INTRODUCTION

How often concrete slabs are poured with the prior knowledge that ceramic tile or natural stone will be the finished flooring material? Even with prior knowledge, how often are concrete slabs finished and cured in accordance with tile industry recommendations? AMERICAN NATIONAL STANDARD INSTITUTE’s (ANSI) 1999 publication, AMERICAN NATIONAL STANDARD SPECIFICATIONS FOR THE INSTALLATION OF CERAMIC TILE, contains several references pertaining to the surface condition of a concrete slab prior to bonding tile directly using a thin-set method. Below are some of those excerpts.

Section AN-3.2.1 Concrete Slabs paragraph AN-3.2.1.2 states, “Where tile is to be bonded directly to concrete slabs with one of the thin-set methods include the following section: Steel trowel and fine-broom finish concrete slabs that are to receive ceramic tile. Cure concrete slabs that are to receive tile before tile application. Do not use liquid curing compounds or other coatings that may prevent bonding of the tile setting materials to slabs.”

Section A-3.1 Inspection of Surfaces and Conditions paragraph A-3.1.1 states, “All surfaces shall be structurally sound, clean, dry, and free of oily or waxy films and all foreign matter. Concrete surfaces shall be free of form oil, curing compounds, and laitance.”

Paragraph A-3.1.2 states, “If tile is to be bonded directly to a concrete floor with one of the thin-set methods, the slab shall have a steel trowel and fine broom finish, wood float finish, or mechanical scarification.”

In addition, several FIELD REPORTS in CERAMIC TILE INSTITUTE OF AMERICA’s, (CTIOA) TILE MANUAL, reference the preparation and condition of concrete slabs for direct
bonding of tile using the thin-set method. For more information log onto [WWW.CTIOA.ORG](http://WWW.CTIOA.ORG), call (310) 574-7800 or fax (310) 821-4655.

This Field Report will discuss the most common types of bond breakers and contaminants, how to determine if bond breakers are present, surface preparation and removal of bond breakers and the effects bond breakers have on a tile installation. This report will not address other criteria concrete slabs must meet such as; stability, deflection, plane tolerances, flatness, patching imperfections, slope requirements, expansion joint requirements, saw cuts, etc. This report pertains to concrete slabs that differ in service requirements but does not include post-tensioned slabs.

**DISCUSSION**

The success of any installation over a concrete slab, where tiles are directly bonded in a thin-set application, begins with identifying potential bond breakers or contaminants and successfully removing them. Curing compounds, sealers, coatings, paint, existing adhesives, remaining residue from previous floor coverings, grease, oil, dead cement, surface laitance¹, dust, dirt, etc. should all be viewed as potential bond breakers. Even clean, potable water on a clean concrete slab could be considered a bond breaker if there is too much of it. Surface contaminants can also react with the bonding mortar or adhesive, which could have a detrimental effect on the success of the installation. Finishing techniques along with the use of some types of concrete additives can also affect the ability of a mortar to form a good bond. Steel or rotary troweled concrete produces a slick, shiny, dense, glass-like surface making it difficult for a mortar to develop a mechanical or adhesive bond. Concrete additives along with finishing techniques can also produce a very dense concrete surface.

Visual assessment is the first and most basic means to identify if potential bond breakers are present. The most obvious bond breakers would be paint, dirt, adhesive residue, pigmented coatings, loose particles, off-white drywall dust or dust from sanding drywall compounds. Oil and grease, which have penetrated the slab, are sometimes difficult to detect visually. Clear, colorless coatings vs. a steel troweled concrete surface may be difficult to differentiate. Penetrating sealers are virtually impossible to detect visually. If a concrete slab appears to be clean, place a few drops of water on various areas of the slab. When water penetrates immediately and readily it is an indication that the concrete needs minimal preparation and will allow the mortar to form a good bond. When water beads for a few minutes before penetrating, it is an indication that contaminants are below the surface of the concrete. When water beads with no signs of absorbing into the concrete bond breakers are present. If a drop of water begins to take on the colors of a rainbow, most likely a petroleum-based contaminant is present. If a drop of water becomes cloudy or dirty, loose materials are present. Chemicals can also be used to determine if bond breakers are present but they are harder to come by. For example, a solution of Phenolphthalein in alcohol can be used to detect either the presence of moisture in a concrete slab, alkalinity or the presence of a potential bond breaker. When this clear, colorless, liquid solution is placed on the concrete and penetrates readily with no color change, no moisture is present in the concrete and because it penetrates readily, no bond breakers are present. If the chemical beads and does not penetrate, a bond breaker is present. If the chemical penetrates and turns a bright magenta color, moisture is present in the concrete and its alkaline pH generates the color change. (See Fig. 1 below)
COMMON BOND BREAKERS/CONTAMINANTS

