CMC Newsletter

Volume 1 No. 1 January - March 2004

CMC Construction Materials Consultants, Inc.

Serving the Industry through Testing, Investigation, Evaluation, & Research

Welcome to CMC's Quarterly Newsletter. In this section, we discuss everyday issues of our industry from past and present projects, materials evaluation and failure investigation, relevant topics, questions and answers, and how our services can assist you. This can also be a good discussion forum for you. We welcome your comments, criticism and any ideas you wish to share with us, which will not only be beneficial in understanding the behavior and properties of construction materials but will also contribute to the success of our industry. We hope you find our newsletter informative.

Driveway & Pavement - Scaling

A common problem of concrete driveways, sidewalks, patios, and pavements is scaling. Scaling is flaking or peeling away of the finished surface to a depth of ⅛ to ¼ in. (Fig 1). Scaling is the consequence of a number of factors, which are related to concrete materials, construction practices, environmental conditions, drainage systems, and post-construction maintenance. Deicing salt—a commonly blamed culprit of scaling—is not mentioned above because salts cause scaling only if the concrete is of poor quality or constructed improperly, or if salt was applied before the attainment of concrete maturity. Good quality concrete properly constructed and maintained can resist the effects of salts. Scaling is common in concrete that lacks air entrainment (Fig 2), or has inadequate air entrainment and is exposed to cyclic freezing and thawing at water-saturated conditions, and/or, in concrete that is finished improperly. In these situations, deicing salts aggravate scaling.

Fig 1: Scaling of Concrete Sidewalk

To investigate causes of scaling, samples from scaled and relatively sound areas should be collected for petrographic examinations, air-void analysis and other supplementary tests like chloride analysis and compressive strength. Additionally, deicing-salt scaling resistance of slabs can be tested.

Once the cause of the scaling has been identified, several corrective measures can be taken to prolong the service life of the concrete.

- D. Jana, CMC.

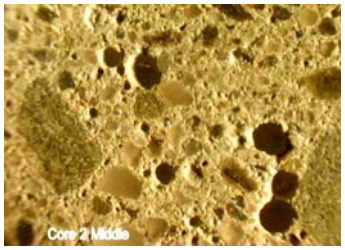
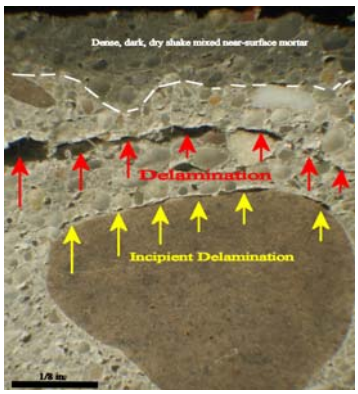


Fig 2: Lack of adequate entrained air is a common cause of scaling.

Delamination of Concrete Slabs

Beware of machine troweling an air-entrained concrete slab. Air entrainment is not necessary in an indoor slab—concrete tends to bleed at a reduced rate so that bleed water sheen does not appear at the surface as fast as in a non air-entrained concrete. If finishing starts before bleeding ends, bleed water can accumulate under the finished surface and cause delamination. Air makes concrete sticky—prolonged finishing of sticky concrete can also lead to delamination.

The right photo shows dense, dark paste at the surface due to finishing that squeezed water and washed air out of the concrete and resulted in a delamination plane below the dense surface mortar (red arrows), and an incipient delamination (yellow arrows). *- D. Jana, CMC.*



Upcoming Events:

- *Jan 11-15: TRB Annual Meeting*
- *Feb 17-20: World of Concrete 2004*
- *Mar 8-10: NRMCA Annual Conv.*
- *Mar 13-18: ACI Spring Conv.*

Future Issues:

- *Low breaks—Why?*
- *Dome Tests & Moisture Problems*
- *Concrete Cracking—A Closer Look*
- *Carbonation—Blessings & Curses*
- *Does salt cause scaling?*
- *Failure of anchoring grouts*
- *Concrete Exposed to Fire*
- *Acid Attack on Concrete Pipe*
- *Backfill Expansion*
- *Popouts & Mortar Lift-offs*
- *Tile Cracking*
- *Delayed Setting—A Case Study*

Inside this issue:

Frozen Concrete

Placing concrete at this time of the year faces a common problem of freezing. If the concrete is not 'warm enough', the subgrade to which it is placed is not 'thawed enough', or if the cement it contains does not hydrate quickly to develop the strength, the concrete freezes at the plastic state.

According to ACI Committee 306 report on 'Cold-Weather Concreting', cold weather is defined as "a period when more than 3 successive days the mean daily temperature drops below 40ºF." Concrete gains very little strength at low temperature. Some common recommendations for keeping concrete from freezing are the use of Type III portland cement, air-entrained concrete, additional portland cement, set-accelerating chemicals, hot water and thawed aggregates in the mix, heated enclosures, insulating blankets, thawed subgrade, heaters, etc. Follow the industry (ACI) recommendations of cold-weather concreting.

