete placed in a manner to prevent segregation?

- Are the bonding surfaces clean and prepared? Earth – is it compacted and moistened? Concrete – is it clean? Has any curing compound been removed thoroughly? Curing compound will act as a bond breaker?
- Does the contractor have all of the necessary equipment and personnel to complete the placement and finishing? Plenty of labor to do the work? Vibrator on site? Finishing equipment? Curing method?
- Does the concrete delivered meet the job mix? Usually just checking the delivery ticket. You may just be looking at the code on the ticket. Was that what was ordered. May need to check the added water. Has all of the water for the design mix been added?
- Is the concrete placed in a manner to prevent segregation? Is it dropped too high through a cage of steel? Is it placed appropriately.

## Unit Weight



Dennis will talk about indicator tests that are usually performed. One of the tests that we don't usually run is the density (unit weight) test. It's done by filling and vibrating a bucket of known volume and weighing the result. This test is the best indicator of compressive strength of the concrete. The other tests have their purpose but, unit weight is the only one that will give us a direct relationship with compressive strength.



We mentioned segregation earlier and this shows a typical example. The photo on the left shows this structure. It's approximately a 8 – 10 ft. pedestal. It appears that it was placed in one pour. If you drop concrete 10 ft. through a cage of steel this is the likely outcome. All of the large aggregate settles out together in the bottom without any paste.

For this reason, we commonly limit the fall height of conventional concrete to 5 feet. If super-plasticizer is used, you can increase that distance because it won't segregate as bad.



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## Consolidating Concrete

- Is all of the concrete consolidated appropriately?
- Is the vibrator being operated properly?

•Is all of the concrete consolidated appropriately? Unless you are using a really high slump/wet mix or self-consolidating concrete, you are going to have to use some method to consolidate the concrete to remove the entrapped air. For small jobs, you may be able to rod it out but for most jobs we see the use of an immersion vibrator.

•Is the vibrator being operated properly? Something very commonly seen is under vibration of concrete. You'll see them quickly jab the vibrator in and pull it out quickly. When you ask them about it, they'll usually say that you don't want to over-vibrate the concrete! We never see that. We never see concrete that has been over-vibrated, what we do see is concrete that is under-vibrated. It's usually the guy who built the forms that warns about over-vibration. The more you vibrate, the more pressure there is going to be on those forms. So, over-vibration is not commonly seen. They need to keep the vibrator inserted until large air bubbles quit appearing and then slowly remove it.

•There are some other suggestions on the next slide.

## Immersion Vibrator Notes

- Vibrator inserted and extracted vertically if possible.
- Vibrator fully immersed horizontally in thin slabs.
- Vibrator is not used to move concrete laterally.
- Large air bubbles cease appearing at the surface before vibrator is extracted.
- More problems with Under vibration than Over vibration.

•Vibrator inserted and extracted vertically if possible. Straight up and down is the best.

•Vibrator fully immersed horizontally in thin slabs.

•Vibrator is not used to move concrete laterally. This can cause segregation.

•Large air bubbles cease appearing at the surface before vibrator is extracted.

•More problems with Under vibration than Over vibration. Talked about on the previous slide.



Just a vibration picture.



Another vibration picture.



This is an impact basin side wall. Notice that the short pours look pretty good. As they get taller we see more problems with consolidation.

Notice about half way down on the tallest row of tie-hoes there is a seam going horizontal. That appears to be a cold joint where either the vibrator wasn't used to properly tie the two placements together or the lower layer set up before placement of the next layer. This was super-plasticized concrete which is probably why we don't see segregation.



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## Removal of Forms

- Are forms being removed too soon?
- Is the concrete being damaged?

Forms should be removed as soon as specifications allow so that any necessary repairs or surface treatments can be made while the concrete is still green and conditions are most favorable for a good bond if patching is required. But the concrete can be damaged if the forms are removed too soon. Forms must be removed carefully to avoid damaging the concrete.



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## Removal of Forms

- Forms not removed too soon
  - Supporting forms
  - Curing forms
  - Insulating forms

Supporting forms are those that must be left in place long enough for the concrete to gain sufficient strength to support itself and any surcharge. Generally, supporting forms for concrete that only has to support itself can be removed when the concrete attains 70 percent of its specified 28-day strength. But, the designer may specify the strength needed before form removal. Concrete compressive strength can be monitored by testing concrete specimens (cylinders) that are cured adjacent to and under the same conditions as the concrete in question.