Curing Compounds
Available as water or petroleum-based, their purpose is to form a surface barrier on the concrete to prevent rapid moisture loss. Water is vital to the hydration process of Portland cement and rapid water loss will lead to weak concrete. Most curing compounds are designed to dissipate after 90 days provided they are exposed to ultra violet rays. However, many concrete slabs are only a few days old when construction of a structure or building begins. The slab is exposed to foot traffic bringing dirt and dust, which gets ground in. Construction materials and tools are placed on the concrete. Roofs and coverings shade the construction and slab. All of these ultimately protect the concrete from direct exposure to UV rays so the curing compound does not break down. Petroleum and water-based curing compounds can be removed by mechanical means such as shot blasting or grinding. After cleaning, always place a few drops of water on various areas of the concrete and check for rate of water absorption.

Coatings, Sealers, Paint, Existing Adhesives, Grease, Oil
Coatings, topical sealers, paint, and existing adhesives can be water or petroleum-based. In most cases, these are surface contaminants and do not penetrate deeply into the concrete. Adhesive and paint removers can be used but use of the appropriate type is important. Some will soften the coating and make it easy to scrape them from the surface. Some contain fast evaporating solvents,
dissipate quickly and leave little to no residue. Some removers can actually do more harm than
good. They dissolve coatings, adhesives or paints and in the process allow the dissolved materials
to penetrate into the concrete forming a bond breaker below the surface. This makes the
contaminant more difficult to detect and more difficult to remove. This creates a situation similar to
removing penetrating sealers, grease and oil where removers that draw out the contaminants must
be used. Some penetrating, water-based sealers are immune to strippers, removers, and cleaners and
can only be removed by mechanical means such as, shot blasting or grinding, where an actual layer
of the concrete’s surface is removed. After cleaning, always place a few drops of water on various
areas of the concrete and check for rate of water absorption.

Dust, Dirt, Dead Cement, Surface Laitance¹
Common sense reminds us that adhesive tape will not stick to a dusty surface. The same holds true
for mortars and adhesives. Whether the mortar is troweled onto the concrete with the notched side
or keyed in first with the flat side of the trowel, if the concrete surface is dusty, troweling methods
will not ensure a good bond will be formed. The contents of the dust on the concrete can have a
profound and detrimental affect on the success of a tile installation. Dead cement on the surface of
concrete can be caused by the use of petroleum-based curing compounds. The curing compound
engulfs the fresh cement particles preventing proper hydration, which leads to a surface layer of
dead cement. Petroleum laden dead cement mixed into freshly troweled thin-set will affect the
working and performance properties of the mortar. Drywall dust and dust from sanding joint
compounds, if not completely removed from the surface of the concrete, can get mixed into the
mortar during troweling, react with the Portland cement in the fresh mortar and set off a chain
reaction. Set time of the mortar is accelerated, open and adjustment times are also affected causing
the mortar to glaze over much faster than normal, which diminishes wet transfer of the mortar to
the back of the tile. This creates a situation where the mortar does not form a good bond to the tile.
Loose tile leads to cracked grout joints and tiles. Taking a few minutes to thoroughly vacuum,
sweep and damp mop the concrete to remove loose contaminants is a small price to pay compared
to the failure and call back waiting to happen.