To identify whether or not a particular concrete was frozen, you need to do petrographic examinations of the concrete. Petrographic examinations search for evidence of freezing of water in concrete such as ice crystal impressions (Fig 1) or ice lens impressions. Usually, frozen water forms an imprint on the plastic or semi-plastic concrete, and after hardening, the imprint remains as a series of parallel, often radiating, elongated depressions. (Fig 1).

The problem is suspected when the strengths of concrete cylinders are lower than expected. Petrographic examination is a powerful method to identify a frozen concrete.

- D. Jana, CMC.

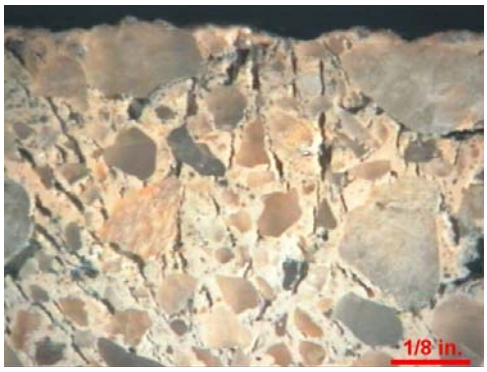


Fig 1: Shown are ice crystal imprints on the lapped section of a concrete.

Water Leakage in Masonry

One of the common problems of brick or concrete masonry structures is water leakage. 80% of our masonry projects are related to water leakage.

Water leakage is a consequence of several factors. The common causes are inadequate flashings, inadequate mortar in the bed or head joints, inadequate bond between the masonry units and mortar, and cracks in mortar or masonry units.

Prior to construction, masonry units should be tested for the initial rate of absorption (ASTM C 67), which affects the strength of the bond between the masonry units and mortar. Units with a high initial rate of absorption should be pre-wetted prior to placement.

Shrinkage of mortar, either due to excessive water in the mix and/or due to placement on a hot, sunny, windy, and dry day are common causes of cracking.

Petrographic examinations provide evidences of causes of water leakage in masonry. Water ponding test in the laboratory on masonry panels is also helpful. *- D. Jana, CMC.*

"80% of our masonry projects are related to water leakage."

Mortar Matching

One common request we get from masons is to determine the composition of an existing pointing mortar so that a matching mortar can be prepared. To determine this, we need a handful of existing mortar fragments removed from joints by hammer and chisel. We do petrographic examinations and chemical analysis to determine the class of the mortar (i.e., lime mortar, portland cement-lime mortar, or masonry cement mortar); and based on the estimated or determined volumetric proportions, the type of the mortar (i.e., M, S, N, or O). Pigments, if present, can also be determined so that a matching pigment can be used.

Additionally, compressive strength of mortar can be tested if a ½ to ¾ in. cube can be saw-cut from a sample. Usually this is not possible in mortars from narrow joints that are less than ½ in. wide (unless mortar is taken from the hollow cores).

Hydrated lime, if occurring as a white lump form (as shown in the right photo), is easy to detect.

To find a close match, the existing mortars must be tested according to ASTM C 1324.

Shown is a white lump of hydrated lime in a portland cement-lime mortar. The bars are at 1/16-in. intervals.

Stone Failure

Cyclic freezing and thawing of natural stones and cast stones at water-saturated conditions can cause cracking, spalling and fracturing. For natural stones it is the type of stone, absorption, pore size and distribution, and environmental conditions that determine the degree of saturation and whether or not the stone is susceptible to deterioration during freezing.

For cast stone, in addition to the above, the air-void system determines its durability.

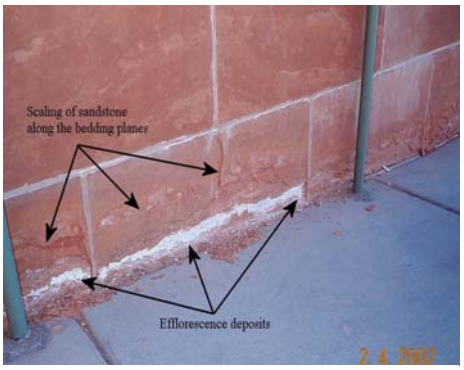
Petrographic examinations provide composition, microstructural, and textural information about the stone to determine its durability and causes of failure.

Accelerated weathering and freeze-thaw durability are two common laboratory tests to determine the resistance to damage by severe weather.

In future issues, we will discuss other types of stone failures such as curling of stone claddings, cracking, and de-bonding.

The right photo shows efflorescence deposits on ashlar sandstone units due to a mechanism called salt hydration distress where cyclic conversion of sodium sulfate salts (from thenardite to mirabilite) causes volume expansion and scaling. Salt crystallization in pore spaces of stones can also cause distress.

- D. Jana, CMC.



Efflorescent deposits and scaling of ashlar sandstone units. The efflorescent deposits are salts of sodium sulfate (thenardite and mirabilite) formed from a sulfate-laden solution migrated through the bedding planes of sandstone from the soil - scaling was due to salt hydration distress where cyclic hydration of thenardite to mirabilite causes a 315% increase in volume and subsequent stresses in the sandstone.

