des moines metro concrete council

DES MOINES METRO CONCRETE COUNCIL

quality concrete reference guide

DES MOINES METRO CONCRETE COUNCIL

Organized in 1986, the Des Moines Metro Concrete Council (DMMCC) is comprised of the five major ready mix concrete producers in the metro area, along with those companies that manufacture and supply those producers with portland cement, aggregates, chemical admixtures, and mineral admixtures.

The original mission of the DMMCC was to simply promote the use of ready mix concrete to new and existing markets. Over the years, however, this council recognized that failures with our product caused specifiers and owners to look at alternate building materials in leu of ready mix concrete. This forced the council to address problems that lead not only to rare failures, but also to more frequent "cosmetic" issues that leave owners less than 100% satisfied. Today's DMMCC mission still includes promoting the use of ready mix concrete, and also promoting sound concreting practices towards those that specify, install, and use our product.

This booklet is a compilation of problems, some common others not so common, that we encounter during the installation and use of ready mix concrete. It is written mainly towards the concrete contractor, but will be useful to architects, engineers, and project managers. It is our intent to prevent problems. If this booklet helps to prevent a single occurrence of any of the listed issues, we will consider it well worth the time and resources that went into it. This is the commitment of the members of this council.

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pre-pour conference agenda

To Define and Allocate Responsibilities

Project Name & Location: ______________________

Personnel to attend conference:

Owner: ______________________

Architect: ______________________

Structural Engineer: ______________________

Contractor, Superintendent and/or Project Manager:

____

Concrete Producer: ______________________

Testing Lab Manager: ______________________

Concrete Materials & Mix Designs:

Have the mix designs been approved? ______________________

If yes, have approved mix designs been distributed to contractor and all project participants?

____

Inspection Responsibilities:

Plant Inspection Requirements:

Full-time: ______________________

Part-time: ______________________

Not required: ______________________

Concrete Sampling & Testing Specification Requirements

Where are the tests to be conducted? ______________________

What is the sampling frequency? ______________________

Number of cylinders/set? ______________________

At what ages are cylinders to be tested? ______________________

Are reserve cylinders required? ______________________

If so, how may? ______________________

Will the jobsite laboratory technician be ACI certified?

____

Will the same person be there for each placement?

____

Cylinders Storage & Transportation:

How are the cylinders going to be stored for the first 24 hours after cylinders are made? ______________________

Who is responsible for maintaining temperature in storage between 60-80° F during the first 24 hours after test cylinders are made? ______________________

Describe how storage box and/or water tank temperature will be maintained: ______________________

When will test cylinders made on days proceeding non-work days be transported to the laboratory?

____

Describe arrangements for access to construction site on non-work days: ______________________

Acceptance/Rejection Responsibility & Authority for Fresh Concrete:

What contractor personnel have the authority to add water to concrete on site? ______________________

Who has the authority to reject a concrete delivery?

____

For what reasons may concrete deliveries be rejected and when? ______________________

Slump? ______________________

Air Content? ______________________

Too Hot? ______________________

Too Cold? ______________________

Time? ______________________

Other? ______________________

Report Distribution:

What is the planned test report distribution? (we suggest all participants) ______________________

____

Testing of Hardened In-Place Concrete?

In what situation will additional testing be required?

____

How do the project specifications handle additional testing? ______________________

If additional testing is required, who will be notified and when? ______________________

What investigative procedures will be used? ______________________

____

Who will do the work and who will select them? ______________________

____

How will the test results be evaluated? ______________________

____

Who will pay the costs of additional testing? ______________________

____

On-site protection of test cylinders ______________________

____

Remarks:

Pouring schedule? ______________________

Expected project duration? ______________________

Truck routing? ______________________

Wash out area? ______________________

Other: ______________________

(This sample form should be retyped on your company letterhead and reproduced)

concrete planner checklist

Producing Quality Concrete

About the job: **PRE-PLANNING**

- Project Name:____
  Concrete Mix ID#: ____________________________________
  (Duplicate this checklist for each structural element requiring different concrete mix)
- Place this mix in these structural elements: ___________
  ____
- Place ready mix order______ hours in advance.
  Only _______________ or ______________ can place orders.
- Reconfirm ready mix order _____ hours before the pour.
- _________________ or _________________ will plan and supervise concrete truck access and maintain open access for ready mix trucks during the pour.

About the job: **PRODUCTION CONTROL**

- Can water be added at the site? ☐ Yes ☐ No
  if water can be added:
  The maximum amount of water that can be added is _______ gallons per cubic yard.
- The Water Cement w/c ratio cannot exceed ± __________
  ____
- The maximum slump cannot exceed ± __________inches.
  ____
- Only __________________ or _________________ have the authority to add water to the trucks.
- Only __________________ or _________________ have the authority to send back ready mix trucks.
- Monitor continuous flow of ready mix. Space trucks ___________ minutes apart.
- Free unloading time is __________ minutes per cubic yard. Additional time is charged at $_________ per hour.

(This sample form should be retyped on your company letterhead and reproduced)

About the job: **PLACING CONCRETE**

- Maximize discharge points by moving ready mix trucks around job site.
- Starting in a corner, then working away from corner.
- Place into (instead of away from) fresh concrete.
- Place up hill instead of down hill.
- Use square-nose shovels, come-alongs, or concrete rakes, other tools cause segregation when moving concrete.
- Do not use unnecessary lengths of chutes.
- Ready mix truck wheels should stay (1) foot away from excavation for each (1) foot of depth.
- ___________________ will direct ready mix trucks to cross sidewalks, curbs, or any area that can be damaged by the truck's weight.
- Wear protective clothing, full-length shirts and trousers, rubber boots and gloves, eye protection. Fresh concrete can cause skin irritation and burns. Wash skin promptly after contact. (Refer to NRMCA Publication cement burn)

About the job: **QUALITY CONTROL**

- If concrete has been in the truck for more than 1 1/2 hours or 300 revolutions then _________________ or __________________ must approve the concrete for use.
- If testing is required, notify _______________ at the testing laboratory. Phone (   )______-_________ at least _____ hours in advance.
- The specifications for this mix requires:
- A slump of ____________ inches.
- An air content of ______________%.
- A unit weight of _____________________ PCF.
- A concrete temperature range of _________ to ________ degree F.
- A 7-day compressive specified strength of _______psi.
- A 28-day compressive specified strength of _______psi.
- A ___-day compressive specified strength of _______psi.

cold weather concreting

Definition

Cold weather is defined as a period when the average daily temperature falls below 40F for more than three consecutive days. Under these circumstances special precautions must be taken when placing, finishing, curing and protecting concrete against the effects of cold weather. Good concrete practices and proper planning are critical since weather conditions can change rapidly in the winter months.

Importance of Cold Weather Consideration

Successful cold weather concreting requires an understanding of the various factors that affect concrete properties. In its plastic state, concrete will freeze if it's temperature falls below about 25F. If plastic concrete freezes, its potential strength can be reduced by more than 50% and its durability will be adversely affected. Concrete should be maintained at 50F or higher for not less than two days after placement in order to attain a minimum compressive strength of 500 psi. Once 500 psi has been reached, the concrete can withstand a single freeze-thaw cycle (if properly air entrained). Low concrete temperature has a major affect on the rate of cement hydration, which results in slower setting and rate of strength gain. On average, the setting time will be doubled with a drop in concrete temperature of 20F. When scheduling construction operations, such as form removal, the slower rate of setting and strength gain should be accounted for.

Even if only during construction, concrete in contact with water and exposed to cycles of freezing and thawing should be air-entrained. Newly placed concrete is saturated with water and should be protected from cycles of freezing and thawing until it has attained a compressive strength of at least 3500-psi.

Cement hydration is a chemical reaction that generates heat. Newly placed concrete should be adequately insulated to retain this heat and thereby maintain favorable curing temperatures. Large temperature differences between the surface and the interior of the concrete mass should be prevented as cracking may result when this difference exceeds about 35F. Insulation or protective measures should be gradually removed to avoid thermal shock.