As an alternative to testing the concrete strength, specifications may allow the forms to be removed at a specific time after the concrete has been placed. Since the concrete will not gain sufficient strength if the air next to it is less than or equal to 50°F, the amount of time that must pass before removing forms must be extended by one day for each day the air temperature is less than or equal to 50°F. NRCS Construction Specification 31, Concrete for Major Structures, provides accumulated form removal times for various types of concrete members.

There should be no measurable deflection or distortion of the concrete during the removal of supporting forms.

Forms can be used for initial curing, but they're not the best for curing, especially when it is hot and dry. Forms in arid climates should be kept wet and removed to

begin finishing and curing as soon as practical.

## Removal of Forms

- Concrete not damaged
  - Care is taken
  - Avoid thermal shock



In cold weather it may be necessary to keep the forms and protective coverings in place to help insulate the concrete.

There is potential for thermal shock when forms are removed during cold weather. This rapid cooling of the concrete surface can cause thermal cracking. It may be possible to loosen the forms to provide a thin space between the concrete surface and the form sheathing to avoid thermal shock. Maintaining this thin space for a few hours will allow the concrete to cool more slowly in an effort to avoid thermal shock.

Leaving the forms in place for a longer period will allow the concrete to gain strength and cool slowly, but, as mentioned earlier, wooden forms must be kept moist to prevent wicking moisture from the concrete.



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## Finishing Formed Surfaces

- Are there defects and tie holes to repair?
- How is the concrete line and grade?
- Must it be rubbed or coated?

There is work to be done after the forms are removed.

## Finishing Formed Surfaces

### ➤ Repair defects and tie holes

- Repair plan
- Prep bonding surfaces
- Use bonding agents
- Dry-pack mortar



The contractor should repair any defects and fill all form tie holes as soon as possible. A written repair plan is needed explaining what will be done and how it will be done. All form fins or burrs should be ground off and the surface finished as specified. The specification may require no further finishing.

If further finishing is specified, the specification will likely require the surface be rubbed with a carborandum stone or coated with a coating specially formulated for concrete.



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## Finishing Formed Surfaces

- Ensure line and grade
  - Check tolerances
  - Remove some concrete if necessary



The inspector should take a close look at the surface of formed concrete as soon as the forms are removed. Look for bulging concrete. Verify that the surface meets the specified tolerances for line and grade or meets industry tolerances when not specified. NEH 645, Appendix E, Construction Tolerances, contains typical industry construction tolerances including tolerances for concrete work..

Bulging concrete may have to be removed, especially if it adversely affects the hydraulics of a hydraulic structure or if it somehow weakens its structural integrity. Otherwise, it would only need to be removed as a matter of aesthetics. Removal can be done by sawing, chipping, or grinding but must be done in a manner that will not damage the structure.

## Finishing Formed Surfaces

- Rub or coat surface
  - Rubbing stone
  - Surface coating
    - Clean surface
    - Bonding agent
    - Follow manufacturer's directions
    - Pay attention to product expiration date



Be prepared to inspect the finishing process by knowing the plan for finishing and understanding the proper way to perform the planned finishing method.

Concrete that is finished by stone rubbing should be rubbed as soon as the forms are removed to remove fins, burrs, and other irregularities before concrete gains significant strength. Bug holes (seen here) may be filled with a sand-cement mortar that is applied during the rubbing process by troweling it on the surface just ahead of the stone rubbing. The contractor should not apply a thick mortar or paste on the surface in lieu of stone rubbing as thick coatings tend to debond or otherwise deteriorate.

Curing should begin soon after rubbing so that the sand-cement mortar and concrete doesn't dry out.

## Start to Finish



The tie holes were filled, burrs and fins rubbed off, and coating applied. The inspector should observe these operations, because you can also achieve a good looking job by applying a thick mortar coating to smooth out a rough surface, but the thick coating will eventually flake off.

## Finishing Flatwork

- Is the concrete to desired grade?
- Is it floated relatively level or planier?
- Is it properly troweled?
- Is it textured properly when required?
- Are contraction joints
  - Installed in a timely manner?
  - Properly located?
  - Properly spaced and at an adequate depth?

Finishing flatwork is a step-by-step process and timing for the various processes is critical.

## Finishing Flatwork

- Grade
  - Screed (Strikeoff)
  - Bullfloat or darby
  - Edge and joint



As seen here, the concrete is screeded as it is being placed. Then it is floated, edged, and jointed. All of these tasks are done before the concrete begins to bleed. The inspector should verify that these steps are done, done properly, and done before the bleed water comes to the surface.