¹ Laitance: A layer of weak and non-durable material containing cement and fines from aggregates,
brought by bleeding water to the top of over-wet concrete, the amount of which is generally
increased by over-working or over-manipulating concrete at the surface by improper finishing or by
job traffic.

² Note: If an existing adhesive, such as cutback, contains asbestos do not scrape, sand or use
removal methods that will create harmful dust. Contact the adhesive manufacturer and follow the
guidelines outlined in the RESILIENT FLOOR COVERING INSTITUTE’s (RFCI) pamphlet,
RECOMMENDED WORK PRACTICES FOR REMOVAL OF RESILIENT FLOOR
COVERINGS.

SHEAR BOND TESTING

At the request of CTIOA, Inc., a series of tests were performed to determine and compare the effect
a bond breaker has on the bond strength of a dry-set mortar and its ability to form a good bond. The
bond breaker used was a common concrete curing compound. The tiles used were unglazed, 4 ¼”
bisque wall tiles. The mortar used was a gray, high-strength, polymer-modified dry-set mortar meeting ANSI A118.4. Full tiles were used for this test and were offset approximately ¼” with a mortar thickness of approximately 1/8” between the tiles. All completed assemblies were kept indoors at room temperature prior to testing. The following are the assemblies that were made and tested in shear on a Tinius Olsen Universal Tester (See Fig. 2 below)
and compared to the minimum shear strength requirements of ANSI A118.4 for glazed wall tile. The assemblies for this test were not made in accordance with ANSI.

**Group 1** - Five shear bond assemblies were made where one tile per assembly was coated with the curing compound and allowed to cure for 72 hours. The other tile was left untreated. Tiles were bonded together with the gray mortar and allowed to cure for 7 days. The assemblies were sheared, the readings recorded, the average calculated and converted to a psi value.

**Group 2** - Five shear bond assemblies were made where both tiles were coated with the curing compound and allowed to cure for 72 hours. The tiles were bonded together with the gray mortar and allowed to cure for 7 days. The assemblies were sheared, the readings recorded, the average calculated and converted to a psi value.

**Group 3** - This represented the control group where none of the tiles in the 5 assemblies were coated with the curing compound. The tiles were bonded together with the gray mortar and allowed to cure for 7 days. They were sheared, the readings recorded, the average calculated and converted to a psi value.

**RESULTS**

**Group 1** - The average shear strength did not meet the minimum ANSI requirement of 300 psi but
was 3 times greater than the average psi achieved by Group 2. On all 5 assemblies, the mortar bonded to the untreated tile and released cleanly from the treated tile. (See Fig. 3a below)

**Group 2** - The average shear strength did not meet the minimum ANSI requirement of 300 psi. All 5 assemblies had varying amounts of mortar bonded to both tiles but the mortar could be removed easily and cleanly from each tile. (See Fig. 3b below)
Group 3 - The control group’s average shear strength far surpassed the minimum ANSI requirement and was three times greater than the average psi of Group 1 and nine times greater than the average psi of Group 2. However, the shear bond values do not reflect the actual strength of the mortar due the fact that on all 5 assemblies, the tiles failed and broke apart prior to the mortar completely shearing from the tiles or within itself. (See Fig. 3c below)

This test highlights the strong probability of an installation failure due to loss of bond when a
dry-set Portland cement mortar is placed onto a contaminated, unprepared concrete substrate. The results also show that a high-strength, A118.4 polymer-modified mortar cannot overcome a poorly prepared concrete substrate.