Placing Concrete in Cold Weather

The ready mixed concrete producer can control concrete temperature by heating the mixing water and/or the aggregates and furnish concrete in accordance with the guidelines in ASTM C 94. Cold weather concrete temperature should not exceed recommended temperatures by more than 20F. Concrete at a higher temperature requires more mixing water, has a higher rate of slump loss, and is more susceptible to cracking. Placing concrete in cold weather provides the opportunity for better quality, as cooler initial concrete temperature will typically result in higher ultimate strength. Slower setting time and strength gain of concrete during cold weather typically delays finishing operation and form removal. Chemical admixtures and other modifications to the concrete mixture can accelerate the rate of setting and strength gain. Accelerating chemical admixtures, conforming to ASTM C 494 — Types C and E are commonly used in the winter months. Calcium chloride is a common and effective accelerating admixture, but should not exceed a maximum dosage of 2% by weight of cement. Flake and pellet calcium chloride should not be added directly into the mix without first dissolving in water. Non-chloride non-corrosive accelerators should be used for prestressed concrete or when corrosion of steel reinforcement or metal in contact with concrete is a concern. Accelerating admixtures do not prevent concrete from freezing and their use does not preclude the requirements for concrete temperature and appropriate curing and protection from freezing.

Accelerating the rate of set and strength gain can also be accomplished by increasing the amount of portland cement or by using a Type III cement. The relative percentage of flyash or ground slag in the cementitious material component may be reduced in cold weather but this may not be possible if the mixture has been specifically designed for durability. The appropriate decision should afford an economically viable solution with the least impact on the ultimate concrete properties.

Concrete should be placed at the lowest practical slump as this reduces bleeding and setting time. Adding 1 to 2 gallons of water per cubic yard may delay set time by 2 hours. Retarded set times will prolong the duration of bleeding. Do not start finishing operations while the concrete continues to bleed as this will result in a weak surface. Adequate preparations should be made prior to concrete placement. Snow, ice and frost should be removed and the temperature of surfaces and metallic embedments in contact with concrete should be above freezing. This might require insulating or heating subgrades and contact surfaces prior to placement.

Materials and equipment should be in place to protect concrete, both during and after placement, from early age freezing and to retain the heat generated by cement hydration. Insulated blankets and tarps, as well as dry straw covered with plastic sheets, are commonly used measures.

Enclosures and insulated forms may be needed for additional protection depending on ambient conditions. Corners and edges are most susceptible to heat loss and need particular attention. Fossil-fueled heaters in enclosed spaces should be vented for safety reasons and to prevent carbonation of newly placed concrete surfaces, which causes dusting.

The concrete surfaces should not be allowed to dry out while it is plastic as this causes plastic shrinkage cracks (see plastic shrinkage). Subsequently, concrete should be adequately cured (see curing). Water curing is not recommended when freezing temperatures are imminent. Use membrane-forming curing compounds or impervious paper and plastic sheets for concrete slabs.

Forming materials, except for metals, serve to maintain and evenly distribute heat, thereby providing adequate protection in moderately cold weather. With extremely cold temperatures, insulating blankets or insulated forms should be used, especially for thin sections. Forms should not be stripped for 1 to 7 days depending on the setting characteristics, ambient conditions and anticipated loading on the structure. Field-cured cylinders or non-destructive methods should be used to estimate in-place concrete strength prior to stripping forms or applying loads. **Field-cured cylinders should not be used for quality assurance.**

Special care should be taken with concrete test specimens used for acceptance of concrete. Cylinders should be stored in insulated boxes, which may need temperature controls, to insure they are cured at 60F to 80F for the first 24 to 48 hours. A minimum/maximum thermometer should be placed in the curing box to maintain a temperature record.

References

NRMCA CIP 27 (1998). *What, Why and How? Cold Weather Concreting*
National Ready Mixed Concrete Association

Cold Weather Concreting, ACI 306R,
American Concrete Institute, Farmington Hills, MI.

hot weather concreting

Definition

Hot weather may be defined as any period of high temperature in which special precautions need to be taken to insure proper handling, placing, finishing and curing of concrete. Hot weather problems are most frequently encountered in the summer, but the associated climactic factors of high winds, low relative humidity and solar radiation can occur at any time, especially in arid or tropical climates. Hot weather conditions can produce a rapid rate of evaporation of moisture from the surface of the concrete and accelerated setting time, among other problems. Generally, high relative humidity tends to reduce the effects of high temperature.

It is important that hot weather be taken into account when planning concrete projects because of the potential effects on fresh and recently placed concrete. High temperatures alone cause increased water demand, which, in turn, will raise the water-cement ratio and result in lower potential strength. Higher temperatures tend to accelerate slump loss and can cause loss of entrained air. Temperature also has a major effect on the setting time of concrete: concrete placed at high temperatures will set quicker and can, therefore, require more rapid finishing. Concrete that is cured at high temperatures at an early age will not be as strong at 28 days as the same concrete cured at temperatures in the range of 70F.

High temperatures, high wind velocity, and low relative humidity can affect fresh concrete in two important ways: the high rate of evaporation may induce early plastic shrinkage or drying shrinkage cracking, and the evaporation rate can remove surface water necessary for hydration unless proper curing methods are employed. Thermal cracking may result from rapid drops in temperature of the concrete, such as when concrete slabs or walls are placed on a hot day followed by a cool night. High temperature also accelerates cement hydration and contributes to the potential for thermal cracking in massive concrete structures. Hot weather increases likelihood of ASR occurrence.

Hot Weather Concrete Recommendation

Use proven local recommendations for adjusting concrete proportions, such as the use of water reducing and set retarding admixtures.

Modifying the mixture to reduce the heat generated by cement hydration, such as the use of an ASTM. Type II moderate heat cement and the use of pozzolans and slag can reduce potential problems with high concrete temperature.

Advance timing and scheduling to avoid delays in delivery, placing and finishing is essential. Trucks should be able to discharge and adequate personnel should be available to place and handle the concrete. When possible, deliveries should be scheduled to avoid the hottest part of the day.

The purchaser may waive limits on maximum concrete temperature if the concrete consistency is adequate for the placement and excessive water addition is not required. In the case of extreme temperature conditions or with mass concrete, the concrete temperatures can be lowered by using chilled water or ice as part of the mixing water. The ready mixed concrete producer should use other measures, such as sprinkling and shading the aggregate prior to mixing, to help lower the temperature of the concrete. If low humidity and high winds are predicted, use one or a combination of; wind-breaks, sunscreens, mist fogging, or evaporation retardant may be needed to avoid plastic shrinkage cracking.

References

NRMCA CIP 4 (1998). *What, Why and How? Cracking Concrete Surfaces*
National Ready Mixed Concrete Association

Hot Weather Concreting, ACI 305R,
American Concrete Institute, Farmington Hills, MI.

jobsite addition of water

Definition

Jobsite addition of water is the addition of water to ready mixed concrete in a truck mixer after arrival at the location of the concrete placement. Such tempering of concrete may be done with a portion of the design mixing water which was held back during the initial mixing, or with water in excess of the design mixing water, at the request of the purchaser.

Why Add Water at the Jobsite

When concrete arrives at the jobsite with a slump that is lower than that allowed by design or specification and/or is of such consistency so as to adversely affect the placability of the concrete, water can be added to the concrete to bring the slump up to an acceptable or specified level. This can be done when the truck arrives on the jobsite as long as the specified slump and/or water-cement ratio is not exceeded. Such an addition of water should be in accordance with ASTM C 94, Standard Specification for Ready Mixed Concrete.