# Bullfloating

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Bullfloating knocks down highs and fills lows in the concrete surface. It also helps to embed any exposed aggregate. The inspector must verify that bullfloating is only done before the bleed water begins accumulating on the surface.

# Darbying



Finishing Flatwork (v.0515)

Darbying does the same thing as a bullfloat but is done in tight places where a bullfloat cannot reach. Like bullfloating, it must be done early before the bleedwater comes to the surface.

## Edging

Edging densifies and compacts concrete next to forms where floating is less effective.




- ▶ Required along all edge forms, isolation and construction joints in floors and exterior slabs
- ▶ Cut concrete away from forms to a depth of 1 inch with a pointed mason or margin trowel
- ▶ Edging may be required after each subsequent finishing operation for interior slabs



Edging is done before the concrete bleeds and after each subsequent finishing operation. Edging removes sharp edges that are prone to chipping, compacts concrete at the edges to make it stronger and more durable, and gives the concrete a nicer looking finish.

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# Finishing Flatwork



- **Float and trowel**
  - Fiberglass
  - Wood
  - Magnesium must be used for air-entrained concrete



When the bleed-water sheen has evaporated and the concrete will sustain foot pressure with only slight indentation, the surface is ready for floating and final finishing operations.

Floating embeds aggregate and removes slight imperfections, humps, and voids. Power floating is common using walk-behind and ride-on equipment.

Unlike magnesium floats, fiberglass and wood floats tend to stick to and tear air-entrained concrete.

Troweling is the last finishing operation. It is not recommended for outdoor concrete as it causes the surface to be smooth and slippery when wet. The same blade used for floating is rotated to trowel the surface. The concrete must be hard so that no footprints are made in the surface.

# Finishing Flatwork

- Texturing
  - Brooming
  - Tining
  - Stamping

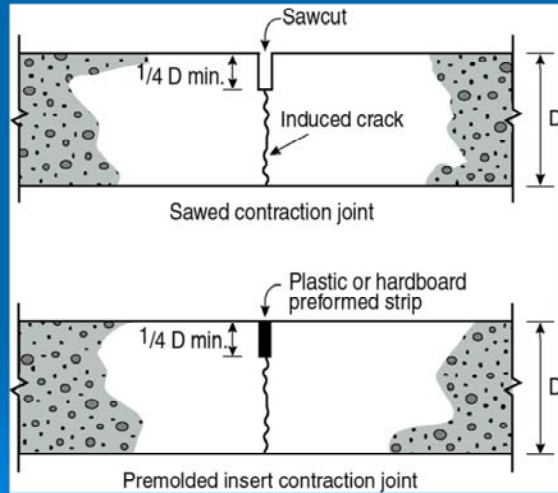


Texturing is common for concrete that is outdoors where a slick surface could be hazardous. Various surface textures have been tried to prevent livestock from slipping in areas like drip sheds and milking parlors.

# Contraction Joints



Wet sawing



Contraction joints induce controlled cracking caused by drying and thermal shrinkage. Sawing a continuous cut in the top of a slab is one of the most economical methods for making a contraction joint.

## Contraction Joints

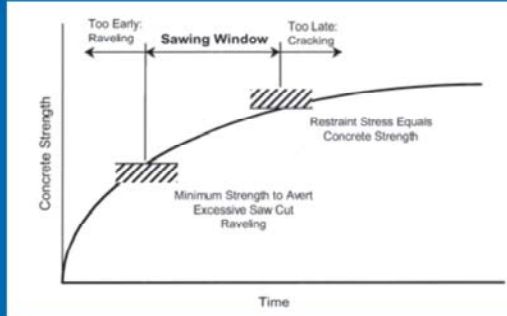
Grooving tool  
on bull-float



Dry-cut sawing concrete

Grooving must be done fairly early after the bleed-water has ceased coming to the surface. Sawsing is done later but not too late.

# Sawing Joints



There is a small window of opportunity to saw cut concrete. To early and the concrete will ravel. To late and the concrete will randomly crack on its own or crack just ahead of the saw as it is being sawed.

## Spacing of Contraction Joints (Ft.)

Slab thickness, in.	Maximum-size aggregate less than $\frac{3}{4}$ in.	Maximum-size aggregate $\frac{3}{4}$ in. and larger
4	8	10
5	10	13
6	12	15
7	14	18
8	16	20
9	18	23
10	20	25

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These spacings are appropriate for concrete with 4 to 6 inch slump. For slumps less than 4 in., joint spacing can be increased by 20%.