De-Bonding of Ceramic Tile

It is not the tile but poor installation procedures that are commonly the cause of de-bonding. The composition and properties of setting bed mortar, the percent coverage of the tile underside by setting bed mortar, improper surface preparation, substrate type, and moisture conditions are some facts that affect the bond strength of tile to the substrate.

For proper bonding, follow the manufacturer's recommendations. For installation procedures, consult the Manual of the Tile Council of America, or a good book such as *Ceramic Tile Setting* by John P. Bridge, McGraw-Hill Publications. The tile network (www.tile.com) also provides a lot of helpful tips. De-bonded tiles are detected by tapping with a metal rod.

Weak bond between ceramic tile and white thin-set leveling mortar

Future issues will discuss various case studies of tile deterioration such as de-bonding of ceramic tile from the setting bed, moisture expansion of quarry tile, curling and de-bonding of stone tile due to expansion of setting bed mortar and many others. *- D. Jana, CMC.*

"It is not the tile but poor installation procedures that are commonly the cause of de-bonding."

Construction Websites To Bookmark

www.concrete.org

American Concrete Institute—Provides a wealth of information on all aspects of concrete.

www.concretenetwork.com

The Concrete Network—A network of concrete construction companies including contractors, suppliers, ready mixed suppliers, testing companies, and consulting firms.

www.nrmca.org

National Ready Mixed Concrete Association—A great source of information for ready mixed suppliers. Good resource of publications on various aspects of concrete.

www.tcausa.com

Tile Council of America—A must visit site for tile manufacturers and suppliers—directories of technical, inspection, consulting services, and the TCA Manual.

www.nahb.com

National Association of Homebuilders—A site for homebuilders—consumer products, meetings, events, education, and more.

www.nssga.org

National Stone, Sand and Gravel Association—Important site for aggregate suppliers—all aspects of aggregates for concrete and asphalt industries.

Industry Publications of CMC

Recent:

Jana, D. and Erlin, B. *Scaling Revisited—Commentary*, Concrete International, 2001.

Erlin, B., and Jana, D., *Forces of Hydration that can cause havoc in concrete—May the force not be with you*, Concrete International, 2003.

Upcoming:

Erlin, B. and Jana D. *So, what about chloride deicing chemicals applied to concrete surfaces before a one year—or longer—waiting period. Where is the truth and what is fantasy?* Concrete Construction.

Jana, D. and Erlin, B. *In air-entrained concrete it's the number of bubbles that count.* Concrete Construction.

Jana, D. and Erlin, B. *Delamination—The sometime curse of entrained air*. Concrete Construction.

CMC -Construction Materials Consultants, Inc.

CMC is a reputable, full-service, independent consulting and testing firm dedicated to providing materials evaluation and failure investigation services of construction materials. We have extensive experience in evaluation and forensic investigations of products related to portland cement and other cementitious materials, aggregates, concretes and concrete-products, natural and building stones, grouts, plasters, clay, stone and concrete masonry units, masonry mortars, and ceramic, quarry, porcelain, mosaic and vinyl tiles. Visit us at www.cmc-concrete.com for a complete listing of services or call us with your questions or concerns at 724-539-1800.

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Q & A

Q: *Can I use an antifreeze in concrete for pouring in cold weather?*

A. No. Antifreeze mixtures used in automobiles will severely damage concrete and should never be used. The common practice is to use a set-accelerating admixture such as calcium chloride, which is not an antifreeze but helps rapid strength development in cold weather. Calcium chloride, however, can cause corrosion of steel in concrete, especially if its amount is more than 2% by mass of cement. Follow the ACI recommendations of precautions to be taken in cold weather construction.

Q. *How long can I work on a concrete after mixing?*

A. It depends on the ingredients of the concrete and the weather conditions. Usually, normal portland cement concrete can be worked 90 minutes after mixing. In hot weather or in the presence of set accelerating chemicals, it sets quickly. In cold weather or in the presence of a retardar, it delays setting and prolongs the working time.

Q. What causes over or under sanding of masonry mortar?

A. Moisture in the sand. Wet sand occupies more volume than the same weight of dry sand. This often causes over or undersanding of the mix and affects the strength and bonding characteristics of the mortar. Oversanded mortar is harsh, unworkable, provides a weak bond with the masonry units, and performs poorly in a cyclic freezing environment.

Q. What is the Mohs scale of hardness?

A. An arbitrary scale of 1 to 10, which provides the scratch hardness of a mineral. Each unit of hardness is represented by a mineral that can scratch any other mineral having a lower-ranking number; the minerals are ranked from talc or 1 (the softest), upward through gypsum or 2, calcite or 3, fluorite or 4, apatite or 5, feldspar or 6, quartz or 7, topaz or 8, corundum or 9, and diamond or 10 (the hardest). The Mohs scale is frequently used for measuring the hardness of stones.

Q. *What is frost heave?*

A. The water in soil freezes and expands, then contracts again when it thaws. This phenomenon is called frost heave. Foundations should be placed below the winter frost line to avoid damage from frost heave. The depth of frost heave depends on climate, location, soil type and composition, altitude, and weather patterns.

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