The ready mixed concrete supplier designs the concrete mixture according to industry standards to provide the intended performance. Addition of water in excess of the design mixing water will affect concrete properties, such as reducing strength, and increasing its suspectibility to cracking. If the purchaser requests additional water, in excess of the design mix, the purchaser assumes responsibility for the resulting concrete quality. The alternative use of water reducing admixture or superplacticizer to increase concrete slump should be considered. Provided segregation is avoided, increasing the slump of concrete using admixtures usually will not significantly alter concrete properties.

Proper Addition of Water at the Jobsite

a. The maximum allowable slump of the concrete must be specified or determined from the specific nominal slump plus tolerances.

b. Prior to discharging concrete on the job, the actual slump of the concrete must be estimated or determined. If the slump is measured, it should be on a sample from the first 1/4 cubic yard of discharged concrete and the result used as an indicator of concrete consistency and not an acceptance test. Tests for acceptance of concrete should be made in accordance with ASTM C 172.

c. At the jobsite, water should be added to the entire batch so that the volume of concrete being retempered is known. A rule of thumb that works reasonable well is – 1 gallon, or roughly 10 pounds of water per cubic yard for 1 inch increase in slump.

d. All water added to the concrete an the jobsite must be measured and recorded.

e. ASTM C 94 requires an additional 30 revolutions of the mixer drum at mixing speed after the addition of water.

f. The amount of water added should be controlled so that the maximum slump is not exceeded. Once a portion of the concrete is discharged, no water addition is permitted.

g. Upon obtaining the desired slump and/or maximum water-cement ratio, no further additional of water on the jobsite is permitted.

h. A pre-concreting conference should be held to establish proper procedures to be followed, to determine who is authorized to request a water addition, and to define the method to be used for documentation of the water added at the jobsite.

i. Maximum allowable water addition without exceeding w/c specification will be included on ticket.

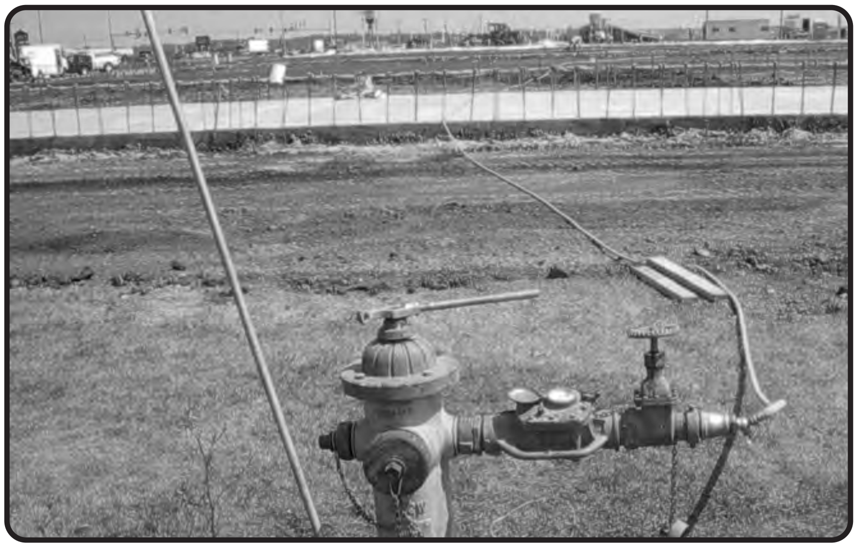
Definition

Curing is maintaining, an adequate moisture AND temperature, in concrete at early ages so that it can develop properties the mixture was designed to achieve. Curing begins immediately after placement and finishing so that the concrete may develop the desired strength and durability. Without an adequate supply of moisture, the concrete will dry out and not achieve its potential properties. Proper curing temperatures should be maintained (generally above 50°F) for an adequate rate of strength gain, and to avoid possible thermal cracking. Curing procedures are of particular interest in central Iowa because of effect it might have on aggravating ASR occurrence. Less expensive curing methods are often not an option because of increased popouts when cured by these methods.

Why Cure Concrete?

Several important reasons are:

- Predictable strength gain. Concrete left to cure in a dry environment will lose as much as 50% of its potential strength when compared to similar concrete cured in a moist environment. Concrete placed in high temperatures will gain early strength quickly, but later strengths may be reduced. Concrete cured in cold temperatures will take longer develop strength, and may delay subsequent construction.



Waterline to soaker hoses on newly placed concrete

- Improved durability. Well-cured concrete has better surface hardness, and will better stand surface wear and abrasion. Curing also makes concrete more watertight.
- Better serviceability and appearance. A concrete slab that has been allowed to dry out too early will have a soft surface with poor resistance to wear and abrasion. Proper curing reduces crazing, dusting, and scaling.

curing

How to Properly Cure Concrete

Concrete should be protected from losing moisture until final finishing, using suitable methods like wind breaks, fogger sprays, or misters to avoid plastic shrinkage cracking. After final finishing, the concrete surface must be kept continuously wet or sealed to prevent evaporation for a period of at least several days.

Systems to keep concrete wet include:

■ Burlap, cotton mats, rugs, etc., used with soaker hose or sprinkler. Do not allow covering to dry out. The edges should be lapped and weighted down so they are not blown away.

■ Straw that is sprinkled with water regularly. Layer should be not less than six inches thick and covered with a tarp. Take measures so straw will not blow away.

■ Damp earth, sand, or sawdust can be used on flatwork. There should be no organics or iron-staining contaminants in the materials used.

■ Sprinklers are acceptable, as long as temperatures remain above freezing. Do not allow the concrete to dry out between soakings, however.

■ Ponding of water is an excellent method of curing. The water should be no more than 11°F cooler than the concrete.

Moisture retaining materials include:

■ Liquid membrane-forming curing compounds. Curing compound must meet ASTM C309. Apply to concrete about one hour after finishing. Do not apply to concrete that is still bleeding, or has visible water at the surface. On smooth-troweled finished floors, will aggravate ASR problem.

■ Plastic sheets. Must be at least 4 mils thick, preferably reinforced with fiberglass. Plastic should be laid in direct contact with the concrete, as soon as possible, without marring the surface. The edges should be weighted down and fastened with waterproof tape. Make sure wind does not get under the plastic. Will make a dark spot when plastic raises up off the surface. Aggravates ASR problem as bad as curing compounds.

■ Waterproof paper. Used like plastic sheeting, but does not mar the surface

Note: Evaporation retarders are not curing agents. They should only be used on concrete in the plastic state, while there is moisture at the surface of the slab. Not recommended for use as finishing aid.

Control of temperature

In cold weather, do not allow concrete to cool faster than a rate of 5°F per hour for the first 24 hours. Concrete should be protected from freezing till it reaches a compressive strength of at least 500 psi. Cure methods that retain moisture, rather than wet curing, should be used when freezing temperatures are anticipated. Guard against rapid temperature changes after removing protective measures.

In hot weather, higher initial curing temperatures will result in rapid strength gain and lower ultimate strengths (see cold weather concreting). Water curing and sprinkling can be used to achieve lower curing temperatures in summer. Day and night temperature extremes that allow for faster cooling than 5°F per hour during the first 24 hour, should be protected against (see hot weather concreting).

References

NRMCA CIP 11 (1998). *What, Why and How? Curing In-Place Concrete*
National Ready Mixed Concrete Association

Standard Practice for Curing Concrete,
ACI 308, ACI manual of Concrete Practice, Part 2
American Concrete Institute, Farmington Hills, MI.

Proper Curing: Preventative Medicine for Concrete,
Concrete Technology Today, September 1982
Portland Cement Association

cracks in basement walls

Definition

Cast-in-place concrete basements provide durable, high quality living space. At times, however, undesirable cracks occur. These cracks result from:

- Temperature and drying shrinkage cracks
- Settlement
- Other structural problems
- Cracks due to lack of joints or improper jointing practices

In concrete basement walls, some cracking is normal. Most builders or third party providers offer limited warranties for basements. A typical warranty will require repair only when cracks leak or exceed the following:

	Crack Width	*Vertical Displacement*
Basement Walls	*1/8" (3mm)*	-
Basement Floors	*3/16" (5mm)*	*1/8" (3mm)*
Garage Slabs	*1/4" (8mm)*	*1/4" (8mm)*

The National Association of Homebuilders requires repair or corrective action when cracks in basement walls allow exterior water to leak into the basement.