OPEN TIME AND SKIN OVER TESTING

Another test was performed to determine if a dry-set mortar’s open and skin over times are affected by airborne construction dust, which has settled onto the concrete’s surface prior to spreading the mortar. For this test, a cementitious backer board was used to simulate a concrete substrate. The surface was cleaned and properly prepared to accept a direct thin-set application of tile prior to placement of simulated airborne dust. The test procedure used for this Field Report did not follow those specified in ANSI. For this test, drywall dust and dust from sanding wallboard joint compound were used as the surface contaminants. The test was performed indoors at room temperature. An A118.4 mortar was used along with 4 ¼” glazed wall tiles. The mortar was spread first with the flat side of the trowel and keyed into the cementitious backer board to mix the contaminants into the mortar. Immediately after mortar was spread with a ¼” x ¼” x ¼” square notched trowel. The troweled mortar was allowed to stand for 5 minutes before placing a tile onto the ridges. The tiles were neither pressed nor twisted into the mortar. They were lightly placed onto the ridges and a 2000 gram (4.4 lbs.) weight was placed on the center of the tile for 30 seconds, then removed. This method was used to ensure an even and equal amount of pressure was applied to each tile. This procedure was repeated every 5 minutes on each section until a total of 25 minutes had elapsed from the initial spreading of the mortar with the notched side of the trowel. The 5 tiles in each section were left undisturbed in the mortar for 24 hours before removal. Removal consisted of prying the tiles off. For this test, the cementitious backer board was divided into 4 equal sections. Each section was treated as follows:

Section 1 - Drywall dust was used as the surface contaminant over the entire area.

Section 2 - Dust from sanding joint compound was used as the surface contaminant over the entire area.

Section 3 - A combination of both was used as the surface contaminant over the entire area.

Section 4 - This section was kept clean and free of any surface contaminants and served as the control.

RESULTS

Section 1 - At 15 minutes wet transfer was approximately 75%. After 20 minutes wet transfer was approximately 25%. After 25 minutes there was no transfer of mortar to the tile.

Section 2 - At 20 minutes wet transfer was approximately 50%. After 25 minutes wet transfer was approximately 20%.

Section 3 - At 15 minutes wet transfer was approximately 50%.
At 20 minutes wet transfer was approximately 10%. At 25 minutes there was no transfer of mortar to the tile.

Section 4 - At 25 minutes wet transfer was approximately 25%.

These results are a clear indication of how surface contaminants, even under ideal conditions, can reduce a mortar’s open time, accelerate its skinning or glaze-over time and affect its performance.

Note: Percentages are approximates. Only time intervals with less than 100% transfer are listed. Several tiles broke during removal or could not be completely separated from the mortar. In some cases coverage or wet transfer could not be precisely determined visually. Based on tile breakage and difficulty in separating tile from the mortar, 100% wet transfer is assumed.

CONCLUSION

When preparing a concrete slab for a direct thin-set application of tile, always take into consideration the service requirement of the slab. Is it residential, light commercial, moderate commercial, heavy or extra heavy? The amount and type of traffic the tile installation and slab will be exposed to will create different and varying dynamic forces that may require some additional preparation and determine the best method(s) to use.

Age of the slab is also a critical factor. Concrete slabs must be cured a minimum of 28 days prior to the installation of tile using a direct thin-set method. Proper surface preparation on concrete slabs less than 28 days old will not overcome the stress forces, shrinkage nor movement occurring within the slab.

Before installing tile directly to a concrete slab, answering a few checklist questions would help to determine the best course of action. Some basic questions:
- How old is the slab? (minimum 28 days)
- Is the surface dirty?
- Is loose debris present?
- Is the slab exposed to other construction trades?
- What type of traffic, substances or materials has the slab been exposed to?
- How was the slab finished? Steel troweled? Rotary finish? Broom finish?
- Is the slab’s surface slick or shiny?
- Does water penetrate readily?
- Does water bead on the surface?
- Was there a previous flooring material on the slab?
- Are existing adhesives present? If so, what type?
- Are there surface (coatings) or below surface (sealers) contaminants?
- Was a curing compound used? If so, what type?
- What is the service rating of the slab?
- Is the slab interior or exterior?
- What type of preparation method is needed? Mechanical or chemical?

The success and longevity of any tile installation begins with common sense and proper surface preparation. Education, knowledge and being aware of the importance of preparation are crucial to
the continued and future use and acceptance of ceramic tile as a finished flooring material. Hopefully, this Field Report has conveyed this important message; proper preparation is the beginning, improper preparation could mean the end.

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