Joints may need to be closer together if concrete is poured in cold weather.

When spacing exceed 15 ft, load transfer by aggregate interlock decreases markedly because the crack will be wider.

## Curing

- Has curing promptly begun?
- Is the curing period long enough?
- Is wet curing required?
- Is curing compound allowed?

Moisture must be present in the concrete for it to continue to gain strength. Once the relative humidity (RH) inside the concrete falls below 80%, cement hydration and the attendant strength gain will cease. It may be difficult and even impossible to rehydrate the concrete if it dries out. Thus, curing must begin ASAP to keep the concrete above 80% RH.

# Curing

- **Begin immediately**
  - Avoid plastic shrinkage
  - Avoid drying
- **Curing period**
  - 3 days, 7 days, ? Days



Plastic shrinkage cracks are a bunch of small cracks on the surface of the concrete. They are caused by rapid drying of the surface resulting in the surface shrinking. They are especially difficult to control in arid climates when it is hot and windy.

The longer the curing period the better. Long term strength is directly related to the curing period.

Curing is something at which contractors seem to fall short in unless someone continues to remind them to keep the concrete wet. Contractor quality control personnel should keep reminding the contractor of the need to address curing matters. When there is no QC person on the job, the NRCS representative may have to discuss curing with the contractor and point out shortfalls in the curing operation.

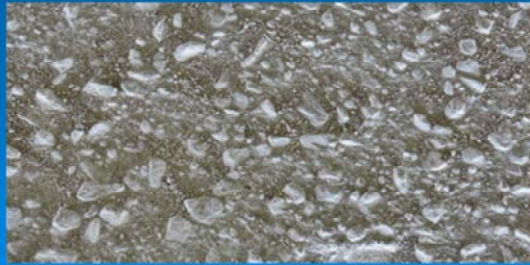
# Curing



An excellent method of wet curing is to completely cover the surface with wet burlap and keep it continuously wet during the curing period. Someone needs to ensure the “completely” and “continuously” requirements are being met. NRCS personnel may have to point out areas that are not completely covered and not continuously wet.

## Curing

- **Wet cure**
  - Complete coverage
  - Continuous curing
  - Avoid damaging concrete



Generally, concrete will not bond to concrete that has been covered by curing compound so curing compound must be kept away from any bonding surface. In the top right photo, burlap is laid on the concrete joint bonding surface and water is supplied by soaker hoses to keep the surface wet. The sides were coated with curing compound.

Avoid spraying large droplets of water on freshly placed concrete as this can damage the surface. Inspectors should verify that complete coverage of curing water is attained continuously throughout the curing period and that the surface is not damaged by the curing operation like the concrete shown in the photo below.

&lt; 400 sq. ft.



For small areas, curing compound may be applied with a roller or a hand sprayer. A roller is good for areas near a bonding surface. Verify that curing compound is not applied to any bonding surface.

## Curing

- Curing compound
  - Use specified type and class
  - Apply in timely manner
  - Avoid bonding surfaces
  - Verify complete coverage
  - Verify adequate coverage



When curing compound is used and the type and class specified, the inspector should verify that the specified type and class of curing compound is being used. Large areas require equipment with a higher flowrate than can be provided by a hand-pump sprayer. Equipment like that shown in the bottom right photo is needed if the area that must be covered is greater than 400 square feet.

Complete coverage is fairly easy to verify if the curing compound contains a dye. The rate of coverage that is required is given in the curing compound manufacturer's instructions. It is generally one gallon per 200 square feet.

Observe the application of curing compound; if it is not being applied in a timely manner (i.e. concrete is drying out on the surface before being covered with compound), bring this to the contractor's attention and request additional resources.



As an inspector, you must say something about the poor effort to avoid getting curing compound on the steel and the concrete where the concrete will be placed around the steel. The contractor may need to remove curing compound in some areas.



This looks like good coverage, but...



This may also be good coverage because some curing compounds don't contain as much dye as others. The inspector should determine the amount of curing compound applied to a known area to verify that coverage is adequate.



This looks like poor coverage; its definitely not uniform. The inspector should discuss this with the contractor and ask the contractor to verify the coverage adequately conforms to the curing compound manufacturer's recommendation for rate (gallons/ft<sup>2</sup>) and uniformity of coverage.