If the following practices are followed, cracking is minimized:

- Uniform soil is provided
- Concrete is placed at a moderate slump – up to 5", and excessive water not added at jobsite
- Proper construction practices are followed
- Control joints are provided every 20 to 30 feet
- Backfilling is done carefully and, if possible, waiting until the first floor is in place in cold weather
- Proper curing practices are followed

How to Construct Quality Basements

Since the performance of concrete basements is affected by climate conditions, unusual loads, materials quality, and workmanship, care should always be exercised in their design and construction. The following steps should be taken:

- Site conditions and excavation. Soil investigation should be thorough enough to insure design and construction of foundations suited to the building site. Excavation should be to the level of the bottom of the footing. Soil or granular fill beneath the entire area of the basement should be well compacted by rolling, vibrating, or tamping. Footings must bear on undisturbed soil.

- Formwork and reinforcement. All formwork must be constructed and braced so that it can withstand pressures of plastic concrete. Reinforcement is effective in controlling shrinkage cracks, and is especially beneficial where uneven side pressures against the walls may be expected.

- Joints. Shrinkage and temperature cracking of basement walls can be controlled by means of properly located and formed joints. As a rule of thumb, in 8-foot high by 8-inch thick walls, vertical control joints should be provided at a spacing of about 30 times the wall thickness. These wall joints can be formed by nailing a 3/4" thick strip of wood, metal, plastic, or rubber, beveled from 3/4" to 1/2" in width, to the inside of both interior and exterior wall forms. Depth of the grooves should be at least 1/4 the wall thickness. After removal, the grooves should be packed with appropriate size backer rod, and caulked with a good quality elastomeric sealant. For large volume pours or with abrupt changes in wall thickness, bonded construction joints should be planned before construction. Construction joints may be horizontal or vertical. Wall reinforcement continues through a construction joint.

cracks in basement walls

■ Concrete. In general, use concrete with a moderate slump up to 5 inches. Avoid re-tempering with water. Concrete with higher slump may be used, provided the mixture is specifically designed to produce the required strength without bleeding and/or segregation. Water-reducing admixtures can be used for this purpose. In areas where the weather is severe and walls may be exposed to moisture and freezing temperatures, air entrained concrete must be used. Maximize large aggregate (both size and quantity) in the mix. Avoid over-sanded mixes. High sand mixes typically lead to more bugholes at the form face surface.

■ Placement and curing. Place concrete in continuous operation to avoid cold joints. If concrete tends to bleed and segregate, a lower slump should be used and the concrete should be placed in the wall every 20 to 30 feet around the perimeter (do not require mix to flow further). Higher slump concrete that does not bleed or segregate will flow horizontally for long distances, and reduce the number of required points to access the forms. Curing should start immediately after finishing. Forms should be left in place five to seven days, or as long as possible. If forms are removed after one day, premature drying at the surface is likely, which can lead to additional cracking. In general, the application of a liquid membrane-forming curing compound or insulated curing blankets immediately after removal of forms will help prevent drying and will provide better surface durability. During cold weather, forms may be insulated or temporarily covered with insulating materials to conserve heat from hydration and avoid the use of an external source of heat. During hot, dry weather, forms should be covered. Walls must be cured with wet burlap or curing compound as soon as forms are removed.

■ Waterproofing and drainage. Spray or paint the exterior of walls with a damp proofing material or use waterproof membrane. Provide foundation drainage by installing drain tile around the exterior of the footing, then cover with clean, granular fill to a height of at least one foot prior to backfilling. Water should be drained to lower elevations suitable to receive storm water run off.

■ Backfilling and final grading. Backfilling should be done carefully to avoid damaging the walls. Brace the walls or, if possible, have the first floor in place before backfill. Keep heavy equipment at least eight feet away from walls. Place backfill in thin layers and with hand-operated equipment. Keep compaction equipment at least 12 inches from walls. Do not backfill with organic material, including topsoil. The finish grade should allow sufficient fall to drain surface water at least 10 feet way from the foundation.

■ Crack repair. In general, epoxy injection, dry-packing, or routing & sealing techniques can be used to repair stabilized cracks. Before repairing leaking cracks, drainage around the structure should be checked and corrected if necessary. Active cracks should be repaired based on professional advice.

References

Joints to Control Cracking Walls,
Concrete Technology Today, September 1984
Portland Cement Association

How to Control Basement Wall Cracks,
Concrete Technology Today, July 1995
Portland Cement Association

Preventing Wet Basements,
Concrete Technology Today, March 1996
Portland Cement Association

alkali-aggregate reaction

Definition

Alkali-Silica reaction is the reaction between the alkalis (sodium and potassium) in Portland Cement and certain siliceous rocks or minerals, such as opaline chert, strained quartz, and acidic volcanic glass, present in some aggregates; the products of the reaction may cause abnormal expansion and cracking in concrete in service.

In Iowa (in our area), alkali aggregate reactions occur in two distinct forms;

1. alkali silica reactivity, which occurs in concrete with reactive coarse aggregate and
2. popouts, which is a surface blemish resulting from an expansive reaction in the fine aggregate near the concrete surface.

By far the most visible defect in our area is popouts. During the last Ice Age, central, north central and northwest Iowa as well as Minnesota and the Dakotas was covered by glacial deposits containing cretaceous shales that were exposed and distributed by glacial action. Opaline microfossils are present in these shales. These shales are contained in our concrete sands.

ASR or the deleterious reaction between alkalis and coarse aggregate is rare in our area. Few coarse aggregates are reactive and those few are well identified.

Contributing Factors

Alkali aggregate reactions need specific conditions to proceed; alkalis, reactive aggregate, appropriate temperatures and water. Concrete blemishes known as popouts can be a potential problem in central and northern Iowa. Researchers have established that these popouts result from a chemical reaction between alkalis in the cement and fly ash and cristobalite or opaline shale in the concrete sand.

The shale particles contain opaline silica. Researchers investigated whether alkali-silica reactivity (ASR) was the cause. Shale particles were embedded in parts of cement paste that contained either high-alkali or low-alkali cement. After curing for 18 hours, numerous popouts had formed on the high-alkali samples, while none had formed on the low-alkali mix.

When concrete dries, evaporating water brings alkalis to the surface, increasing the alkali concentration. Therefore the researchers investigated factors that could influence the rate and amount of evaporation, these included: temperature and humidity, slab thickness, covering before final finishing, and curing procedures.

The researchers also reasoned that the permeability of the concrete near the surface would also influence the formation of popouts. Concrete with low permeability would be more likely to trap ASR gel within the concrete, increasing the internal pressure and the chance for popouts. Therefore, the following variables were tested: cement content, finishing technique, air entrainment, and curing procedure.

Results

Low-alkali cements produced fewer popouts than high-alkali cements, and 30% replacement of cement with slag was also shown to significantly reduce popouts. However, the benefits of these materials were diminished when the concrete was exposed to high temperature and low humidity between the time of casting and troweling, which significantly increased the number of popouts. For example, popouts formed in significant numbers even with cement of 0.4% alkali content when the concrete was placed under hot and dry conditions.

Slabs that were protected from drying with a polyethylene cover before troweling developed fewer popouts than slabs that were not covered. Six inch thick slabs developed more popouts that three inch thick slabs.

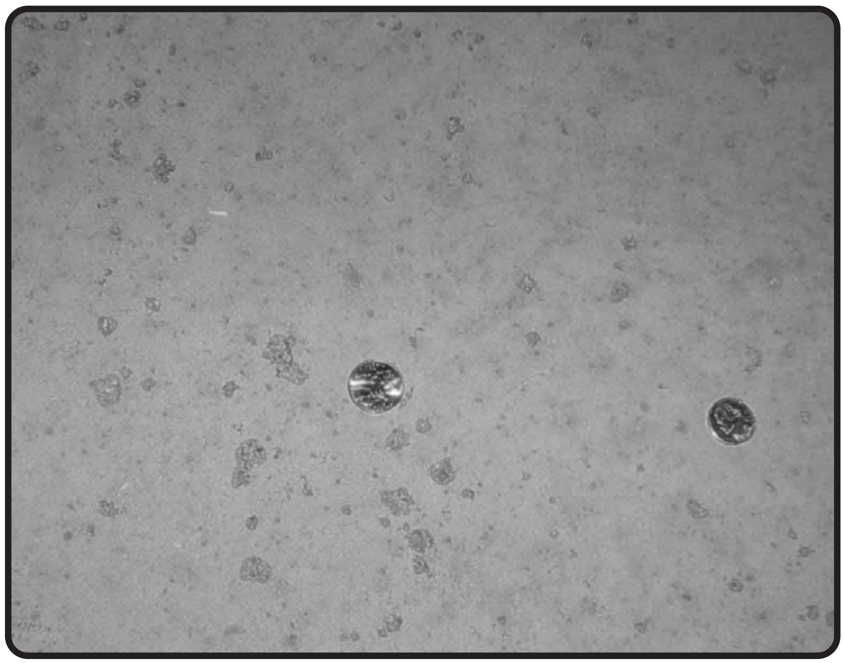
Slabs cured with a polyethylene film after troweling produced as many, if not more popouts than slabs that were air-cured. A liquid-membrane curing compound caused more popouts than polyethylene curing. However, curing the concrete with ponding or continually moist sand or burlap nearly eliminated popouts. To be effective, however, these curing techniques must be initiated soon after finishing is complete,

Concrete with a lower cement content suffered fewer popouts than concrete with a high cement content. Air entrainment had little effect on popout formation. Finishing technique was also found to have an effect on popout formation. Slabs that were finished by wood screed alone or with magnesium floating did not develop popouts, whereas slabs that were steel troweled did. Late steel troweling resulted in more popouts than earlier steel troweling.

There is one more form of surface blemish, not related to ASR. This blemish is similar to popouts but the action that forms this blemish is different and relies on freeze/thaw action. Some aggregates in this area have a soft porous layer in the limestone formation that is mixed in the stone during processing. This porous stone absorbs water. Upon experiencing freezing temperatures an expansion occurs and a "pop out" happens. The blemish is the same but the cause is different. These types of popouts usually do not occur until the slab has gone through a winter. These popouts, like those caused by ASR, are not structural and will not affect the serviceability of the slab. Because this type of popout occurs in the coarse aggregate, the blemish may be as large as the largest aggregate particle in a concrete mix.

Recommendations

Cure the concrete properly. Use a method for curing, which maintains water on the surface of the concrete. These include ponding, continuously spraying or saturated wet covers such as wet burlap or wet sand. Such methods provide some cooling of the surface and allow the reaction of the products to leave the concrete. It is essential before allowing the concrete to dry, to rinse and flush the surface to remove reactive products. It has been reported that proper wet curing can virtually eliminate pop outs.



Use the proper concrete mix. Use a concrete mix with workability suited to the type of mechanical placing and finishing equipment to be used. The greater the slump, the more likely small, lighter weight particles will be displaced to the top of the surface.

continued...

Recommendations continued

Reduce the temperature of the concrete. The rate of the alkali-silica reaction evidently increases with an increase in temperature. At lower concrete temperatures the possibility of popout development can be reduced. Provide pre-troweling protection to the concrete. Protect the concrete against rapid evaporation between the time it is placed, troweled, and afterwards. Proper protection might be achieved by use of windbreaks, fog sprays, polyethylene film or monomolecular film that retards evaporation.

Avoid a vapor barrier under the slab. Place a vapor barrier under the slab only when the floor is to receive an impermeable surface finish or be used for any purpose where the passage of water vapor through the floor is undesirable. If a vapor barrier is necessary, cover it with 2-3 inches of damp compacted sand before placing the concrete.

Adhere to the correct timing sequence when finishing. Do not begin any finishing operation while there is excess moisture or bleed water on the surface. Such action would only aggravate the concentration of alkalies at the surface.

References

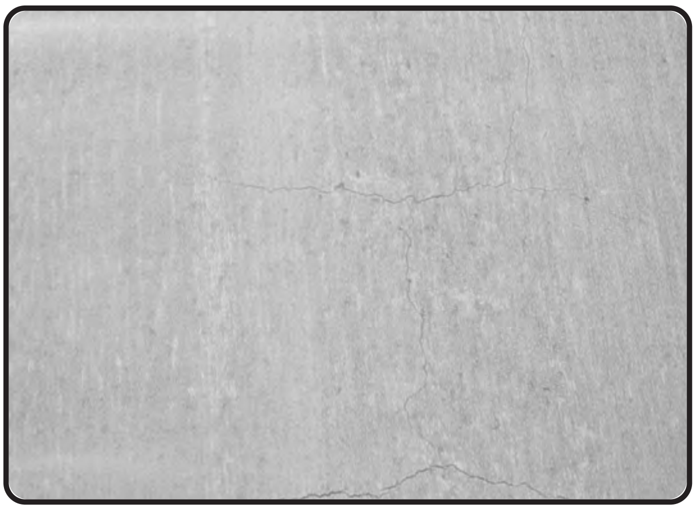
Plastic Shrinkage Cracking, NRMCA, CIP #5, 1998

plastic shrinkage cracking

Definition

Plastic shrinkage cracks are cracks that appear on the surface of a freshly place concrete slab during finishing operation or soon after. Plastic shrinkage cracks are usually parallel to each other. The cracks are usually 1 to 2 inches deep and rarely affect the permeability of the slab. Plastic shrinkage cracks rarely impair the strength of the concrete.

Contributing Factors



Plastic shrinkage cracks occur when the rate of evaporation of surface moisture exceeds the rate at which the rising bleed water can replace it and the surface dries. As the bleed water evaporates and recedes below the concrete surface, small cracks develop between the fine particles of cement and aggregate causing a tensile force to develop in the surface layers. If the concrete surface has started to set and has developed sufficient tensile strength, cracks do not form. However, if the surface dries before sufficient tensile strength develops, the tensile force in the layers will exceed the tensile strength of the concrete and cracks will develop. If the surface dries very rapidly, the concrete may still be plastic, and cracks do not occur at that time, they will as soon as the concrete stiffens more.

How to Minimize Plastic Shrinkage Cracks

■ Have proper manpower, equipment and supplies on hand so that the concrete can be placed and finished properly. If delays occur, cover the concrete with wet burlap or polyethylene sheeting between finishing operations. Spraying a chlorinated rubber curing compound or a monomolecular film on the surface behind the screening operation and before floating or toweling and help minimize plastic shrinkage cracks.

■ Start curing the concrete as soon as possible. Spray the surface with a liquid membrane curing compound or cover with a wet burlap and keep moist for a minimum of 3 days.

■ If concrete is to be placed on a dry subgrade or on previously placed concrete, the subgrade or the concrete base should be thoroughly dampened. The form-work and reinforcement should also be dampened.

■ In the very hot and dry periods, use of fog sprays can minimize plastic shrinkage cracks.

■ Erect temporary windbreaks to reduce wind velocity over the surface of the concrete and if possible, also provide sun shades to control surface temperature of the slab. If conditions are critical, schedule the place-ment for later afternoon or early evening.

■ If protection cannot be provided, then do not place concrete that day.

References

Plastic Shrinkage Cracking,
NRMCA, CIP#5, 1998

Definition

ACI 116 defines scaling as "local flaking or peeling away of the near surface portion of hardened concrete..." ACI further defines various degrees of scaling:

- Light Scaling is defined as a condition that does not expose coarse aggregate.

- Medium Scaling is the loss of surface mortar, 5 to 10 mm in depth, with exposure of aggregate

- Severe Scaling is a loss of surface mortar 5 to 10 mm in depth, with a loss of some mortar surrounding the aggregate particles, 10 to 20 mm in depth.

- Very Severe Scaling is the loss of coarse aggregate as well as mortar, generally greater than 20 mm in depth.

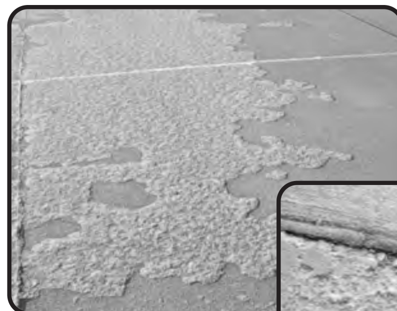
Discussion

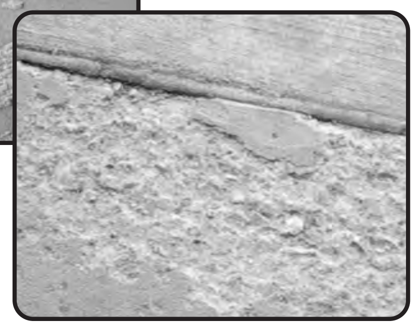
Scaling occurs when water saturated concrete experiences freezing and thawing cycles. As water goes from a liquid to solid form (freezes), its volume will expand by 9%. All concretes have a structure of channels, pores, and voids which in wet environments, will fill with water. When the concrete temperature drops below 32 degrees F, this water expansion takes place within the concrete. If the concrete was not properly designed and placed to withstand this occurrence, internal pressures will exceed the concrete tensile strengths and scaling will occur.

We know how to make concrete resistant to scaling, but it takes a combined effort on the part of the ready mix producer, contractor, and owner. The problem usually boils down to cost. The remedies to prevent scaling add to the cost of concrete placement.

Causes of Scaling

1. Detrimental actions of deicing chemicals and severe cycles of freezing and thawing. Chemicals used for melting snow and ice aggravate surface scaling. Their problem is two fold;
   a. the freezing point of water is lowered resulting in additional freeze thaw cycles and,
   b. salts, commonly present in these de-icers, absorb water and keep the concrete surface wet for a longer period.





2. Improper finishing and workmanship. Resistance to scaling is most needed at the surface exposed to weather elements. It is this same surface which is most abused during placement. Working bleed water or adding water to the surface to aid in finishing makes the concrete surface weaker and destroys the air void system. Over-working the surface may not add water, but will also destroy the entrained air system.

3. Improper curing. Curing is critical to maximize concrete durability (see curing). Concrete which is not allowed to properly cure, will have a lower compressive strength, be more absorptive, and more susceptible to scaling.

4. Unsound aggregates. Aggregates with high percentage of unsound particles will cause excessive popouts, and lead to progressive scaling.

Prevention of Scaling

■ Air Entrainment

Properly sized and spaced air voids within the concrete are critical in producing scale-resistant concrete. In normal concretes, this is usually measured as 6% of total volume. While having air entrained concrete does not guarantee against scaling, non-air entrained concrete will most certainly experience scaling in a wet, freeze-thaw environment. Further guidance on proper air content can be found in ACI 318, "Building Code Requirements for Reinforced Concrete."

■ Finishing

Minimize "working" the surface of exterior, air-entrained concrete. Do not work water, from any source, into the surface. Protect the plastic concrete during placement from additional water or premature drying.

■ Aggregates

Fine and coarse aggregates should meet the requirements of ASTM C 33.

■ Maximum Water-Cementitious Ratio

Concrete exposed to freeze-thaw cycles should not exceed a water-cement ratio of 0.45. With a normal water reducer included in the mix, this equates to approximately 4-inch slump. The likelihood of scaling increases dramatically as the w/c ratio increases. If higher slump mix is necessary, use a mid-range water reducer.

■ Adequate Strength and Drying

ACI 318 specifies a minimum compressive design strength of 4500 psi for concrete exposed to freeze-thaw in a moist environment, or deicing chemicals. Like air entrainment, however, meeting 4500 psi does not guarantee freeze-thaw durability. After adequate cure time, a period (one month) of air-drying will increase the durability of concrete exposed to freeze-thaw conditions.

■ Curing

Curing is essential to ensure a durable surface. Curing should begin as soon as the surface will allow (will not mar), and should continue till the concrete has achieved not less than 70% of the specified compressive or flexural strength. Curing should be as long as practical, by the most practical method (see curing). Not curing concrete can reduce compressive strength by as much as 50%.

■ Late Season Exterior Concrete

Extra care and caution should be taken for late season, exterior concrete placement. Shorter hours of sunlight and cooler nighttime temperatures will severely effect strength gain in the concrete. Added to the potentially lower strength is the fact that the concrete will be saturated with water and inclimate weather will soon bring freezing temperatures, snow, ice, and deicing materials. Attempts to keep de-icers off the new slab are useless as cars carry salts off city streets onto the new concrete. Late season, exterior concrete mix designs should be modified to include the following:

a. lower the w/c ratio by using a mid-range water reducer at a moderate dosage, and,

b. use liquid accelerators (chloride if acceptable, else non-chloride) at higher dosages to reach design strengths early, extend drying period.

References

Scaling Concrete Surfaces,
NRMCA, Concrete in Practice #2, 1998

Scaling of Concrete,
Master Builders, Inc., concrete Technology Update, April 1994

Scaling Revisited,
David Lankard, Concrete International, May 2001

wall defects

Air Pockets / Bugholes

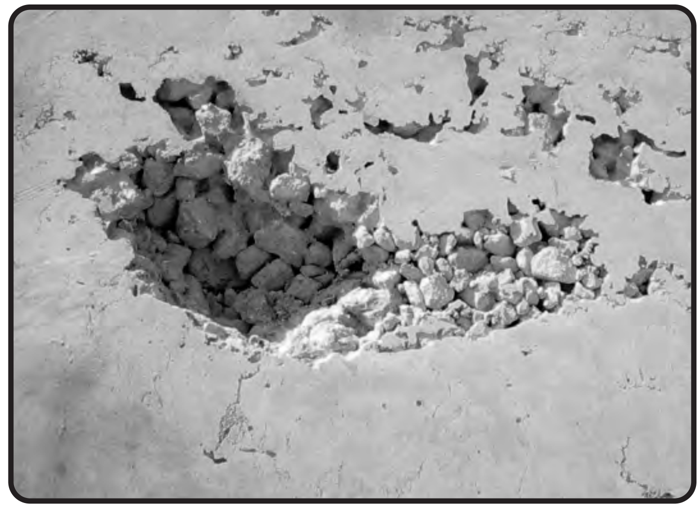
■ Problem. Small voids or pits, which often appear in vertical or sloping surfaces. They result from pockets of air or water trapped against the forms during placing and are generally less than 1/2" in diameter. The main objection is appearance. Bugholes do not lead to deterioration or harm the structural qualities of the concrete.

■ Causes. Main cause is placement methods. Air is entrapped within the plastic concrete during mixing and placing. Large voids quickly exit the surface. Medium size voids exit during consolidation. Smaller voids are not worked out as easy, tend to stay within the concrete. External vibration will often cause bubbles to collect on the form face. Some form release agents also cause air to collect on the surface.

■ Solution/Prevention. It is extremely difficult to fully eliminate bugholes. Thorough consolidation efforts with smaller lifts will minimize the size and number of voids. Do not over vibrate. Minimize the fall of concrete during placement, by whatever means available. Determine which form release agent results in best appearance and ensure it is applied at the recommended rate. Work with your ready mix producer to optimize concrete mix for best appearance. Lower sand to total aggregate ratios tend to lead to less bugholes. Self-consolidating concrete may be a solution.

Honeycomb / Rock Pockets

■ Problem. Both the most common defect and the easiest to prevent. It consists of exposed pockets of coarse aggregate not covered by mortar. May also be evident, to a lesser degree, by "shadowing" (mortar loss) along form joints.



■ Causes. Most often caused by improper consolidation, or leaky forms which allows mortar to escape. May also be caused by a stiff, unworkable mix, which cannot be properly consolidated. Coarse aggregate may also separate from mix when dropped from bucket or pump. This separated stone is then pushed into a corner or collects along some obstruction casing a honeycomb.

■ Solution/Prevention. Attention to detail! Before placement, check tightness of forms at joints and penetrations. Do not exceed 4" slump mix unless using mid-range or high-range water reducer. Deposit concrete as vertically and uniformly as possible. Use a tremie if necessary. Place smaller lifts and thoroughly vibrate each lift. Adjust mix to include intermediate aggregate. Consider use of self consolidating concrete.

Sandstreaking

■ Problem. A vertical streak of exposed fine aggregate on a formed concrete surface, characterized by irregular lines, usually at the top of a lift.

■ Causes. Too much water and/or improper aggregate gradation are the causes of sand streaking. These lines develop when excess water moves through the mix towards the surface (bleeds). High-range water reducers can aggravate an unstable mix, causing additional bleed.

■ Solution/Prevention. Avoid excessive amounts of water in the mix. Air-entrained concrete, containing well-graded sand and the proper amount of water will not produce sand streaking.

References

U.S. Army Corps of Engineers, "Concrete Construction Inspection" September 1984
NRMCA, "Concrete in Practice"

cracking concrete surfaces

Definition

Concrete, like other construction materials, contracts and expands with changes in moisture content and temperature and deflects depending on load and support conditions. When provisions for these movements are not made in design and construction, then cracks can occur.

Cracks rarely affect the structural integrity of the concrete. Most random individual cracks look bad and although they permit water to enter, they do not lead to progressive deterioration. Closed spaced pattern cracks or D-cracks due to freezing and thawing are an exception and may lead to ultimate deterioration.

Contributing Factors

The majority of concrete cracks usually occur due to improper design and construction practices such as:

1. Omission of isolation and control joints
2. Delay in cutting joints and/or inadequate depth
3. Improper subgrade preparation
4. The use of high slump concrete and or the addition of water at jobsite
5. Improper finishing
6. Inadequate or no curing

How to Prevent or Minimize Cracking

All concrete has a tendency to crack and it is not possible to produce completely crack-free concrete. However, cracking can be reduced and controlled if the following safeguards are followed.

■ **Subgrade and Formwork.** All top soil and soft spots should be removed. Regardless of the type of soil beneath, the slab should be constructed on compacted soil or granular fill, well compacted by rolling, vibrating or tamping. All formwork must be constructed and braced so that it can withstand the pressure of the concrete without movement. Polyethylene vapor barriers increase bleeding and greatly increase cracking of high slump concrete. Cover the vapor barrier with 2-3 inches of damp sand to reduce bleeding. Immediately prior to concrete placement, dampen the subgrade, formwork and the reinforcement.

■ **Concrete.** In general, use concrete with an increased rock to sand ratio, lower cement content, water reducing admixtures and a moderate slump (not over 5 inches). Avoid retempering. If higher slump, up to 7 inches, is to be used, proportions will have to be changed and special mixtures developed to avoid excessive bleeding, segregation and low strength. Specify air-entrained concrete for outdoor slabs that will be subject to freeze-thaw cycles.

■ **Finishing. Do Not** perform finishing operations with water present on the surface. Initial screeding must be promptly followed by bullfloating. If evaporation is excessive, control it by some means to avoid plastic shrinkage cracking (see plastic shrinkage). Cover the concrete with wet burlap or polyethylene sheets between finishing operations.

■ **Curing.** Start during as soon as possible (see curing).

■ **Joints.** Provisions for contraction or expansion movements due to temperature and/or moisture change should be provided with construction of control or contraction joints by sawing, forming or tooling a groove approximately 1/4 the thickness of the slab, no further apart than 30 times the thickness. Often it is necessary to space control joints closer to avoid long thin areas. The length of an area should not exceed 1.5 times the width of the panel. Isolation joints should be provided whenever vertical or horizontal freedom of movement is anticipated; such as where a floor meets walls, columns or footings. Isolations joints are full-depth joints and are constructed by inserting a barrier of some type to prevent the bond between the slab and the other elements.

■ **Cover over reinforcement.** Cracks in reinforced concrete caused by expansion of rust on reinforcing steel should be prevented by providing sufficient cover (at least 2 inches) to keep salt and moisture from contacting the steel.

References

NRMCA CIP 4 (1998). *What, Why and How? Cracking Concrete Surfaces*
National Ready Mixed Concrete Association

NRMCA CIP 6 (1998). *What, Why and How? Joints in Concrete Slabs on Grade*
National Ready Mixed Concrete Association

crazing concrete

Definition

Crazing is the development of fine random cracks on the surface of the concrete caused by shrinkage of the surface layer. These cracks are rarely more than 1/8 inch deep and are more noticeable on steel troweled surfaces. The cracks are shaped like irregular hexagon and are typically no more than 1 1/2 inch across. Generally craze cracks develop at an early age and are apparent the day after placement. The crazing is more prevalent when the surface is wet.

Crazing cracks are sometimes referred to as shallow map or pattern cracking. **They do not affect the structural integrity of the concrete.**

Contributing Factors

■ Poor or inadequate curing (see curing).

■ Too wet a mix, excessive floating, the use of a jitterbug or any other procedure which depresses the coarse aggregate and produces an excessive concentration of cement paste and fines at the surface.

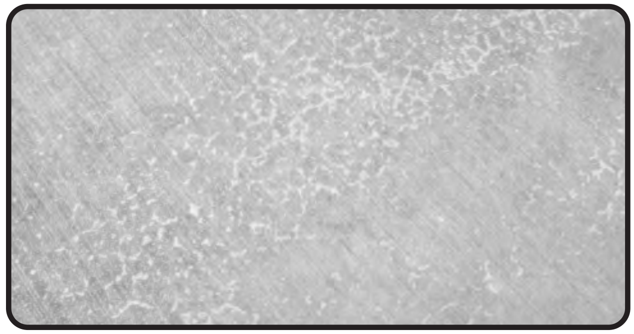
■ Finishing while there is bleed water present on the surface or the use of steel trowel at a time when the smooth surface brings up too much water and cement fines. The use of a darby or bullfloat while bleed water is present will produce a high water-cement ratio at the surface, which makes the slab more susceptible to crazing (see finishing).

■ Sprinkling cement on the surface to dry up bleed water. This concentrates fines on the surface.

■ Occasionally carbonation of the surface can cause crazing. (Carbonation is a chemical reaction between the cement and carbon dioxide or carbon monoxide from unvented heaters or power trowels.

How to Prevent Crazing

■ Start curing the concrete as soon as possible. The surface should be kept wet by either flooding with water or covering with wet burlap and keeping moist for a minimum of 3 days. (see curing).



■ Use of moderate slump (3 to 5 inches), air-entrained concrete. Higher slump (up to 6 or 7 inches) can be used, provided the mixture is designed to produce the required strength without excessive bleeding and segregation. (Please consult your local ready mix producer for help with mix designs.) Air entrainment helps to reduce the rate of bleeding of fresh concrete and thereby reduces the chance of crazing.

■ Never sprinkle or trowel dry cement or a mixture of cement and fine sand into the surface of the plastic concrete to absorb bleed water. Remove bleed water by dragging a garden hose across the surface. DO NOT perform any finishing operation while bleed water is present on the surface.

■ Dampen the subgrade prior to concrete placement to prevent it from absorbing too much water from the concrete. If an impervious membrane, such as a polyethylene, is required on the sub grade, cover it with 2 to 3 inches of damp sand to reduce bleeding.

References

NRMCA CIP 3 (1998). *What, Why and How? Crazing Concrete Surfaces*
National Ready Mixed Concrete Association

blistering

Definition

Blisters are hollow, low-profile bumps on the concrete surface, typically the size of a dime up to an inch, occasionally even two to three inches in diameter. A dense troweled skin of mortar about 1/8-inch thick covers an underlying void which moves around under the surface during troweling.

Voids form under a dense surface skin by one of two phenomenons. Some believe that incidental air voids rise in sticky concretes and are trapped under the dense surface skin, produced by troweling. Others believe that bleed water rises and collects to form a void under this skin. That water is re-absorbed into the underlying concrete, leaving a layer of irregular void space under the surface which is then consolidated by troweling to form a round blister. Frequently, the blister is lined with a faint layer of "washed" sand.

In poorly lighted areas, small blisters may be difficult to see during finishing and may not be detected until they break under traffic.

Contributing Factors

Blisters form when the fresh concrete surface is sealed by troweling while the underlying concrete is plastic or bleeding, or able to release air. The small, round blisters form late in the finishing process, after floating and first troweling. Blisters are more likely to form if:

1. The subgrade is cool and the concrete on the bottom sets slowly.
2. Wind or air blowing over the concrete surface.
3. Premature finishing.
4. The concrete is sticky from higher cement content or excessive fine sand.
5. The slab is thick.
6. The slab is on polyethylene and the slump is three to four inches.
7. Excessive use of jitterbug or vibrating screed, which works up a thick mortar layer on top.

Recommendations

The finisher should be wary of a concrete surface that appears to be ready to trowel before it normally would be expected. Finishing should not take place until the water sheen has left the surface of the concrete and the concrete can bear a man's weight with only indentation of no more than 1/2 inch. Emphasis in finishing should be on placing, straight edge, and floating the concrete as rapidly as possible, without working up an excess layer of fat. After these operations are completed, further finishing should be delayed as long as possible, and the surface covered with polyethylene or otherwise protected from evaporation. Fog sprays should be kept to a minimum. In initial floating the float blades should be flat, to avoid densifying the surface too early (see finishing). Use of an accelerator or heated concrete often prevents blisters in cool weather.

If blisters are forming, try to either flatten the trowel blades, or tear the surface with a wood float and delay finishing as long as possible. Any steps that can be taken to slow evaporation should help.

References

NRMCA CIP 13 (1983). *What, Why and How? Concrete Blisters*
National Ready Mixed Concrete Association

Peterson, Carl, (1974). Blistering of Concrete Surfaces During Finishing
Portland Cement Association

dusting

Definition

Dusting is the occurrence of chalking or powdering at the surface of a concrete slab. This weak surface can be easily scratched with a nail, and gets its name by the constant accumulation of dust under nearly any traffic.

Contributing Factors

A concrete floor dusts under traffic because the wearing surface is weak. This weakness can be caused by caused by one or a combination of the following:

1. Any finishing operation performed while bleed water is on the surface. Working the bleed water back into the top 1/4 inch of the slab produces a very high water-cement ratio and, therefore, a low strength surface layer.
2. Placement over a non-absorptive subgrade or polyethylene. This reduces normal absorption by the sub-grade, increases bleeding and, as a result, the risk of surface dusting.
3. Insufficient or no curing. This omission often results in a soft surface skin which will easily dust under foot traffic.
4. Floating or troweling of condensation moisture from warm, humid air on cold concrete. In cold weather, the concrete sets slowly, in particular cold concrete basement floors. If the humidity is relatively high, water will condense on the freshly placed concrete. If this water is troweled into the surface, dusting is likely.
5. Inadequate ventilation in close quarters. Carbon dioxide from open salamander heaters, gas engines, generators, power buggies, or mixer trucks may cause a chemical reaction known as carbonation which greatly reduces the strength and hardness of the concrete surface.
6. Inadequate protection of freshly placed concrete from rain, snow, or drying winds.

How to Minimize Dusting

1. In general, use concrete with a moderate slump, not to exceed five inches. Higher slump concrete may be used, provided the mixture is designed to produce the required strength without excessive bleeding or segregation. Higher slumps can be used in hot weather when setting times are reduced and time is available for bleeding. In cold weather, delayed set times will increase bleeding. Lower slump mixes should be used in cold weather. Concrete having a low water-cement ratio and moderate slump helps provide a strong, wear resistant surface.
2. Never sprinkle or trowel dry cement powder into the surface of plastic concrete to absorb bleed water. Remove bleed water by dragging a garden hose across the surface. Excessive bleeding of the concrete can be reduced by using air entrained concrete, modifying mix proportions, and reducing set times.
3. Do not perform any finishing operation with water present on the surface. Bleed water can be worked into surface fines from delayed bullfloating. Initial screeding must be promptly followed by bullfloating. Do not use a jitterbug to bring excess mortar to the surface.
4. Avoid direct placement of concrete on polyethylene or non-absorptive sub-grades. Place 2 to 3 inches of damp sand over polyethylene or non-absorptive sub-grade prior to concrete placement. On absorptive sub-grades, dampen the surface just prior to concrete placement
5. Provide proper curing by using liquid membrane forming curing compound, or by covering with wet burlap. Protect the concrete from the environment.
6. When placing concrete in cold weather, use accelerators (non-chloride and/or chloride bearing).

References

NRMCA CIP 1 (1998). *What, Why and How? Dusting Concrete Surfaces*
National Ready Mixed Concrete Association

curling (differential shrinkage)

Definition

Nearly, all concrete floor slabs curl. Curling is the distortion of a slab into a curved shape by upward or downward bending of the edges. This distortion can lift the edges of the slab from the base leaving an unsupported corner. It is common when thin slabs are poured on top of older concrete. Sometimes, curling is evident at an early age. In other cases, slabs may curl over an extended period. Slabs on ground tend to curl more often than suspended slabs. Curling has always been a problem, but is more so today because of our higher strength concrete mixes and changed placement methods.

Why do Concrete Slabs Curl?

Curling occurs when the upper portion of a slab tries to occupy a smaller volume than the lower portion. The change in volume can be due to temperature, moisture, shrinkage, and other variables, or combination of variables. Curling and shrinkage are closely related, and anything that effects shrinkage will have a like effect on curling. Factors which increase curling potential include:

1. Wide joint spacing
2. Gap graded aggregate
3. Thin slabs
4. High slump
5. Too many revolutions on the mixer
6. High placement temperatures
7. Small stone used when larger could have been in mix
8. Bleeding
9. High shrinkage potential aggregates
10. Chlorides
11. Some admixtures

How to Minimize Curling

The primary factors controlling dimensional changes of concrete which lead to curling are: drying shrinkage, construction practices, moist or wet sub-grades, and day/night temperature cycles. The following will help minimize the potential for curling:

- Thicken slab, or at least edges of slab
- Use of synthetic, polypropylene fibers
- If placing over a vapor barrier, include a dry blotter between vapor barrier and concrete
- Use lowest strength concrete as possible (if abrasion resistance is needed, add mineral or metallic dry-shake to slab surface)
- Place at lowest possible slump, avoid retempering
- Shorten joint spacing – not more than 24 times floor thickness
- Use continuous reinforcing (or steel fibers)
- Do not place concrete at elevated temperatures
- Properly cure slab

References

NRMCA, Concrete in Practice #11, Curling of Concrete Slabs

Concrete International, "Thou Shalt Not Curl Nor Crack....," January 1999

Concrete International, "Why Slabs Curl," March 2002
Portland Cement Association

Portland Cement Association,
Concrete Technology Today,
"Slab Curling is Not a Game Played on Ice," (June 1982)

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